Ministry of Sustainable Development, Environment, Climate Action and Constituency Empowerment

St. Kitts and Nevis

TECHNOLOGY NEEDS ASSESSMENT REPORT

ADAPTATION & MITIGATION

TECHNOLOGY NEEDS ASSESSMENT

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TECHNOLOGY NEEDS ASSESSMENT REPORT

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Background

The Federation of St. Kitts and Nevis is highly vulnerable to climate hazards, including hurricanes, storms, and droughts. Climate change is projected to increase mean temperatures, result in sea level rise, change rainfall patterns, and increase intensity and severity of storms. These projections and impacts are well documented, and the country needs to take decisive action on climate change adaptation. As such, climate change adaptation has been the primary focus of the Federation together with other SIDS worldwide.

While contributing very little to global GHG emissions, the Federation recognizes its commitments under the Paris Agreement and has taken actions to mitigate against climate change. Mitigation efforts are mainly related to advancing the use of renewable energies, improving energy efficiency, and maintaining carbon sequestration potential. The twin-island federation is simultaneously encouraging increased sustainable mobility but recognises that improvements in the power generation sector are foremost important. In addition, SKN recognises that mitigation actions identified have many co-benefits associated with human health, energy security, biodiversity conservation, employment, and economic growth, among others (GOSKN, 2022a,b).

The National Climate Change Policy (2017) provides the mandate and policy framework for climate action in St. Kitts and Nevis (GOSKN, 2017). The National Climate Change Adaptation Strategy (2018) operationalizes the National Climate Change Policy and was developed using a participatory approach, gaining input and recommendations from diverse stakeholder groups through national consultations (GOSKN, 2018). The Strategy details specific adaptation objectives and measures across eight sectors (agriculture, coastal and marine ecosystems, forest and terrestrial ecosystems, finance and banking, human health, infrastructure and physical development, tourism and water) and five cross-cutting areas (stakeholder capacity building and engagement, information management, research and monitoring, integrated adaptation and disaster risk reduction and inter-sectoral coordination) for the time period of 2018-2030.

The most recent vulnerability assessment for the Federation was completed in 2021 during the development of the St. Kitts and Nevis Third National Communication (3NC) to the UNFCCC. Specifically, Chapter 3 of the report related to vulnerability and adaptation assessment (GOSKN, 2021a). Climate change vulnerability was explored under two categories: hazard-based vulnerability and sectoral vulnerability. The most vulnerable sectors identified were human settlements and infrastructure, human health, gender, vulnerable groups and community-based adaptation, coastal, marine resources and fisheries, water, tourism, and agriculture.

Key challenges for adaptation planning that have emerged include the lack of data management systems to support adaptation planning, the lack of resources (funding, human resources, technology), the adaptation deficits and setbacks associated with the ongoing COVID-19 pandemic and drought, as well as hurricane Maria and Irma in 2017 (GOSKN, 2021a). Similarly, challenges to mitigation action include lack of adequate data for modelling and decision-making, high capital costs of renewable energy technologies, suitability and availability of appropriate technologies, land availability, natural disasters, and lack of political will (GOSKN, 2022b).

One important process for overcoming challenges related to both adaptation and mitigation is technology needs assessment. The Technology Needs Assessment (TNA) report for St. Kitts and Nevis represents the first deliverable of a three-step process that seeks to identify and create climate technology pathways for implementation of the Paris Agreement. The TNAs lead to the development of national Technology Action Plans (TAPs) that recommend enabling frameworks for the diffusion of nationally prioritized technologies and facilitate the identification of viable technology transfer projects with links to relevant financing sources. The TAPs systematically document practical actions necessary to reduce or remove policy, finance, and technology related barriers.

The TNA process for St. Kitts and Nevis is informed by the Second National Communication (2NC) (GOSKN, 2015) and available chapters of the Third National Communication (3NC) (GOSKN, 2021a, 2022b) and the first Biennial Update Report (BUR1) (GOSKN, 2022a), the Nationally Determined Contributions (NDCs) (GOSKN, 2021c), the SKN Water Utility Adaptation Plan (GOSKN, 2021b), the National Climate Change Policy (GOSKN, 2017) and Strategy (GOSKN, 2018), the St. Kitts Strategy and Action Plan for Agriculture (GOSKN, 2016) and the SKN Energy Policy and Action Plan (GOSKN, 2011).

TNA Process

The national TNA team for St. Kitts and Nevis was trained through a capacity building workshop related to technology needs assessment which was held virtually in May 2021. The TNA Multi-Criteria Analysis (MCA) methodology was shared for the prioritization of climate change adaptation and mitigation technologies. The priority sectors chosen for the adaptation component of the TNA were the water and agriculture sectors because of their importance to the overall socioeconomic well-being of the nation and the need for urgent and effective climate change adaptation actions. The priority sectors chosen for mitigation were the energy and transport sector as they emit the most GHGs in the Federation.

A stakeholder mapping process for each sector was first completed by the team which included stakeholders from the public sector, private sector, NGOs, and others. Gender balance was sought during the stakeholder mapping and the selection of the working groups for each sector. Sector working groups (SWG) were formed for each of the prioritized sectors (water and agriculture for adaptation and energy and transport for mitigation). The SWGs contributed throughout the entire TNA process and through a series of consultations which included interviews, online surveys and working group meetings.

A long list of adaptation and mitigation technologies for each sector was compiled by the national consultant based on a thorough review of national policies, strategies, and national communications, TNA reports from other developing countries, TNA factsheets, online databases, scientific literature, and consultation with stakeholders. The sector working groups were initially engaged through an online survey which allowed for the determination of a short list of technologies. Technology fact sheets were then prepared for each shortlisted technology. This was done through consultations with professionals within each sector with knowledge of the technologies, through review of technology fact sheets from other countries and additional research of technology options via the scientific literature and online. The sector working groups ultimately prioritized climate technologies from the short list of technologies using the TNA MCA methodology. This was done primarily through two sector working group meetings (one for water and agriculture and one for energy and transport) where the SWGs discussed and chose the evaluation criteria based on costs, and economic, social, environmental, climate and technology related benefits. The SWGs also developed weights for each criterion. Then breakout sessions were held, and each group discussed the technology factsheets, adjusted the factsheets where needed and then scored each of the technologies in their respective sector.

Technology Prioritization
Four technologies for climate change adaptation and four technologies for climate change mitigation for St. Kitts and Nevis were prioritized using this process. The prioritized technologies are given below.

Water Sector
1. Non-revenue water and demand management programme (including smart metering)
2. Leakage detection and repair and pressure management

Agriculture Sector
1. Integrated pest management
2. Soil moisture conservation monitoring and techniques

Energy Sector
1. Solar water heating
2. Residential scale grid-tied solar

Transport Sector
1. Hybrids and battery electric vehicles
2. Development and rehabilitation of sidewalks, cycle ways and lanes and safe cycle parking

These technologies will be further analyzed in the second step of the TNA Process, the Barrier Analysis and Enabling Framework.

Chapter 1 Introduction

This report represents the first deliverable in the Technology Needs Assessment (TNA) for St. Kitts and Nevis. It outlines the process followed to determine the prioritized technologies for adaptation to in both the water and agriculture sectors and prioritized technologies for mitigation in both the energy and transport sectors.

Document review including completed Technology Needs Assessment (TNA) fact sheets and reports from other territories, scientific literature, and grey literature (including national policy, strategy, and assessment documents). A long list of technologies was formulated based on this document review and stakeholder consultation. A shorter list of technologies was then extracted based on survey feedback and consultation with the sector working groups. Working group sessions were conducted for each sector in which TNA fact sheets were discussed and multi-criteria analysis (MCA) conducted to prioritize the technologies for each sector.

The TNA process for St. Kitts and Nevis is informed by the Second National Communication (2NC) (GOSKN, 2015) and available chapters of the Third National Communication (3NC) (GOSKN, 2021a, 2022b) and the first Biennial Update Report (BUR1) (GOSKN, 2022a), the Nationally Determined Contributions (NDCs) (GOSKN, 2021c), the SKN Water Utility Adaptation Plan (GOSKN, 2021b), the National Climate Change Policy (GOSKN, 2017) and Strategy (GOSKN, 2018), the St. Kitts Strategy and Action Plan for Agriculture (GOSKN, 2016) and the SKN Energy Policy and Action Plan (GOSKN, 2011).

1.1 About the TNA project

The Global Technology Needs Assessment project is funded by the Global Environment Facility (GEF) and executed by the United Nations Environment Programme (UNEP) in collaboration with the UNEP-CCC (Copenhagen Climate Centre). The Global TNA is a strategic programme on technology transfer, designed to support developing countries to carry out Technology Needs Assessments within the framework of the United Nations Framework Convention on Climate Change (UNFCCC) and under the Paris Agreement. Its main aim is to avert the risks and impacts of climate change and to reduce national greenhouse gas (GHG) emissions. The fourth phase of the TNA project was initiated in October 2020 and includes seventeen countries consisting of Small Island Developing States and Least Developed Countries in Africa, Asia, the Pacific, and the Caribbean (including the Bahamas and St. Kitts and Nevis).

Identification of the National TNA coordinator and selection of key (prioritized) sectors for the TNA was finalized by the end of 2020. The National Consultants for adaptation and mitigation were hired in March 2021 and a virtual national inception workshop was held on April 22, 2011. After submission of the workplan and online training for national consultants in May 2021, the TNA adaptation and mitigation working groups were established in September 2021. Soon after, the adaptation group worked through the long list of technologies. A short list of technologies was selected based on evaluation by the group in October 2021 (10 for the water sector and 10 for the agriculture sector). Technology fact sheets were compiled for each of the short-listed technologies and shared with the working group in mid-February 2022. The prioritization exercise was completed in March 2022 and a draft TNA report for adaptation submitted in early April 2022. In September 2022, the national consultant for adapation took over the mitigation aspect of the TNA as well. The mitigation working group worked through a long list of technologies to arrive at a short list in October 2022 (6 for the energy sector and 4 for the transport sector). Technology fact sheets were compiled for each of the short-listed technologies and shared with the working group in late January 2023. The prioritization exercise was completed on February 8, 2023.

1.2 Existing National Policies Related to Climate Change and Development Priorities

1.2.1 Country Profile

The estimated population of St. Kitts and Nevis for 2020 was 53,821, with about 20% of the population residing in Nevis. Between 2015 and 2019, the nation made major economic strides with the Gross Domestic Product (GDP) per capita increasing from 18,000 USD to 19,000 USD and five years of positive economic growth (GOSKN, 2020b). This period saw the introduction of the Poverty Alleviation Programme with over 4,000 beneficiaries, value added tax (VAT) reductions and significant investments in infrastructure (e.g., the second cruise pier at Port Zante and the upgrade to the Island Main Road) (GOSKN, 2021a).

Since 2015, however, the country has also been set back by significant disasters and shocks. This includes the effects of two major hurricanes in September 2017 (Maria and Irma) and associated recovery costs; the strongest El Niño event (2014 to 2016) of the past century, which was associated with variable weather patterns and severe drought, and the 2020-2022 COVID-19 pandemic. The economic and social impacts of the pandemic has been significant on the travel and tourism sector, as this sector is estimated to contribute more than half of the national GDP in 2019 (WTTC, 2021) and almost 60% of the total employment (GOSKN, 2020b). According to the WTTC (2021), tourism-sector activity in 2020 contracted substantially (more than 70%) because of the pandemic's effect on international travel. In fact, tourism and allied services continue to be affected as they rely heavily on cruise and airline-based arrivals (GOSKN, 2020b). In fact, the COVID-19 pandemic resulted in a decrease of over 73% in air and sea visitor arrivals (GOSKN, 2020c). Nevertheless, tourism remains the country's main strategy to transition away from an agricultural base notably sugar manufacturing.

Development in St. Kitts and Nevis is still guided by the 2006-2013 National Adaptation Strategy (NAS), which served as Government's blueprint for economic transformation following the closure of the sugar industry in 2005 (GOSKN 2020a, 2006). The NAS is built around three pillars: (1) economic development and enhanced livelihoods, (2) inclusive social development and (3) environmental protection and infrastructural development. GOSKN's social and economic development strategies outlined in the NAS focus on:

1. Attracting foreign direct investment particularly within the tourism sector,
2. Developing the private sector particularly ongoing support services being provided to ensure the development of small to medium sized enterprises,
3. Supporting the diversification of agriculture,
4. Providing affordable housing to at-risk populations, and to empower all citizens in home ownership, and
5. Reduction of poverty.

An update to the 2006-2021 National Development Plan is currently being prepared (delayed due to the Covid-19 pandemic) which is expected to reflect Government's continued commitment to these three pillars within the broader framework of an increased focus on climate change resilience.

Recent work on mitigation analysis for the BUR1 and TNC for SKN gives a thorough summary of the trends in GHG emissions for the Federation. An excerpt is included to give an idea of where the country stands in terms of their emissions (GOSKN 2022 a,b).

The SKN 2018 National Inventory Report (NIR) indicates that the top three categories in level assessment for SKN were (the Industrial Processes and Product Use (IPPU) sector was not estimated due to data limitations) (GOSKN, 2022c):

- Energy Industries – CO_2
- Land Converted to Forest land – CO_2
- Road transport – CO_2

Total GHG emissions for the Federation increased by 19.7% or approximately 60 ktCO_2eq in 2018 compared to the 2010 levels (excluding emissions/removals from the Land Use, Land Use Change and Forestry (LULUCF) according to the latest NIR (GOSKN, 2022c). This increase corresponds to an increase in GHG emissions of 26% in the energy sector over the same period, mainly attributed to the transport sector with an increase of approximately 91% in 2018 from 2010 levels. The energy sector (which includes transport) represented 77% and 81% of total GHG emissions in 2010 and 2018, respectively (GOSKN, 2022a)

1.2.2 National Policies Related to Climate Change Adaptation and Mitigation

The National Climate Change Policy (NCC) (2017) provides the mandate and policy framework for climate action in St. Kitts and Nevis (GOSKN, 2017). The National Climate Change Adaptation Strategy (NCCAS) (2018) operationalizes the National Climate Change Policy and was developed using a participatory approach, gaining input and recommendations from diverse stakeholder groups through national consultations (GOSKN, 2018). The Strategy details specific adaptation objectives and measures across eight sectors (agriculture, coastal and marine ecosystems, forest and terrestrial ecosystems, finance and banking, human health, infrastructure and physical development, tourism and water) and five cross-cutting areas (stakeholder capacity building and engagement, information management, research and monitoring, integrated adaptation and disaster risk reduction and inter-sectoral coordination) for the time period of 2018-2030.

On the mitigation side, SKN in its initial and second National Communications to the UNFCCC highlighted mitigation actions focused on the energy, transport and building sectors but did not have a stand-alone chapter on mitigation assessment (GOSKN, 1994 and 2015). The SKN Energy Policy and Energy Action Plan of 2011 outlines key policies for the transition of the electricity generation sector to integrate more renewables into the grid system and decrease imported fossil fuels (GOSKN, 2011). The plan focused on wind and geothermal energy development in Nevis, biomass energy development from sugarcane production and the grid interconnection between both islands to facilitate renewable energy interchange.

St. Kitts and Nevis (SKN) submitted its First Nationally Determined Contribution (NDC) in April 2016 and their updated NDC in October 2021. The NDCs are national climate actions, related targets, policies, and measures to implement in response to climate action and as contributions to global action and operate on a 5-year cycle. The NDCs submitted by SKN are conditional and based upon available financing and technology support. The updated NDCs aim to reduce economy-wide CO_2 emissions by 61% by 2030, compared to the base year of 2010 GHG emission levels. This reduction is based on achieving 100% renewable energy in electricity generation and increasing the share of electric vehicles in the vehicle fleet to at least 2%. As a result, SKN anticipates that the emissions will reduce to 124 $GgCO_2$-eq (124 $ktCO_2$-eq) in 2030 within the energy sector (GOSKN, 2021c).

1.3 Vulnerability Assessments in the Country

The NCCAS (2018) is built on principles of enhanced stakeholder participation; building capacity to address climate change impacts; decision-making based on scientific and local knowledge; sustainable use and management of the environment and natural resources; preservation of St. Kitts and Nevis' cultural heritage; gender equity; enhanced inter-sectoral coordination; the precautionary principle; adoption of a low regret approach; recognition that adaptation is an additional burden for St. Kitts and Nevis; integrity and good governance; and promotion of regional cooperation (GOSKN, 2021c). Adaptation measures included in the NCCAS largely focus on building adaptive capacity and readiness including the enabling conditions needed for implementing effective adaptation; reducing exposure to climate hazards; and reducing inherent sensitivities to climate change impacts.

The most recent vulnerability assessment for the Federation was completed in 2021 during development of the St. Kitts and Nevis Third National Communication to the UNFCCC, specifically Chapter 3 (GOSKN, 2021a). Climate change vulnerability was explored under two categories: hazard-based vulnerability and sectoral vulnerability. These are summarized in Table 1.1.

Table 1.1: Summary of Vulnerabilities to Climate Change

Vulnerability	Summary
Hazard-based vulnerability	
Sea level rise	Vulnerability to sea level rise (SLR) ranks high among the climate hazards modelled. Vulnerability to SLR was found to be higher in the low-lying lands of both islands of St. Kitts and Nevis, pointing to the potential to lose built infrastructure to the sea in the future. When SLR is coupled with extreme events like the high category hurricanes that are projected to increase in frequency, the risk of loss and damage related to coastal flooding increases.
Heat stress	Increasing heat vulnerability is projected to be the most significant change in climate vulnerability for both islands, and especially in urban areas where vegetated cover is lower than in rural and remote areas. Higher air temperatures are expected to increase heat stress, the potential for heat waves, cooling needs and costs, and water losses from evapotranspiration. When coupled with decreasing rainfall conditions and saline intrusion from SLR, increasing water stress is a grave concern as baseline freshwater resources are already limited. Higher air temperatures also result in increasing sea surface temperatures.
Flood and landslides	As both flooding and landslides are a function of rainfall, increasingly dry conditions result in decreased vulnerability to both these hazards.

Vulnerability	Summary
Drought	Projections indicate more substantial increases for drought during the dry season, especially considering long-term trends. Historical droughts and future climate modelling suggest that both St. Kitts and Nevis will need to find ways to benefit from rain-fed water originated from intense downpours and extreme rainfall events. If these water excesses are stored correctly, water could be used for more severe drought periods.
Sectoral Vulnerability	
Built environment	Rapid-onset climate hazards (e.g., hurricanes, intense rainfall events) that result in major physical damage are of prime concern for this sector. However, there is also the potential for structural damage from slow-onset climate hazards like SLR and sustained high temperatures.
Human health	The health impacts of climate change reflect the strong linkages between several priority areas that affect basic needs (thermal comfort, mental well-being, food, water, livelihoods) and environmental quality (air quality, exposure to natural hazards, spread of waterborne and communicable diseases etc.) as well as vulnerable groups.
Gender and vulnerable groups	Stakeholders in St Kitts and Nevis have identified migrants, the elderly, youth, single mothers, women and those in the informal sector as the most vulnerable. Aside from identifying differentiated vulnerabilities making special efforts to engage these groups in adaptation planning is necessary.
Coastal, marine ecosystems and fisheries	Hurricanes, SLR, increasing sea surface temperatures (SSTs) and changes in marine water chemistry are the main threats associated with climate change in this sector. These climate stressors are compounded by non-climate stressors like coastal development, overfishing and invasive alien species.
Water resources	Freshwater resources are already limited on St Kitts and Nevis and climate change further threatens this sector. Threats to the sector include increased variability in rainfall, more intense rainfall events, droughts, increases in air temperature, greater risk of extreme heat events, SLR and increase in intensity and frequency of stronger storms.
Tourism	Climate change is expected to have a number of impacts on this sector. Because of its critical dependencies with the natural asset base, water and food supply chains, as well as energy demands, this sector is also vulnerable indirectly as those supporting assets and sectors are themselves impacted.
Agriculture	A warmer dryer climate in tropical small island settings can have significant and far-reaching effects on the availability of basic inputs to agricultural production – such as suitable arable land, freshwater supply and thermal limits. Additionally, there can also be significant crop and livestock loss related to extreme events like drought, heat waves, storms and related floods.

Cross-cutting areas including inter-sectoral coordination, stakeholder capacity building, research and monitoring and evaluation are critical to supporting adaptation efforts (GOSKN, 2021a). Programs of action for each of these priority areas have been developed and specific actions and activities to be implemented in the short, medium, and long term have been identified.

1.4 Sector Selection for Climate Change Adaptation

Based on the overall vulnerability assessment in Chapter 3 of the Third National Communications (GOSKN, 2021a), the most vulnerable sectors identified were:

1. Human settlements and infrastructure (built environment)
2. Human health
3. Gender, vulnerable groups and community-based adaptation
4. Coastal, marine resources and fisheries
5. Water
6. Tourism
7. Agriculture

Overall, priority programs of actions were further refined from the NCCAS to fulfill adaptation needs. Inter-sectoral coordination is essential to establish linkages between sectors and build stakeholder capacity for effective coordination and implementation of climate change adaptation. Information management, research and monitoring, and evaluation will support comprehensive adaptation planning and decision-making. Climate smart agriculture could integrate technology to ensure food and nutrition security and resilient rural livelihoods. Integrated water resources management provides safe and reliable water supply for the country and build resilience to climate change. Disease prevention will improve public health through enhanced disease prevention and response. Integrated coastal zone management will enhance coastal and marine ecosystems resilience and associated livelihoods to climate change disasters. Lastly, climate proofing for tourism will increase sustainable tourism through adaptation and disaster risk reduction.

In addition to the above priority programs of action, more recent stakeholder engagement has identified priority adaptation actions for the key sectors and cross-cutting areas that complement actions identified in the NCCAS (GOSKN, 2021c). Table 1.2 details additional adaptation measures not included in the NCCAS but identified in 2021 stakeholder consultations and included in the St. Kitts and Nevis Third National Communication to the UNFCCC.

Table 1.2: Priority Adaptations Actions by Sector

Sector/Area	Priority Adaptation Actions
National Readiness	• Integrate adaptation into relevant national legislation • Provide training and guidance on mainstreaming adaptation into sectoral governance and management • Improve capacities for sectoral, evidence-based adaptation planning • Monitor and evaluate implemented adaptation
Settlements and Infrastructure	• Develop and implement national land development policy • Protect key natural and built assets in low-lying areas • Retrofit public buildings and infrastructure with climate-smart technology • Update building codes to account for increased climate hazards
Public Health	• Increase safe water storage measures in households • Develop program to address mental health issues in the aftermath of disasters • Develop and implement urban heat response plan including urban greening measures

Sector/Area	Priority Adaptation Actions
Vulnerable Groups and Community-Based Adaptation	● Catalyze development of community-based organizations to improve adaptive capacity of communities ● Identify and scale up previous successful community coping strategies ● Develop information access points for early warning systems in rural communities
Coastal and Marine Ecosystems	● Develop and implement seasonal and post-storm beach monitoring program ● Develop and implement emergency response plan for sargassum stranding ● Model and map coastal assets to support adaptation planning
Freshwater Resources	● Identify and support methods to expand water supply and storage capacities ● Improve operational efficiencies
Agriculture	● Expand SMART aquaponics and aquaculture systems ● Develop alternative livelihoods and training and diversify away from at-risk crops
Tourism	● Conduct beach replenishment and install coastal protection measures to prevent beach erosion ● Expand marine tourism and eco-tourism sectors ● Develop and implement emergency response plans for hotels and resorts

The priority sectors for adaptation chosen for analysis under the TNA were selected by the Ministry of Environment, Climate Action and Constituency Empowerment based on the vulnerability of the sectors to climate change, GDP contributions, and current development priorities. This evaluation led to the selection of the **water and agriculture sectors** for the TNA process.

Chapter 3 of the Third National Communications (GOSKN, 2021a) highlights the climate change impacts on both the water (Table 1.3) and agriculture (Table 1.4) sectors.

Table 1.3: Climate Change Impacts on Water

Projected Change in Climate Parameter	Sectoral Impacts
Slow onset drier conditions with lower rainfall between September to November & rainfall variability or unpredictability.	• Reduced aquifer recharge and reducing sustained yields from ground water sources • Possible over-pumping in coastal aquifers leading to salinization • Water deficits for all users – compounded by increasing evapotranspiration losses • Possible increased reliance on desalination, imported or bottled water sources • Indirect waste management issues related to bottled water packaging • Water stress to vegetation and increase in fire risk • Increased watershed degradation and changes in vegetation succession to less humid-adapted plants • Desertification of marginal lands in extreme cases – with increased dustiness • Reduced infiltration capacity related to denuded soils • Increasing hillside denudation can lead to increases in windspeeds, which can exacerbate dustiness and wildfire risk
Increasing intensity of extreme rainfall events	• Lower rates of infiltration and aquifer recharge - more water lost as flashfloods

Projected Change in Climate Parameter	Sectoral Impacts
	• Damage to water infrastructure and distribution systems – increased losses and non-revenue water • Increased sedimentation of water storage and treatment facilities – loss of efficiency and increased repair or maintenance costs. • Impacts on water quality due to contamination of aquifers (dead animals, sewage, etc.) • Indirect effects of these on water supply and possible shortages and rationing of piped/municipal water supplies
Drought (normal level of risk up to 2050)	• Loss of forest cover and decline in infiltration rates, which impact aquifer recharge potential and water supply
Slow onset increase in air temperatures	• Increased water demand from vegetation (evapotranspiration losses) – possible decline or change community assemblages or shift in land cover.
Greater risk of extreme heat events (July to October)	• Watershed vegetation may be impacted by heat stress • Higher risk of bush-fires due to dry hot conditions; maybe windier as well.
Sea level rise	• Salinization of coastal aquifers affecting water supplies
Increase in the intensity and frequency of stronger storms (>Cat 3).	• Physical damage and loss to facilities and water infrastructure • Increased sediment loads and suspended solids clogging water uptake and treatment facilities • Maintenance costs and indirect impacts on design life of facilities • Damage to forests and upper watersheds and physical damage to watershed cover (recharge areas). • Soil erosion and slope instability in upland areas, or where slopes have been previously disturbed by hillside farming or construction
Warming sea surface temperatures and possible ocean acidification and changes in salinity	• Possible impacts on reverse osmosis uptake systems and efficiency

Table 1.4: Climate Change Impacts on Agriculture

Projected Change in Climate Parameter	Sectoral Impacts
Slow onset drier conditions with lower rainfall in peak rainy (between September to November) as well as drier months & rainfall variability or unpredictability	• Higher losses in farms unable to transition away from rainfed agriculture – farmers rely on rains between September and October • Increasing demand for irrigation and soil moisture retention technologies • Declining profitability of producing high-water demand crops • Declines in crop yields and quality of pasture for livestock • Decline in soil fertility with lower organic and moisture content, increasing friability and erosivity • Declining quality of pasturelands and increased demand for feedstock or greater acreage to support herds • Increased competition with non-agricultural consumers for water supply • Shortages of traditional foods and national staples • Increased reliance on imported, frozen and processed foods. • Possible impacts on crop diversity, which can affect the economics of farming and resilience to shocks • Increased need for government relief for farmers to maintain domestic food production systems • Increased susceptibility to diseases and pests – resulting in higher costs • Possible impacts on pollinators

Projected Change in Climate Parameter	Sectoral Impacts
Increasing intensity of extreme rainfall events	• Physical loss and damage to crops and immediate financial setbacks for farmers. Indirect adverse impacts along agrobusiness value chains and food security • Waterlogging of agricultural soils • Soil loss and leaching of soil nutrients and decline in soil quality • Storage facilities impacted • Grain storage may be lost with increased humidity or flood damage – mold • Transportation corridors and markets impacted (for crops, livestock, and fisheries) • Landslides and erosion in hilly areas may impact marginalized small farmers disproportionately • Damage to hillsides from soil erosion or landslides may result in small farmers going into more pristine areas in the interior for cultivation and subsistence farming • Increased susceptibility to diseases and pests – resulting in higher costs
Drought (normal level of risk up to 2050)	• High vulnerability and risk of economic losses of rainfed systems • Increased costs associated with irrigation and soil moisture retention. Indirect impacts on the cost of mulch grass species • Possible declining productivity and yields of crops that require higher moisture • Nevis is particularly vulnerable to low and unreliable rainfall and extended periods of drought – limiting food security on that island and increasing reliance on imported food
Slow onset increase in air temperatures	• Decrease in crop yields for crops not adapted to higher prevalent temperatures throughout growing season. • Decreased weight gain livestock • Potential impacts on productivity (breeding) • Increased prevalence of diseases and pests, which tend to proliferate in hotter spells, which will have indirect effects on the percentage of food crops lost. Temperature and rainfall are major drivers of affecting the spread pests and diseases • Declining quality of pasturelands – and need for more acreage to support herds • Impacts of sargassum mega blooms on fish landing beaches and nearshore fisheries • Impacts on productivity of agricultural labor force. Both fields and shade houses are becoming increasingly hot • Increasing bush fires, exacerbated by dried out vegetation • Effects of warming on produce storage and increased potential for spoilage or contamination (bacteria, pests, molds)
Greater risk of extreme heat events (July to October)	• Heat stress and possible death in livestock • Heat damage to crops in field • Increased demand for irrigation water and electricity for pumping • Farmers and fishermen working outdoors are impacted – lower productivity
Sea level rise	• Salinization of coastal aquifers affecting water supplies • Salinization of coastal plains and soils affecting crops

Projected Change in Climate Parameter	Sectoral Impacts
Increase in the intensity and frequency of stronger storms (>Cat 3)	• Physical damage to crops in field, irrigation systems, storage facilities, agro-processing facilities, and land-based fisheries infrastructure • Soil erosion • Potential injury and loss of livestock
Warming sea surface temperatures and possible ocean acidification and changes in salinity	• Implications for availability and cost of supplementary water from reverse osmosis systems • Declining habitat suitability for a range of fishery species, resulting in lower catches

1.5 Sector Selection for Climate Change Mitigation

The priority sectors for mitigation chosen for analysis under the TNA were selected by the Ministry of Environment, Climate Action and Constituency Empowerment. This selection was based on the mitigation analysis and assessment outlined in recently completed chapters for the TNC and BUR1, national development priorities and contributions to GDP from each sector (GOSKN, 2022 a,b). This evaluation led to the selection of the **energy and transport sectors** for the TNA process. The importance of these two sectors is also highlighted by the number of mitigation actions selected for each sector shown in Table 1.5.

Table 1.5: Summary of Mitigation Actions by Key GHG Emitting Sectors

Sector	Mitigation Action
Energy Demand	• Increase the adoption of solar water heaters by 2030 • Energy efficiency measures resulting in a 20% reduction in energy demand by 2030 • Streetlighting retrofits by 2022 • Retrofit of floodlights at sporting facilities by 2023 • Implementation of measures identified in energy audits of public buildings and water pumping stations by 2025
Electricity Generation	• Transition to 100% renewable energy by 2035 • 35.7 MW of utility-scale solar PV capacity for St. Kitts with 44.2 MWh lithium battery storage by 2025 • 6.6 MWh of wind power capacity installed in St. Kitts by 2030 • 15 MWh of geothermal capacity in St. Kitts by 2035 • 10 MWh of geothermal capacity in Nevis by 2030 • Improve efficiency in transmission and distribution of electricity by 2030 • Electricity interconnection system for the two islands by 2030
Transport	• Development of electric vehicles charging infrastructure by 2030 • 2% of the total number of vehicles are electric vehicles and 2% of the total will be hybrid by 2030 • Public transportation expansion and improvement for a shift of 20% of personal cars and SUVs after 2025
Industrial Processes and Product Use (IPPU)	• 10% phase-down of HFCs
Land Use, Land Use Change and Forestry (LULUCF)	• Increase of 3% of carbon sinks through reforestation and related practices

Sector	Mitigation Action
Waste	• Reduction of landfill waste by 2% through recycling and composting systems

Various mitigation scenarios were modelled using the Low Emissions Analysis Platform (LEAP) software and documented in the relevant chapter of the TNC (GOSKN, 2022b). The scenario with the current mitigation actions, listed in Table 1.5, reduces emissions by 34% by 2030 and 44% by 2035 compared to the 2010 value (240.6 ktCO_2e).

Chapter 2 Institutional Arrangement for the TNA and Stakeholder Involvement

The Climate Action Unit (CAU) in the Ministry of Environment, Climate Action and Constituency Empowerment is the driver of the climate change mitigation and adaptation agenda in St. Kitts and Nevis. In terms of climate change, the CAU provides strategic support, to coordinate and manage the transformational change towards a climate resilient society in St. Kitts and Nevis. The CAU will be supported by the Department of Environment (DOE). The core functions of the CAU, in terms of climate change are:

1. Coordinate the mainstreaming of climate change adaptation in strategic policy formulation, development planning and decision-making.
2. Promote the implementation of specific adaptation measures to address key vulnerabilities in St. Kitts and Nevis.
3. Promote actions to reduce GHG emissions through fossil fuel reduction, conservation, and by switching to renewable and cleaner energy.
4. Promote awareness of climate variability and climate change and corresponding behavioural changes.

2.1 National TNA Team

The structure of the TNA Project in St. Kitts and Nevis followed the structure recommended by the TNA Process (Figure 2.1). The TNA National Coordinator is supported by a National Project Steering Committee, and provides the consulting team with overall vision, leadership support, communication, and guidance.

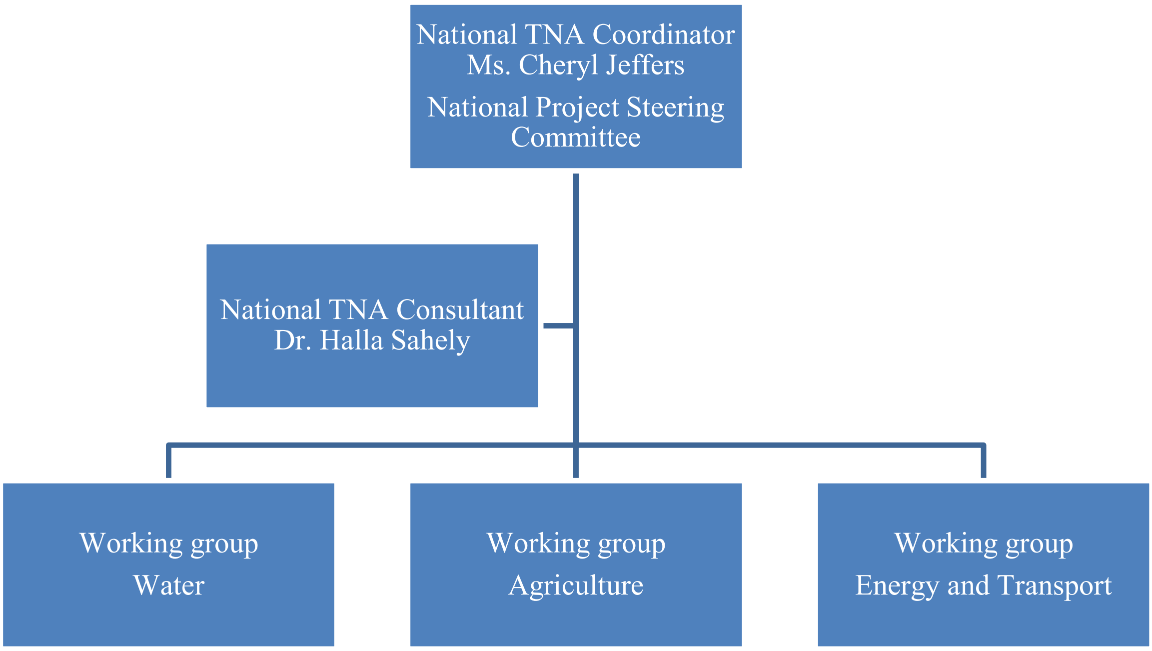

Figure 2.1: Structure of the TNA Team for St. Kitts and Nevis

2.2 Stakeholder Engagement Process

Stakeholder mapping was first conducted to identify persons in the relevant sectors for the islands of St. Kitts and Nevis. This included persons in government and public agencies (Sustainable Development, Agriculture, Water, Marine Resources, Environment, Tourism, Physical Planning, Met Office, Bureau of Standards, Energy, Maritime Affairs, Transport, Urban Development), statutory bodies (SKELEC and NEVLEC), private sector (SKN Chamber of Commerce), consultants, NGOs and research and educational institutes (Nevis Historical and Conservation Society, St. Kitts National Trust, IICA, CARDI, CFBC), and individual entrepreneurs. Over 30 persons attended the inception workshop held via virtually on April 22, 2021.

After submission of the workplan and execution of an online training for national consultants in May 2021, the TNA adaptation and mitigation working groups were established in September 2021. The working groups for each sector were also determined from the stakeholder mapping exercise. The adaptation working group worked through the long list of technologies provided by the TNA adaptation consultant soon after being established. However, the mitigation group did not begin their work until September 2022 after the Adaptation national consultant took over the mitigation component of the TNA. The working group members for each sector are listed in **Annex I**. Gender balance was considered during the stakeholder mapping and the selection of the working groups for each sector. This was guided by the TNA Guidance for Gender-Responsiveness (De Groot, 2018).

A short list of adaptation technologies was selected based on evaluation by the group in October 2021 (10 for the water sector and 10 for the agriculture sector). Technology fact sheets were compiled for each of the shortlisted technologies and shared with the working group in mid-February 2022 (**Annex II and III**). Most interactions with the working groups were done via virtual means due to COVID-19 restrictions. The prioritization exercise was completed on March 3, 2022, where the criteria for the MCA were developed and confirmed along with weights for each criterion. The water working group completed the scoring for each technology at the in-person session, while the agriculture working group were sent the MCA worksheet to complete scoring at home. Scoring at the in-person session was more effective and allowed for quick compilation by the national consultant. For the agriculture working group, the allocated time during our in-person meeting was not enough to allow for additional discussion and so they decided each member should complete the scoring at home. The scores were then compiled by the national consultant and results shared with the group via email.

A short list of mitigation technologies was selected based on evaluation by the group in October 2022 (6 for the energy sector and 4 for the transport sector). The factsheets were compiled and shared with the group in late January 2023 (**Annex IV and V**). The prioritization exercise was completed on February 8, 2023, where the criteria for the MCA were developed and confirmed along with weights for each criterion. Given the limited number of members, we decided all members could score technologies from each key sector. The working group members all had broad-based knowledge of both sectors sufficient to complete the scoring exercise. The working group completed the scoring for each technology and the scores were compiled by the national consultant at the in-person session.

2.3 Consideration of Gender in the TNA process

A National Gender Equality Policy and Action Plan for St. Kitts and Nevis was recently completed (GOSKN, 2021d). Stakeholders consulted in the preparation of the country's Third National Communication (TNC) to the UNFCCC identified migrants, the elderly, youth, single mothers, women, and those in the informal sector as the most vulnerable to climate change. St. Kitts and Nevis has a high number of female-headed households, many of whom are poor (GOSKN, 2021d). When there is limited or no water supply and food insecurity, women often bear a significant burden caring for their households. This can have negative impacts on sanitation, health, hygiene, and nutrition. Unfortunately, the social effects of climate change on the water and agriculture sectors are rarely quantified and poorly understood. This can lead to disastrous consequences for many households (GOSKN, 2021b).

The National Gender Equality Policy infuses and informs the TNA process along with guidance provided by the Global TNA Team (GOSKN, 2021d and DeGroot, 2018). The working groups are generally gender balanced and each of the technology factsheets included a section on gender considerations.

Chapter 3 Technology Prioritisation for the Water Sector

3.1 Water Sector Profile in St. Kitts and Nevis

The water sector broadly encompasses activities related to the provision, treatment, management, distribution, and use of water. Potable water is retrieved from either surface sources (springs) or groundwater (wells). In 2019, in St. Kitts, 70% (3.37 MGD) of the water was derived from groundwater and the remaining 30% (1.49 MGD) was from springs. In Nevis, 99% (1.44 MGD) of water was derived from groundwater and remaining 1% (0.16 MGD) from springs.

Surface water is tapped into six intake areas in St. Kitts and three in Nevis. On St. Kitts, these water intake areas are at Wingfield, Franklands, Stonefort, Lodge, Phillips, and Greenhill. From 2010-2014, these springs produced on average a total of 3.2 MGD (million imperial gallons per day) but since the major drought of 2015, the average production between 2015-2020 has dropped to less than 2 MGD. On Nevis, the intake areas are at Nevis Peak Source (Stoney Hill) (30 imperial gallons per minute {gpm}), Camps Spring (40 gpm) and Maddens (14 gpm) (GOSKN, 2021b). The condition of these watersheds is good especially the upper watershed areas which are above 1000 feet in elevation which have a protected status in the Federation. In the lower watershed areas, there are pollution pressures from inappropriate disposal of liquid and solid waste which are well documented (Sahely, 2010).

In terms of water consumption by sector, in St. Kitts, about 60% of water supplies are consumed by the domestic sector, while the government, tourism and commercial sectors each use between 10 to 15% of the island's water resources. It is estimated that less than 5% of the supply goes to the agricultural sector. In Nevis, 52% goes to the domestic sector, 31% to government buildings and installations, while hotels and the commercial sector use about 8% each. As such, it is estimated that less than 1% of the supply goes to the agricultural sector. In recent times, after the closure of the sugar industry in the Federation, there has been a major focus on diversifying the agricultural sector. One of the main barriers to this is the availability of water for irrigation especially during the dry season. Overall, the water supply on both islands can no longer keep up with the demand especially with the renewed effort to grow the tourism sector post COVID-19. It is clear additional water resources would have to be developed and water demand control measures fully implemented to be able to supply sufficient water to all sectors. Enhancing the ability of stakeholders to understand climate change risks more fully will also greatly aid in management of water resources and ensure resiliency of the sector (GOSKN, 2021b).

3.2 Climate Change Vulnerabilities in the Water Sector

Freshwater resources are vital to all economic sectors (especially tourism, agriculture and health), municipal demand (residential, institutional, and commercial) as well as the viability of terrestrial ecosystems. Agriculture in St. Kitts and Nevis is primarily rain-fed, whilst tourism is supported by a combination of municipal supplies and reverse osmosis (desalination) plants. Water insecurity not only impacts food security, but also has implications for energy intensity as energy is needed to produce, treat and distribute potable water (GOSKN, 2021a). There are also major implications for the health sector, including potential for water-borne diseases and breeding of biological vectors when there are chronic disruptions to piped water services and inadequate water for sanitation and hygiene. Table 1.3 summarizes possible impacts of climate change on freshwater resources in St. Kitts and Nevis (GOSKN, 2021a).

Climate change will exacerbate the risks already present in St. Kitts and Nevis, especially through increased occurrence of drought and the potential for more extreme rainfall and storms in the future. The impact of heavy rainfall on raw water quality, damage to intake structures and landslides on pipelines and other assets is a major concern. Climate change is likely to worsen these risks and action is required to reduce loss and damage (GOSKN, 2021b). Drought is also a major concern, especially since the impacts of the drought of 2015 / 2016 are still felt and resulted in widespread disruption to the water sector. Both islands are operating with very limited spare capacity in terms of source and well yields, especially in coastal wells where there is a risk of saline intrusion during dry periods and because sea level rise is a major concern.

The focus areas of the TNA analysis will be on climate adaptation technologies to enhance water use efficiency, water quality control and overall management of water resources. Technologies to diversify water supply options to better serve the various economic sectors especially agriculture will also be considered.

3.3 Decision Context

Both the recent NDC (GOSKN, 2021c) and Chapter 3 of the Third National Communication (GOSKN, 2021a) assess progress towards adaptation measures identified in the National Climate Change Policy (GOSKN, 2017) and National Climate Change Adaptation Plan (GOSKN, 2018). Progress in the water sector included coordination with the DOE to improve private sector resilience (e.g., an adaptation project that outfitted learning institutions with water storage tanks or retrofitted existing cisterns). The St. Kitts Water Services Department (SKWSD) reported advances in data collection, which was facilitated by hydro-meteorological equipment installed by the National Emergency Management Agency (NEMA) and Meteorological Office. The SKWSD has also recently installed tank level controls at most storage reservoirs which are linked by a web application to be able to monitor storage levels in real-time. Overall, there has been inadequate investment in the water sector in St. Kitts and Nevis over the past 20 years to meet the ever-increasing water demand while creating resilience to climate change. On the positive side, there has some investment in water infrastructure in Nevis. This included drilling of deep wells in 2008 under a public-private partnership and the Nevis Supply Enhancement project, funded by the Caribbean Development Bank, which allowed for improvements in treatment, storage, and distribution infrastructure.

The Water Utility Adaptation Plan of 2021 (GOSKN, 2021b) paves the way for future actions needed for this sector. The Plan is structured under six thematic programmes which are in line with the key focus areas outlined in 3.2. These include water policy, legislation and capacity building, watershed management, climate resilient water supplies, water demand management, energy efficiency and renewable energy and disaster risk management.

3.4 Overview of Existing Technologies in the Water Sector

Table 3.1 highlights some of the existing technologies in the water sector in St. Kitts and Nevis grouped by the focus areas discussed in 3.2.

Table 3.1: Existing Technologies in the Water Sector

No	Technology Category	Specific Technology	Description
1	Water Conservation	Leakage detection and repair	Leak management methods rely heavily of leaks being reported by consumers or by utility staff. The SKWSD owns some acoustic based leak detection equipment, but they are outdated and rarely utilized.
2		Pressure management	Both utilities manage the distribution systems by pressure zones. Pressure reducing valves are utilized. No widespread use of district area meters.
3		Non-revenue water and demand management programme	The St. Kitts Water Conservation plan of 2013 (GOSKN, 2013) utilized the IWA audit methodology to estimate non-revenue water at over 50%. This study has not been revisited since. In Nevis, NRW is measured in an ad-hoc manner. Some progress over the decade with more sophisticated billing software has helped in demand management.
4		Smart metering	A few smart meters have been installed on both islands but it is not widespread.
5	Improved knowledge of water resources and demand	Groundwater assessment, mapping, and modelling	For both islands, hydrogeological studies have advanced the knowledge of groundwater resources, but these have not been systematically mapped or modelled. Both islands have both shallow and deep production water wells.
6		Water safety plans	None implemented
7		Real-time data monitoring	Nevis WD has a SCADA system. SKWSD has recently installed tank level controls at most storage reservoirs. In conjunction with the Met office and disaster management agencies, a few stations for monitoring weather, rainfall and water quality have been installed in recent times.
8		Integrated Water Resources Management	Not widely practiced. The Nevis Island Administration has recently set up an IWRM Unit to focus on this.
9		Enhanced potable water storage	Nevis has invested in new storage reservoirs in the past ten years.
10	Diversification of Water Supply	Stormwater catchment	Not widely practiced.

3.5 Adaptation Technologies for the Water Sector

A long list of technology options was prepared from the reviews of previous national policies, plans and national communications, TNA Reports, TNA fact sheets, online databases, scientific literature and from consultations with stakeholders from the water sector. The long list of technologies is given in Table 3.2. The technologies have been grouped into broad themes including water conservation, water quality control, improved knowledge of water resources, water supply diversification and stormwater management.

Table 3.2: Long List of Technologies for the Water Sector

No	Technology Category	Specific Technology	Recommended adaptation measure
1	Water Conservation	Efficient water fixtures and appliances	Second National Communication (2NC) (2015)
2		Leakage detection and repair	Water Utility Adaptation Plan (2021)
3		Pressure management	Vulnerability and Adaptation Assessment (2021)
4		Non-revenue water and demand management programme	Water Utility Adaptation Plan (2021)
5		Smart metering	
6		Pipe material selection and pipe laying techniques	
7		Progressive pricing schemes	
8	Water Quality Protection	Subsurface physical barriers to saltwater intrusion	
9		Encasement and retrofitting of wells to protect from flood and contamination	
10		Wastewater treatment	
11	Improved knowledge of water resources and demand	Groundwater assessment, mapping, and modelling	Water Utility Adaptation Plan (2021)
12		Surface water assessment, mapping, and modelling	Water Utility Adaptation Plan (2021)
13		Water safety plans	National Climate Change Adaptation Strategy (2018)
14		Real-time data monitoring (automated weather stations, tank level control etc.)	Water Utility Adaptation Plan (2021)
15		Integrated Water Resources Management	National Climate Change Adaptation Strategy (2018)
16		Utility Master Plans	Water Utility Adaptation Plan (2021)
17		Enhanced potable water storage	Water Utility Adaptation Plan (2021)
18		Drought prediction modelling / mapping	
19	Diversification of Water Supply	Desalination	2NC (2015), Water Utility Adaptation Plan (2021)
20		Water reclamation and reuse	Water Utility Adaptation Plan (2021)
21		Rainwater harvesting from roofs	
22		Stormwater catchment (small reservoirs and micro-catchments)	2NC (2015) Water Utility Adaptation Plan (2021)
23		Atmospheric water generator /Fog harvesting	
24		Artificial aquifer recharge / Managed aquifer recharge	
25		Groundwater exploration and drilling of new wells	Water Utility Adaptation Plan (2021)
26	Stormwater management	Permeable pavements	
27		Bioswales	

The main adaptation benefits related to water conservation and improved knowledge of water resources are overall improved water use efficiency, reduction in environmental impact and improved sustainability. Efficient use of water reduces the strain on water utilities thus making more water available to customers (GOSKN, 2021b). It can also offset the need for supply side infrastructure upgrades by reducing demand growth and enhance the resiliency of water systems in the face of climate change. Water quality control technologies improves health and allows offers a systematic framework to manage climate risks. Stormwater management technologies can provide a convenient and reliable water supply during seasonal dry periods and droughts. Additionally, widespread stormwater storage capacity can greatly reduce land erosion and contribute greatly to the stabilization of declining groundwater tables. Finally, integrated water resources management (IWRM) allows wide stakeholder participation in management practices and policy development and ensures that the most vulnerable groups are considered. IWRM instruments directly assist communities to cope with climate variability.

A short list of technologies was extracted from the long list. This was done by conducting a survey with working group members. The process also allowed for feedback and comments which facilitated the inclusion of additional technologies which included namely desalination. The short list identifies 10 climate change adaptation technologies for the sector. The short list of technologies and descriptions for each is given in Table 3.3.

Table 3.3: Short List of Technologies for the Water Sector

No	Technology Category	Specific Technology	Description
1	Water Conservation	Leakage detection and repair	Leak management methods can prevent or reduce leakage volume and leak detection technology can improve the ability of water utilities to respond quickly and repair leaks.
2		Pressure management	Pressure management can be defined as the practice of managing system pressures to the optimum levels of service while reducing unnecessary excess pressure and eliminating transients both of which cause distribution systems to leak.
3		Non-revenue water and demand management programme	The steps in a strategy to reduce Non-revenue water (NRW) and control water demand include continuous water accounting, identification and removal of illegal connections, audits of large-volume users and ensuring the integrity of the billing and customer information system. The other parts of a NRW reduction plan include universal metering and public awareness and outreach.
4		Smart metering	Smart meters, sometimes called 'digital meters' are devices that automatically record water use, then electronically report that information at regular intervals.
5	Improved knowledge of water resources and demand	Groundwater assessment, mapping, and modelling	Mapping provides the data and information needed to develop an accurate inventory of groundwater resources, including the classification of aquifers and other water resources. Monitoring / Modelling provides critical data about system behavior throughout the monitoring network. Management success depends upon accurate mapping and monitoring information at all scales.

No	Technology Category	Specific Technology	Description
6		Water safety plans	Water safety plans (WSPs) were introduced by the World Health Organization in 2004, as a health-based, risk assessment approach to managing drinking water quality.
7		Real-time data monitoring	Tools for real-time monitoring include GIS and SCADA to capture, store, update, manipulate, analyze and display all of forms of geographically referenced information.
8		Integrated Water Resources Management	IWRM is a process which promotes the co-ordinated development and management of water, land and related resources, in order to maximize the resultant economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems.
9		Enhanced potable water storage	Vessels or tanks for storing potable water are critical to the efficient operation of any water distribution system. Storage tanks serve two major purposes. One is to provide storage volume and the other is to provide pressure to the distribution system.
10	Diversification of Water Supply	Stormwater catchment	Collecting rainfall from ground surfaces utilizing "micro-catchments" to divert or slow runoff so that it can be stored before it can evaporate or enter watercourses.

Technology fact sheets for each shortlisted technology were developed from the review of previous TNA Reports, TNA Fact Sheets, online databases and scientific literature, feedback from stakeholders in the water sector and the working group. The TNA fact sheets for the shortlisted technologies are presented in **Annex II.**

3.6 Criteria and Process of Technology Prioritisation

During the prioritization workshop, the water working group decided to group similar technologies together and to add one more technology to the short list. In the final shortlist shown in Table 3.4 leakage detection and repair, and pressure management were grouped together. Also, non-revenue and demand management programme was combined with smart metering. The group also decided to expand the technology related to groundwater assessment, mapping, and modelling to also include development of groundwater resources (drilling of production wells). Finally, after some discussion, the group agreed to add desalination to the list as this technology is now being actively considered as an option for freshwater production whereas in the past, the focus had solely on groundwater exploration as a means of increasing water supply in the Federation. No technology factsheet was prepared for desalination but working group members felt they had sufficient knowledge about it to complete the MCA exercise.

Table 3.4: Final Short List of Technologies for the Water Sector

No	Technology Category	Specific Technology
1	Water Conservation	Leakage detection and repair and pressure management
2		Non-revenue water and demand management programme and smart metering
3	Improved knowledge of water resources and demand	Groundwater assessment, mapping, modelling and development
4		Water safety plans
5		Real-time data monitoring / GIS / SCADA
6		Integrated Water Resources Management
6		Enhanced potable water storage
8	Diversification of Water Supply	Stormwater catchment
9		Desalination

The Multi-Criteria Analysis (MCA) methodology was used for the prioritisation of the technologies from the shortlist for St. Kitts and Nevis. The consulting team attended the 1st Regional Capacity Building Workshop virtually from May 17-20, 2021. The team was trained in the MCA methodology required by the TNA. At the Sector Working Group Session for Water, the MCA was explained to the group, and they were taken through the following steps:

I. **Discussion of Technology Fact Sheets:** The technology fact sheets were discussed for some of the shortlisted technology options especially related to capital and operational costs and how each technology could be compared in the absence of concrete data on the costs. The group also discussed how the technology could assist the sector in adapting to the effects of climate change.

II. **Development of Criteria:** Criteria were developed and proposed by the national consultant and discussed by the working group and were selected based the categories proposed by the TNA guidance documents (UNEP DTU, 2015). The approved criteria were used for rating the technology options are shown in Table 3.5.

III. **Development of Weights for each Criterion:** The weighting system was discussed, and the working group agreed to the weighting of each criterion also shown in Table 3.5.

IV. **Rating each Technology Option:** The team was then shown how to rate each technology option based on the criterion giving a score between 0 and 100. Scores were discussed and agreed upon during the working group session. The national consultant compiled the scores, and the final ranking was shared with the group before the end of the session.

Table 3.5: Agreed Criterion and Weights for the Water Sector

Category	Criteria	Description	Weight
Costs	Capital	Costs of set-up of the technology generally incurred during start-up phase.	10
	Operational and Maintenance	Costs of the technology over time, which encompasses the operational costs as well as the maintenance of the technology.	10
Economic Benefits	Improve economic performance	Technologies should aim to improve economic performance in the water sector including aspects of increasing productivity as well as generating interest and demand in the market for its output.	20
Social Benefits	Build technical capacity	This criterion assesses the effect of technologies in building the technical capacity of target beneficiaries.	10
	Improve health	This criterion is associated with health improvements to the population that is affected by the technology improvements. Such technology should ideally reduce morbidity and mortality rates resulting from climate change.	10
Environmental Benefits	Protect environmental (water) resources	Water quality, quantity and integrity needs to remain intact, and at best improved following the introduction of the technology.	15
Climate-related Benefits	Reduces vulnerability to climate change impacts	Adaptation to climate change works towards reducing the vulnerability of populations facing climate change and building their resilience to cope with the impacts.	15
Technology-related Benefits	Ease of implementation / Replicability / Appropriateness	The technology should be easy to implement and replicate and be appropriate to conditions on the ground.	10

3.7 Results of Technology Prioritisation

The MCA was completed by the sector working group for the nine shortlisted technology options. During the MCA process, consensus was achieved for the scoring. The MCA analysis scores, and weighted scores are presented in **Annex VI**. Based on the weighted scores (Table 3.6), the prioritised adaptation technologies for the water sector for St. Kitts and Nevis are:

1. Non-revenue water and demand management programme (including smart metering)
2. Leakage detection and repair and pressure management

Table 3.6: Final List of Prioritized Technologies for the Water Sector

Rank	Technology	Weighted score (out of 100)
1	Non-revenue water and demand management programme (including smart metering)	82
2	Leakage detection and repair and pressure management	77
3	Integrated water resources management	76
4	Real-time data monitoring / SCADA / GIS	73
5	Water safety plans	72
6	Stormwater harvesting (small reservoirs and micro-catchments)	63
7	Enhanced potable water storage	58
8	Desalination	55
9	Groundwater assessment, mapping, modelling, and development	54

Chapter 4 Technology Prioritisation for the Agriculture Sector

4.1 Agriculture Sector Profile in St. Kitts and Nevis

The agriculture sector represents a critical component of the St. Kitts and Nevis economy, especially for its national identity, its impact on rural development and its role in providing food and nutrition security (GOSKN, 2016). Although agriculture contributes less than 2% of the GDP, as much as 20% of the labor force may be engaged in agricultural activities, and approximately 24% of the total land area is used for agricultural purposes (63.4 km^2) (GOSKN, 2021a). The main crops grown are sweet potatoes, yams, vegetables, mangoes, limes, bananas, and coconuts (GOSKN, 2016). With about 1,000 hectares dedicated to pasture, livestock production is focused on beef, mutton, pork, and poultry (Sealy, 2015). The GOSKN has committed to supporting agricultural production as a national priority to bolster food security, reduce the food import bill and the cost of food, enhance rural livelihoods and job creation opportunities in agribusiness value chains, and promote more sustainable economic growth (GOSKN, 2020).

The overall decline in the contribution of agriculture to the overall economy is also due to numerous challenges of low on-farm productivity, high pest and disease incidence for crops and livestock, poor marketing arrangements, damage from tropical storms, droughts, and crop damage by monkeys. An example of how drought impacts this sector is evidenced by the major drought which occurred in 2015 which severely affected the rain-fed dominated agriculture. Local crop production in St. Kitts reached 755 metric tonnes in 2015 compared to 1097 metric tonnes in 2014, a decrease in output of 31.2% (GOSKN, 2016).

4.2 Climate Change Vulnerabilities in the Agriculture Sector

The Caribbean has experienced notable increases in temperature over the past 40 years marked by an increased in frequency and intensity of hurricanes and droughts (Climate Studies Group Mona, 2020). A warmer dryer climate can have significant and far-reaching effects on the availability of basic inputs to agricultural production – such as suitable arable land, freshwater supply and thermal limits. Additionally, there can also be significant loss and damage related to extreme events like drought, heat waves, storms, and related floods (GOSKN, 2021a). According to the State of the Caribbean Climate Report (2020), droughts have been costly to the agriculture sector, especially given the over reliance on rain fed agriculture which is the case in St. Kitts and Nevis (Climate Studies Group Mona, 2020). The expected impacts of climate change on agricultural systems in St Kitts and Nevis, particularly small farming systems that currently supply both domestic and export markets, are summarized in Table 1.4.

The focus areas of the TNA analysis will be on technologies to enhance crop and livestock management, sustainable farming systems and soil moisture conservation to mitigate against extreme events, especially droughts.

Both the recent NDC (GOSKN, 2021c) and Chapter 3 of the Third National Communication (GOSKN, 2021a) document progress towards adaptation measured identified in the National Climate Change Policy (GOSKN, 2017) and National Climate Change Adaptation Plan (GOSKN, 2018). Progress in the agriculture sector has included vulnerability assessment and the development of measures to increase climate resilience (e.g., a livestock feed bank in Nevis). The DOE collaborated with the

Ministry of Agriculture on three pilot projects, which included the use of organic mulch as an adaptive response to climate change, forage banking to provide feed for livestock during dry periods and the use of a shade house to intensify production (GOSKN, 2021c).

The Draft St. Kitts Strategy and Action Plan of 2016 provides some guidance on future actions needed for this sector, but an updated national level policy is lacking (GOSKN, 2016).

4.3 Overview of Existing Technologies in the Agriculture Sector

Chapter 3 of the Third National Communication (GOSKN, 2021a) provides a summary of existing technologies in the agriculture sector across three themes: building knowledge and information systems, strengthening institutional capacity, and reducing climate risks as shown in Table 4.1.

Table 4.1: Existing Technologies in the Agriculture Sector

Theme	Technology
Building knowledge and information systems	• The St Kitts and Nevis Enhancing Agricultural Adaptive Capacity to Climate Variability Project with aid from the Taiwan ICF implemented, including installation of 4 weather stations, support for early warning systems and set up of demonstration plots (crop protection from extreme weather and pests).
Strengthening institutional capacity	• Extension officers trained and ratios of extension officers to farmers increased • Farmers trained on best management practices to reduce run-offs, prevent erosion, and improve soil water retention
Reducing climate risks	• Evaluation of crop (sweet potato and cabbage) resistance to pets and diseases and drought by CARDI • Surveillance program established by the Quarantine Unit targeting the West Indian fruit fly and Black Sigatoka disease affecting banana and plantain • Sales of compost to the public as a means of improving soil quality underway through Needmust Estate program • Development of agro-tourism supported through ventures such as the ECO Park • Reliance on field cropping reduced through promotion of shade houses and hydroponics

The main barriers to implementation of adaptation technologies in agriculture (GOSKN, 2021c) are:
1. Lack of funding to implement identified adaptation actions
2. Available technical and human resources have been completely inadequate for any level of implementation of adaptation actions

Less than 50% of the adaptation actions identified in the NCCAS have been integrated into annual operational plans or have been implemented (GOSKN, 2021c).

4.4 Adaptation Technologies for the Agriculture Sector

A long list of technology options was prepared from the reviews of previous TNA Reports, TNA fact sheets, online databases, scientific literature, national communications, plans and policies and from consultations with stakeholders from the agriculture sector. The long list of technologies is given in Table 4.2. The technologies have been grouped into broad themes including crop management, livestock management, sustainable farming systems, soil conservation and management and others.

Table 4.2: Long List of Technologies for the Agriculture Sector

No	Technology Category	Specific Technology	Recommended adaptation measure
1	Crop management	Integrated Pest Management / Farmer field schools	
2		Crop diversification (inc. varietal development for salinity, flood, drought, pests)	2NC (2015), Vulnerability and Adaptation Assessment (2021)
3		Tissue culture and micropropagation	
4	Livestock management	Selective livestock breeding	
5		Pasture restoration	
6		Fodder banks	
7		Livestock disease management	
8		Optimizing livestock feed provision	
9	Sustainable farming systems	Agroforestry	
10		Integrated mixed farming	
11		Shade house / greenhouse	
12		Soilless Agriculture / Aquaponics / Hydroponics	Vulnerability and Adaptation Assessment (2021)
13		Conservation agriculture	2NC (2015)
14	Sustainable water use / management	Micro-irrigation (drip/sprinkler)	2NC (2015)
15		Rainwater harvesting	
16		Macro-catchment stormwater harvesting (dams / lined catchments)	
17		Wastewater reuse	
18		Real-time soil moisture monitoring	
19		Groundwater extraction	
20	Sustainable waste management	Composting of agriculture solid waste (livestock and crop)	
21		Anaerobic digestion	
22	Planning for climate change and variability	National agrometeorological systems for forecasting / early warning	
23		Community led monitoring / early warning systems	
24		Climate / agriculture insurance	National Climate Change Adaptation Strategy (2018)
25	Soil conservation and management	Soil moisture conservation techniques	
26		Contour drainage / Terracing	
27		Wind breaks	
28		Integrated soil nutrient management	
29	Capacity building and stakeholder organisations	User groups / farmers cooperatives	
30		Community based extension services	National Climate Change Adaptation Strategy (2018)

No	Technology Category	Specific Technology	Recommended adaptation measure
31	Post-harvest / processing / distribution	Food preservation/storage/ agroprocessing	
32		Seed and grain storage	
33		In-regional ferry to transport produces and livestock	
34		App / Media Website to aid farmer with marketing their goods	

Technologies related to crop management such as integrated pest management, crop diversification and plant tissue culture contribute to climate change adaptation by providing a healthy and balanced ecosystem. These technologies decrease the vulnerability of plants to pests and diseases by protecting biodiversity, by reducing the risk of total crop failure and by improving food security. Effective livestock management including livestock disease management and feed production are critical for climate change adaptation and for making livestock production systems more resilient. Key breeding traits associated with climate change resilience and adaptation include thermal tolerance, low quality feed, high kid survival rate, disease resistance, good body condition and animal morphology.

Sustainable farming systems such as agroforestry can improve the resilience of agricultural production to current climate variability as well as long-term climate change using trees for intensification, diversification and buffering of farming systems. Trees have an important role in reducing vulnerability, increasing resilience of farming systems and buffering agricultural production against climate-related risks. On the other hand, soilless agriculture is a controlled system which is protected by a greenhouse as such production is not hindered by to sudden or long-term environmental stressors which makes it resilient in terms of climate change. Soil conservation practices facilitate adaptation to climate change by optimizing water use, enhancing soil quality and fertility and crop productivity. Finally, technologies for reducing waste of agricultural produce reduce vulnerability to climate change by improving food security.

A short list of technologies was extracted from the long list. This was done by conducting a survey with working group members. The process also allowed for feedback and comments which facilitated the inclusion of additional technologies. During this time, the short list was refined to include livestock feed management and to focus the agroforestry technology specifically on agrosilviculture (planning of trees with crops). The short list identifies 10 climate change adaptation technologies for the sector. The final short list of technologies and descriptions for each is given in Table 4.3.

Table 4.3: Shortlist of Technologies for the Agriculture Sector

No	Technology Category	Specific Technology	Description
1	Crop management	Integrated Pest Management	IPM is an ecosystem-based strategy that focuses on long-term prevention of pests or their damage through a combination of techniques such as biological control, habitat manipulation, modification of cultural practices, and use of resistant varieties.
2		Crop diversification and new varieties	Crop diversification means growing more than one crop in an area. Diversification can be accomplished by adding a new crop species or different variety, or by changing the cropping system.

No	Technology Category	Specific Technology	Description
3		Plant tissue culture	Plant tissue culture is the cultivation of plant cells, tissues or organs on specially formulated nutrient media. Tissue culture is seen as an important technology for developing countries to produce disease-free, high quality planting material and the rapid production of many uniform plants.
4	Livestock management	Livestock disease management including selective livestock breeding	Livestock disease management can reduce diseases through improved animal husbandry practices. These includes controlled breeding, controlling entry to farm lots, and quarantining sick animals and through developing and improving antibiotics, vaccines and diagnostic tools, evaluation of ethno-therapeutic options, and vector control techniques.
5		Livestock feed production	Production of animal feed locally using a feed mill as well as growing of a supplemental fodder crop using hydroponics.
6	Sustainable farming systems	Agrisilviculture	Agroforestry can be defined as a dynamic, ecologically based, natural resource management system that, through the integration of trees on farms and in the agricultural landscape, diversifies and sustains production for increased social, economic and environmental benefits for land users at all levels. Agrosilviculture is the planting of trees with crops.
7		Soilless Agriculture / Aquaponics / Hydroponics	Soilless cultivation generally refers to any method of growing plants without soil as a rooting medium.
8	Soil conservation and management	Soil moisture conservation monitoring and techniques	The main objective of soil moisture conservation is to minimize the amount of water lost from the soils through evaporation (water loss directly from the soil) and transpiration (water loss occurring through the plants) – or combined, the evapotranspiration. Includes crop rotation, intercropping, mulching, green manuring, conservation tillage, contour drainage, terraces etc.
9		Integrated soil nutrient management	Integrated Nutrient Management refers to the maintenance of soil fertility and of plant nutrient supply at an optimum level for sustaining the desired productivity through optimization of the benefits from all possible sources of organic, inorganic and biological components in an integrated manner.
10	Post-harvest / processing / distribution	Food storage, preservation, and processing	Food storage includes techniques to store food (including seeds) to ensure domestic food security and maintaining value prior to sale. Food preservation and processing techniques combine science-based knowledge with technologies to prevent spoilage and extend shelf-life and prevent foodborne illness while maintaining nutritional value, texture and flavour.

Technology fact sheets for each shortlisted technology were developed from the review of previous TNA Reports, TNA fact sheets, online databases and scientific literature, feedback from stakeholders in the agriculture sector and the working group. The TNA factsheets for the shortlisted technologies are presented in **Annex III.**

4.5 Criteria and Process of Technology Prioritisation

The Multi-Criteria Analysis (MCA) methodology was used for the prioritisation of the technologies from the shortlist for St. Kitts and Nevis. The consulting team attended the 1st Regional Capacity Building Workshop virtually from May 17-20, 2021. The team was trained in the MCA methodology required by the TNA. At the Sector Working Group Session for Agriculture, the MCA was explained to the group, and they were taken through the following steps:

1. **Discussion of Technology Fact Sheets:** The technology fact sheets were discussed for some of the shortlisted technology options especially related to capital and operational costs and how each technology could be compared in the absence of concrete data on the costs. The group also discussed how the technology could assist the sector in adapting to the effects of climate change.

2. **Development of Criteria:** Criteria were developed and proposed by the national consultant and discussed by the working group and were selected based the categories proposed by the TNA guidance documents (UNEP DTU, 2015). The approved criteria were used for rating the technology options are shown in Table 4.4.

3. **Development of Weights for each Criterion:** The weighting system was discussed, and the working group agreed to the weighting of each criterion also shown in Table 4.4.

4. **Rating each Technology Option:** The team was then shown how to rate each technology option based on the criterion giving a score between 0 and 100. Scores were discussed and agreed upon during the working group session except for four technologies which the group did not have time to score. As such, the scoresheet was completed by the members later and shared with the national consultant via email. The scores were then compiled by the national consultant and results shared with the group via email.

Table 4.4: Agreed Criterion and Weights for the Agriculture Sector

Category	Criteria	Description	Weight
Costs	Capital	Costs of set-up of the technology generally incurred during start-up phase.	10
	Operational and Maintenance	Costs of the technology over time, which encompasses the operational costs as well as the maintenance of the technology.	10
Economic Benefits	Improve economic performance	Technologies should aim to improve economic performance in the agriculture sector including aspects of increasing crop and livestock productivity as well as generating interest and demand in the market for its output.	20
Social Benefits	Build technical capacity	This criterion assesses the effect of technologies in building the technical capacity of target beneficiaries.	10
	Improve health	This criterion is associated with health improvements to the population that is affected by the technology improvements. Such technology should ideally reduce	10

Category	Criteria	Description	Weight
		morbidity and mortality rates resulting from climate change.	
Environmental Benefits	Support to ecosystems services	This criterion assesses how the given technology contributes to supporting ecosystem services - broadly categorised into provisioning, regulating, supporting and cultural services. Provisioning services relate to the production of food and water. Regulating services relate to regulation of climate and disease/pest control. Supporting services relate to nutrient cycles, seed dispersal, and pollination, where cultural ecosystem services relate to the spiritual and recreational benefits.	15
Climate-related Benefits	Reduces vulnerability to climate change impacts	Adaptation to climate change works towards reducing the vulnerability of populations facing climate change and building their resilience to cope with the impacts.	15
Technology-related Benefits	Ease of implementation / Replicability / Appropriateness	The technology should be easy to implement and replicate and be appropriate to conditions on the ground.	10

4.6 Results of Technology Prioritisation

The MCA was completed by the sector working group for the ten technology options. During the MCA process consensus was achieved for the scoring and where there was a difference, an aggregated score was used. The MCA analysis scores, and weighted scores are presented in **Annex VII**. Based on the weighted scores (Table 4.5), the prioritised adaptation technologies for the agriculture sector for St. Kitts and Nevis are:

1. Integrated pest management
2. Soil moisture conservation monitoring and techniques

Table 4.5: Final List of Prioritized Technologies for the Agriculture Sector

Rank	Technology	Weighted score (out of 100)
1	Integrated pest management	60.9
2	Soil moisture conservation monitoring and techniques	60.6
3	Agrisilviculture	60.4
4	Crop diversification and new varieties	60.3
5	Soilless agriculture / Aquaponics / Hydroponics	58.2

6	Integrated soil nutrient management	57.2
7	Livestock feed production	50.9
8	Food storage, preservation, and processing	49.5
9	Livestock disease management	45.4
10	Plant tissue culture	40.3

Chapter 5 Technology Prioritisation for the Energy Sector

5.1 Energy Sector Profile in St. Kitts and Nevis

The St. Kitts Electricity Company Ltd. (SKELEC) was formed in 2011 (formerly the St. Kitts Electricity Department) and serves all of St. Kitts. Nevis Electricity Company Ltd. (NEVLEC) was formed in 2000 as a subsidiary of the Nevis Island Administration and serves all of Nevis Island. Both utilities provide electricity powered by diesel generators. Total installed capacity is 66 MW with 45.4 MW in St. Kitts and 20.6 MW in Nevis (NREL and CCREEE, 2020). Renewable energy including both solar (1.5 MW) and wind (2.2 MW) represents about 5.6% of installed capacity. Transmission and distribution losses are approximated at 20%.

GHG emissions in 2018 reached 182 ktCO_2-eq, which is an increase of 13.4% from 2014 (shown in Figure 5.1) (GOSKN 2022c). Further investments in renewable sources such as geothermal and photovoltaics have been announced and will be contributing to the future emission reductions in this sector.

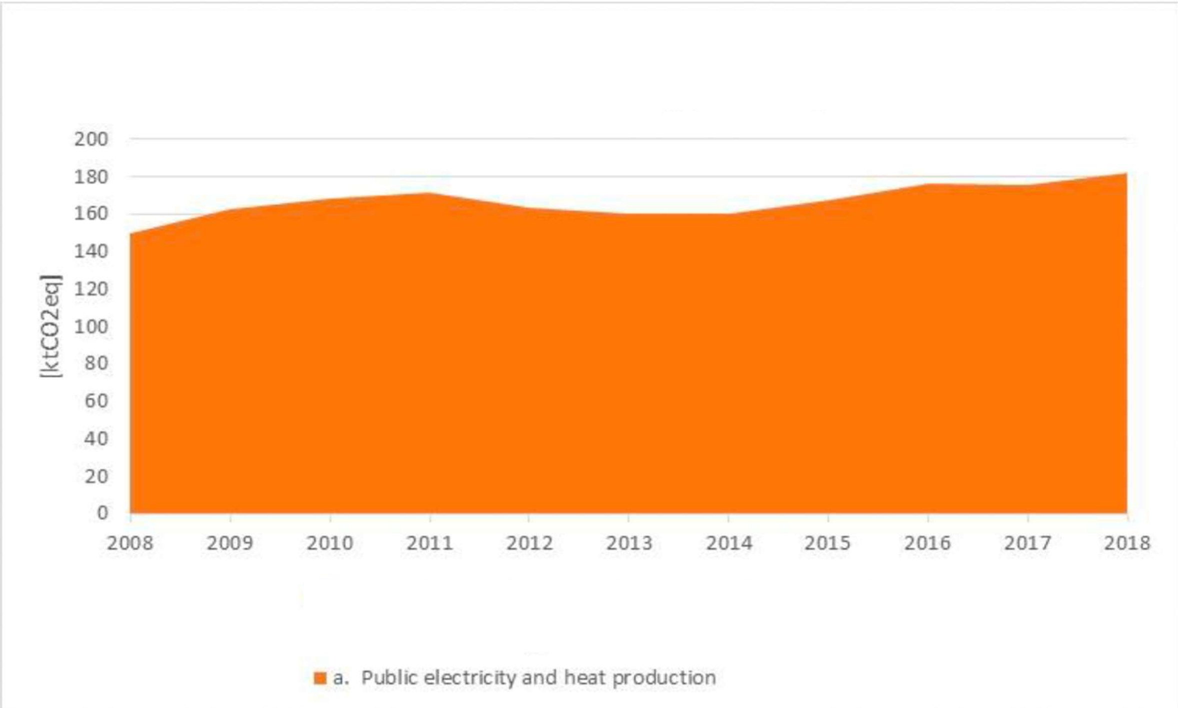

Figure 5.1: GHG emissions for the Energy Sector for St. Kitts and Nevis (2018)

Both the recent NDC (GOSKN, 2021c) and mitigation analysis chapters in the BUR1 and TNC (GOSKN, 2022a,b) assess progress towards mitigation actions identified in the National Climate Change Policy (GOSKN, 2017) and National Energy Policy and Action Plan (GOSKN, 2011). These important policy tools and action plans provide the roadmap for climate change mitigation in the Federation.

5.2 Overview of Existing Technologies in the Energy Sector

Both the recent NDC (GOSKN, 2021c) and mitigation analysis chapters in the BUR1 and TNC (GOSKN, 2022a,b) provides a summary of existing technologies in the energy sector across two themes: energy demand and electricity generation as shown in Table 5.1.

Table 5.1: Existing Technologies in the Energy Sector

Theme	Technology
Energy demand	• Lighting retrofit projects for street lighting. • Lighting retrofit projects for sporting facilities floodlights. • Energy audits of public buildings and water pumps.
Electricity generation	• Commissioning of two solar PV farms of 0.75 MW and 0.5 MW. • Integrated Resource Plan and Assessment for the Power Sector for the twin-island federation. • Wind development of 1.9MW in Nevis • Continued geothermal development in Nevis. • Approval of a 35.7 MW solar with battery storage.

The main barriers to implementation of mitigation technologies in energy (GOSKN, 2022a,b) are:

- Lack of adequate data
- High capital cost of RE projects
- Technology suitability / availability
- Natural disasters
- Land availability

5.3 Mitigation Technologies for the Energy Sector

A long list of technology options was prepared from the reviews of previous TNA Reports, TNA fact sheets, online databases, scientific literature, national communications, plans and policies and from consultations with stakeholders from the energy sector. The long list of technologies is given in Table 5.2. The technologies have been grouped into broad themes including energy demand and electricity generation.

Table 5.2: Long List of Technologies for the Energy Sector

No	Technology Category	Specific Technology
1	Energy Demand	Solar water heating
2		Energy efficient lighting (LED)
3		Energy efficient HVAC systems
4		Energy efficient water pumping systems (solar)
5		Seawater air conditioning
6		Cogeneration (heat and power) plants

7	Electricity Generation	Utility scale solar
8		Utility scale wind power
9		Utility scale geothermal
10		Residential grid-tied solar
11		Residential grid-tied wind
12		Improve efficiency in transmission and distribution (smart grids)
13		Ocean thermal energy conversion
14		Wave energy conversion
15		Waste to energy
16		Landfill methane gas recovery and combustion
17		Battery Energy Storage System (BESS)

Energy demand incorporates the end-use consumption of energy in SKN. This comprises energy demand for residential buildings, commercial buildings (public buildings, schools, churches, restaurants, hotels), industry and street light use. Mitigation actions for energy demand primarily relate to the affected changes in the end-use of electricity and fossil fuels. These actions are normally related to changes in fuel and/or equipment used for lighting, cooling, refrigeration, cooking, water heating and other appliances. Demand-side energy efficiency (EE) is achieved when less energy input is used to deliver the same service or when the same amount of energy input delivers more services. This concept is relevant considering climate change challenges in two ways: (i) the less energy used, the fewer emissions produced, and (ii) cost effective EE achieves environmental benefits at low cost, and thus could reduce the economic costs of achieving climate change policy goals (e.g., CO2 emission reduction, resilience enhancement).

Saint Kitts and Nevis' energy mix is currently dominated by fossil fuels. Saint Kitts and Nevis has declared a 61% CO2 emission reduction target by 2030, based on 2010 levels. Transitioning to 100% renewable energy in power generation by 2030 can help the islands achieve their overall targets.

The twin-island Federation has set a goal to reach 100% renewable energy (RE) generation through the following renewable energy projects:

1. 35.7 MW utility-scale solar PV capacity with 44.2 MWh lithium-ion battery storage facility by 2025
2. 10 MW geothermal power in Nevis by 2030
3. 6.6 MW wind power in St. Kitts by 2030
4. 15 MW geothermal power capacity in St. Kitts by 2035

The estimated GHG emission reduction related to the implementation of RE in the Federation as outlined above (when implemented alone) is 129.15 ktCO2-eq compared to the baseline. Successful implementation of the RE in SKN would increase the proportion of clean renewable energy in the national energy mix; lower and stabilize energy prices; reduce reliance on imported fossil fuels; reduce carbon emissions; increase energy independence; and promote economic development.

A short list of technologies was extracted from the long list. This was done by conducting a survey with working group members. The process also allowed for feedback and comments which facilitated the inclusion of additional technologies. The short list identifies 6 climate change mitigation technologies for the sector. The final short list of technologies and descriptions for each is given in Table 5.3.

Table 5.3: Shortlist of Technologies for the Energy Sector

No	Technology Category	Specific Technology
1	Energy Demand	Solar water heating
2		Energy efficient HVAC systems
3		Energy efficient water pumping systems (solar)
4	Electricity Generation	Utility scale geothermal
5		Residential grid-tied solar
6		Improve efficiency in transmission and distribution (smart grid)

Technology fact sheets for each shortlisted technology were developed from the review of previous TNA Reports, TNA fact sheets, online databases and scientific literature, feedback from stakeholders in the energy sector and the working group. The TNA factsheets for the shortlisted technologies are presented in **Annex IV.**

5.4 Criteria and Process of Technology Prioritisation

The Multi-Criteria Analysis (MCA) methodology was used for the prioritisation of the technologies from the shortlist for St. Kitts and Nevis. The consulting team attended the 1st Regional Capacity Building Workshop virtually from May 17-20, 2021. The team was trained in the MCA methodology required by the TNA. At the Sector Working Group Session for Energy, the MCA was explained to the group, and they were taken through the following steps:

1. **Discussion of Technology Fact Sheets:** The technology fact sheets were discussed for some of the shortlisted technology options especially related to capital and operational costs and how each technology could be compared in the absence of concrete data on the costs. The group also discussed how the technology could assist the sector in reducing GHG emissions.

2. **Development of Criteria:** Criteria were developed and proposed by the national consultant and discussed by the working group and were selected based the categories proposed by the TNA guidance documents (UNEP DTU, 2015). The approved criteria were used for rating the technology options are shown in Table 5.4.

3. **Development of Weights for each Criterion:** The weighting system was discussed, and the working group agreed to the weighting of each criterion also shown in Table 5.4.

4. **Rating each Technology Option:** The team was then shown how to rate each technology option based on the criterion giving a score between 0 and 100. Scores were discussed and

agreed upon during the working group session. The scores were then compiled by the national consultant and results shared at the end of the session.

Table 5.4: Agreed Criterion and Weights for the Energy Sector

Category	Criteria	Description	Weight
Costs	Capital	Costs of set-up of the technology generally incurred during start-up phase.	10
	Operational and Maintenance	Costs of the technology over time, which encompasses the operational costs as well as the maintenance of the technology.	10
Economic Benefits	Improve economic performance	Technologies should aim to improve economic performance in the energy sector specifically and nationally. This also includes job creation.	20
Social Benefits	Build technical capacity	This criterion assesses the effect of technologies in building the technical capacity of target beneficiaries.	10
	Improve health	This criterion is associated with health improvements to the population that is affected by the technology improvements. Such technology should ideally reduce morbidity and mortality rates resulting from climate change.	10
Environmental Benefits	Protect environmental resources (air)	Air quality needs to remain intact, and at best improved following the introduction of the technology.	15
Climate-related Benefits	Reduces GHG emissions	Technologies should aim to reduce GHG emissions	15
Technology-related Benefits	Ease of implementation / Replicability / Appropriateness	The technology should be easy to implement and replicate and be appropriate to conditions on the ground.	10

5.5 Results of Technology Prioritisation

The MCA was completed by the sector working group for the six technology options. During the MCA process, consensus was achieved for the scoring. The MCA analysis scores, and weighted scores are given in **Annex VIII**. Based on the weighted scores (Table 5.5) and additional discussion of the current landscape in the Federation for the development and implementation of these technologies, the prioritised mitigation technologies for the energy sector for St. Kitts and Nevis are:

1. Solar water heating
2. Residential grid-tied solar

Although utility scale geothermal scored higher than residential grid-tied solar, it was decided to prioritise residential grid-tied solar ahead of geothermal as it would benefit from the next steps of the TNA process. Currently, utility scale geothermal is being actively pursued in the Federation with extensive cost benefit, environmental and social impact studies already undertaken (ERM, 2022). In addition, the Caribbean Development Bank (CDB) in collaboration with the Inter-American Development Bank (IDB) has already approved US$17 million in financing for a geothermal energy development project in Nevis. The first phase (10 MW) drilling campaign will include drilling five geothermal wells (1 vertical and 4 directional) to approx. 4,500-5,000 feet measured depth (CBD, 2022).

Table 5.5: Final List of Prioritized Technologies for the Energy Sector

Rank	Technology	Weighted score (out of 100)
1	Solar water heating	60.5
2	Utility scale geothermal	57.5
3	Residential grid-tied solar	56.5
4	Energy efficient water pumping systems (solar)	55
5	Energy efficient HVAC systems	51.5
6	Smart grids	47.5

Chapter 6 Technology prioritisation for the Transport Sector

6.1 Transport Sector Profile in St. Kitts and Nevis

Almost all GHG emissions from Transport Sector in St. Kitts and Nevis are coming from road transport. Emissions from railways are very small and limited to St. Kitts Scenic Railway (29km long narrow-gauge railway) which is exclusively transporting tourists along the coastline of the St. Kitts. GHG Emissions from road transport sector has in 2018 (approximately 100 ktCO_2-eq) increased by 28.1% compared to 2014 and 48.6% compared to year 2008.

Within the Transport sector in 2018, emissions from cars represent 63.3% of the overall emissions. Second largest share goes to heavy duty vehicles (HDV) and busses with 24.0% of emissions (down from 26.9% in 2008). The biggest increase in share is observed for light duty vehicles (LDV) where the share in emissions increased from 8.4% in 2008 to 12.6% in 2018 (shown in Figure 6.1) (GOSKN, 2022c).

Evolution of the emissions from passenger car transport is closely linked to macroeconomic environment, growth of GDP and with increased purchase power of St. Kitts and Nevis residents. Number of vehicles per capita has increased from 365 cars per thousand inhabitants in 2008 to 404 cars per thousand inhabitants in 2018.

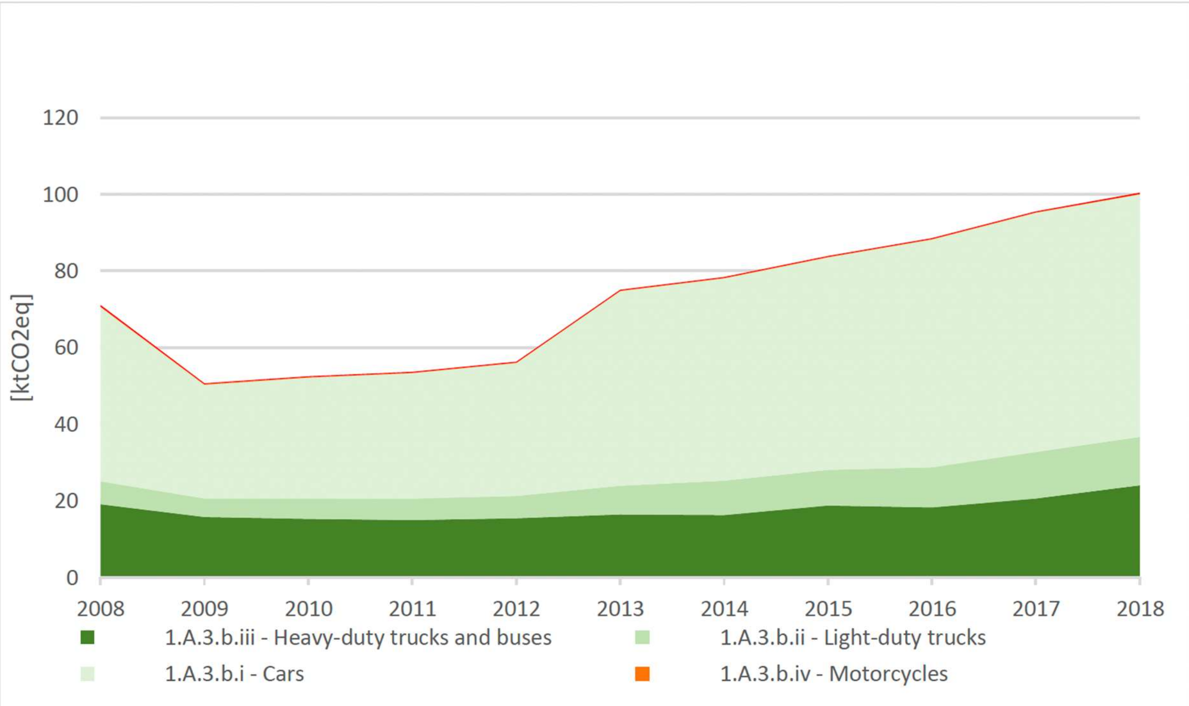

Figure 6.1: GHG Emissions from the Transport Sector St. Kitts and Nevis (2018)

Both the recent NDC (GOSKN, 2021c) and mitigation analysis chapters in the BUR1 and TNC (GOSKN, 2022a,b) assess progress towards mitigation actions identified in the National Climate Change Policy (GOSKN, 2017) and National Energy Policy and Action Plan (GOSKN, 2011). These important policy tools and action plans provide the roadmap for climate change mitigation in the Federation.

6.2 Overview of Existing Technologies in the Transport Sector

Both the recent NDC (GOSKN, 2021c) and mitigation analysis chapters in the BUR1 and TNC (GOSKN, 2022a,b) highlight that the only existing technology considered in the transport sector are electric buses piloted in collaboration with the Italian government. There have not been a lot of focus on the transport sector until recently.

The main barriers to implementation of mitigation technologies in transport (GOSKN, 2022a,b) are:

- Lack of adequate data
- High capital cost of EVs
- Technology suitability / availability
- Natural disasters

6.3 Mitigation Technologies for the Transport Sector

A long list of technology options was prepared from the reviews of previous TNA Reports, TNA fact sheets, online databases, scientific literature, national communications, plans and policies and from consultations with stakeholders from the transport sector. The long list of technologies is given in Table 6.1. The technologies have been grouped into the thematic framework of 'avoid, shift and improve' which is detailed in the TNA guidebook for Cities (UNEP DTU Partnership 2021). The 'avoid, shift and improve' framework envisages the reduction of greenhouse-gas emissions through avoiding travel as far as possible, shifting unavoidable demand to more efficient modes of transport, and reducing the GHG intensity of the technologies used to meet the demand for travel.

Table 6.1: Long List of Technologies for the Transport Sector

No	Technology Category	Strategy	Specific technology / practice
1	AVOID long and unnecessary motor vehicle trips	Dense and mixed-use urban design	Transit-oriented land use planning and development
2		Use of information technologies to reduce trips	Tele-work and virtual meetings through improved connectivity
3	SHIFT individual motorization towards public transport, cycling and walking	Improved facilities for cycling and walking	Development and rehabilitation of sidewalks
4			Cycle ways and lanes, safe cycle parking
5		Improved public transport systems	Integrated systems (ticketing / planning) and expansion of bus routes
6		Smart mobility	Car sharing / ride hailing
7			Intelligent transport systems

8		Disincentives on individual motor vehicle use	Taxes on fuels / registration / tolls
9	IMPROVE technologies and transport management systems	Increase share of clean and low-carbon fuels	Use of biofuels and other fuel alternatives
10		Increase share of clean and low-carbon vehicles (all types) for road-based transport	Hybrids
11			Battery electric vehicles
12			Fuel-cell hydrogen vehicles
13		Increase share of clean and low-carbon marine vessels	Use of biofuels and other fuel alternatives
14		Improved transport management systems	Technical inspection programs
15			Traffic control networks, centralized dispatch and control of transit services

SKN total GHG emissions increased by 19.7% or approximately 60 ktCO2eq in 2018 compared to the 2010 levels (excluding emissions/removals from LULUCF) according to the latest National Inventory Report. This increase corresponds to an increase in GHG emissions of 26% in the energy sector over the same period, mainly attributed to the transport sector, with an increase of approximately 91% in 2018 from 2010 levels. The energy sector represented 77% and 81% of total GHG emissions in 2010 and 2018, respectively (GOSKN 2022a). The transport sector is the second largest emitter in the Federation of SKN.

An important part of the equation in trying to reform the transportation section is a revival of non-motorized transport (NMT), more specifically promotion of walking and cycling to move around for short distances. Another critical step is more efficient management of transportation systems using ICT. Smart mobility and more specifically intelligent transport systems directly results in fuel savings thereby reducing dependence on import of fuel, fewer costs to health from pollution and accidents and cost savings by not having to invest in new road infrastructure. Social benefits include increased safety and health of residents thus increasing the quality of living. Finally, increasing the share of low carbon vehicles on the road is the final element needed to reform the transport sector. With progressive incentives and policies, the economic benefits of EVs include greater public / private partnerships and investment. By ultimately reducing dependence on fossil fuels and associated air pollution and GHG emissions, EVs can promote greater health and more available income assuming the electricity powering the battery is from renewables.

A short list of technologies was extracted from the long list. This was done by conducting a survey with working group members. The process also allowed for feedback and comments which allowed the list to be refined. Specific technologies related to non-motorised transport were combined to include improved facilities for both walking and cycling. The short list identifies 4 climate change mitigation technologies for the transport sector. The final short list of technologies is presented in Table 6.2.

Table 6.2: Shortlist of Technologies for the Transport Sector

No	Technology Category	Strategy	Specific technology / practice
1	SHIFT individual motorization towards public transport, cycling and walking	Improved facilities for cycling and walking	Development and rehabilitation of sidewalks, cycle ways and lanes and safe cycle parking
2		Smart mobility	Intelligent transport systems
3	IMPROVE technologies and transport management systems	Increase share of clean and low-carbon vehicles (all types) for road-based transport	Hybrids and Battery electric vehicles
4			Fuel-cell hydrogen vehicles

Technology fact sheets for each shortlisted technology were developed from the review of previous TNA Reports, TNA fact sheets, online databases and scientific literature, feedback from stakeholders in the transport sector and the working group. The TNA factsheets for the shortlisted technologies are given in **Annex V.**

6.4 Criteria and Process of Technology Prioritisation

The Multi-Criteria Analysis (MCA) methodology was used for the prioritisation of the technologies from the shortlist for St. Kitts and Nevis. The consulting team attended the 1st Regional Capacity Building Workshop virtually from May 17-20, 2021. The team was trained in the MCA methodology required by the TNA. At the Sector Working Group Session for Transport, the MCA was explained to the group, and they were taken through the following steps:

1. **Discussion of Technology Fact Sheets:** The technology fact sheets were discussed for some of the shortlisted technology options especially related to capital and operational costs and how each technology could be compared in the absence of concrete data on the costs. The group also discussed how the technology could assist the sector in reducing GHG emission.

2. **Development of Criteria:** Criteria were developed and proposed by the national consultant and discussed by the working group and were selected based the categories proposed by the TNA guidance documents (UNEP DTU, 2015). The approved criteria were used for rating the technology options are shown in Table 6.3.

3. **Development of Weights for each Criterion:** The weighting system was discussed, and the working group agreed to the weighting of each criterion also shown in Table 6.3.

4. **Rating each Technology Option:** The team was then shown how to rate each technology option based on the criterion giving a score between 0 and 100. Scores were discussed and agreed upon during the working group session The scores were then compiled by the national consultant and results shared with the group at the end of the session.

Table 6.3: Agreed Criterion and Weights for the Transport Sector

Category	Criteria	Description	Weight
Costs	Capital	Costs of set-up of the technology generally incurred during start-up phase.	10
	Operational and Maintenance	Costs of the technology over time, which encompasses the operational costs as well as the maintenance of the technology.	10
Economic Benefits	Improve economic performance	Technologies should aim to improve economic performance in the energy sector specifically and nationally. This also includes job creation.	20
Social Benefits	Build technical capacity	This criterion assesses the effect of technologies in building the technical capacity of target beneficiaries.	10
	Improve health	This criterion is associated with health improvements to the population that is affected by the technology improvements. Such technology should ideally reduce morbidity and mortality rates resulting from climate change.	10
Environmental Benefits	Protect environmental resources (air)	Air quality needs to remain intact, and at best improved following the introduction of the technology.	15
Climate-related Benefits	Reduces GHG emissions	Technologies should aim to reduce GHG emissions	15
Technology-related Benefits	Ease of implementation / Replicability / Appropriateness	The technology should be easy to implement and replicate and be appropriate to conditions on the ground.	10

6.5 Results of Technology Prioritisation

The MCA was completed by the sector working group for the four technology options. During the MCA process, consensus was achieved for the scoring. The MCA analysis scores, and weighted scores are given in **Annex IX**. Based on the weighted scores (Table 6.4), the prioritised mitigation technologies for the transport sector for St. Kitts and Nevis are:

1. Hybrids and battery electric vehicles
2. Development and rehabilitation of sidewalks, cycle ways and lanes and safe cycle parking

Table 6.4: Final List of Prioritized Technologies for the Transport Sector

Rank	Technology	Weighted score (out of 100)
1	Hybrids and battery electric vehicles	62.8
2	Development and rehabilitation of sidewalks, cycle ways and lanes and safe cycle parking	62
3	Intelligent transport systems	54
4	Hydrogen fuel cell vehicles	53.8

Chapter 7 Summary and Conclusions

The Technology Needs Assessment for St. Kitts and Nevis represents the first deliverable of a three-step process that seeks to identify and create climate technology pathways for implementation of the Paris Agreement. The national TNA team for St. Kitts and Nevis was trained through a capacity building workshop held virtually in May 2021. A key component of this stage of the TNA methodology is the use of the Multi-Criteria Analysis (MCA) tool, for the prioritization of climate change adaptation and mitigation technologies. This was implemented through a participatory process, involving relevant stakeholders.

A stakeholder mapping process for each sector was first completed by the team, which considered stakeholders from the public sector, private sector, NGOs and others. Gender balance was prioritized during the stakeholder mapping and the selection of the working groups for each sector. Sector working groups were formed for each of the prioritized sectors (water and agriculture for adaptation and energy and transport for mitigation). They contributed throughout the entire TNA process and through a series of consultations which included interviews, online surveys and working group meetings.

A long list of adaptation and mitigation technologies for each sector was compiled by the national consultant based on a thorough review of national policies, strategies, and national communications, TNA reports, TNA fact sheets, online databases, scientific literature, and consultation with stakeholders. Sector working groups were initially engaged through an online survey which allowed for the determination of a short list of technologies. Technology fact sheets were then prepared for each shortlisted technology. This was done through consultations with professionals within each sector with knowledge of the technologies, as well as through the review of technology fact sheets from other countries and additional research of technology options via the scientific literature and online.

The sector working groups ultimately prioritized climate technologies from the short list of technologies using the MCA tool as part of the TNA methodology. This was done primarily through two sector working group meeting where members of the SWGs discussed and chose the evaluation criteria based on costs, and economic, social, environmental, climate and technology related benefits. The groups also developed weights for each criterion. Then a breakout session was held, and each group discussed the technology factsheets, and then scored each of the technologies in their respective sector. Four technologies for climate change adaptation and four technologies for climate change mitigation for St. Kitts and Nevis were prioritized using this process. The identification of climate technologies in each sector aligns with national development objectives and goals for sustainable development. The prioritized technologies are given below.

Water sector (adaptation)

1. Non-revenue water and demand management programme (including smart metering)
2. Leakage detection and repair and pressure management

Agriculture sector (adaptation)

1. Integrated pest management
2. Soil moisture conservation monitoring and techniques

Energy sector (mitigation)

1. Solar water heating
2. Residential grid-tied solar

Transport sector (mitigation)

1. Hybrids and battery electric vehicles
2. Development and rehabilitation of sidewalks, cycle ways and lanes and safe cycle parking

These technologies will be further analyzed in the second step of the TNA Process, the Barrier Analysis and Enabling Framework.

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Please note that each technology factsheet also has a list of references.

Annex I: List of Stakeholders

Stakeholder	Primary function	Agency Representative on the SWG Name and Email Address
Climate Action Unit Ministry of Environment, Climate Action and Constituency Empowerment	Primary focal agency for climate change action in St. Kitts and Nevis, with responsibility for compliance with the reporting requirements under the UNFCCC.	Cheryl Jeffers, Conservation Officer National TNA Coordinator
Water Working Group		
Integrated Water Resources Management Unit Ministry of Communications Nevis Island Administration	Responsible for the identification, upkeep and protection of water supply sources on Nevis.	Floyd Robinson, Engineer floyd.robinson@niagov.com
Water Services Department Ministry of Public Infrastructure, Utilities, Posts and Urban Development	Maintains control over water production and distribution.	Cromwell Williams, Manager / Water Engineer cromwell.williams@gov.kn
Private Sector – Waterworks Solutions Inc.	Provision of services to the water sector including installation of water distribution and storage systems.	Denison Paul, Engineer wwsolutions.paul@gmail.com
Agriculture Working Group		
Nevis Department of Agriculture Ministry of Agriculture	Provides technical support that is needed to ensure that the citizens and residents of the Federation are food and nutritionally secured through various initiatives and programmes.	Quincy Bart, Quarantine Officer agriculture.dept@niagov.com bartquincy@gmail.com
Department of Agriculture Ministry of Agriculture, Fisheries and Marine Resources	Provides technical support that is needed to ensure that the citizens and residents of the Federation are food and nutritionally secured through various initiatives and programmes.	Yushaner Jeffers, Agronomist yushaner.jeffers@gov.kn
Private sector – agriculture consultant	Provision of services to the agricultural sector through consultancy services.	Stephen Duggins, Consultant / Agriculture expert dugskn@gmail.com

Stakeholder	Primary function	Agency Representative on the SWG Name and Email Address
GEF – Small Grants Programme / UNDP	GEF-SGP provides financial and technical support to community-based projects that conserve and restore the environment while enhancing well-being and livelihoods.	Ilis Watts, National Project Coordinator and Agronomist Iliswatts@unops.org
Energy and Transport Working Group		
Energy Unit Ministry of Public Infrastructure, Utilities, Posts and Urban Development	Strategic and planning unit for the energy and transport sector	Bertill Browne, Engineer bertillb@skelec.kn Denasio Frank, Engineer Denasio.frank@gov.kn
SKELEC	St. Kitts Electricity Company, sole electricity provider in St. Kitts	Jonathan Kelley, Engineer jkelly@skelec.kn
NEVLEC	Nevis Electricity Company, sole electricity provider in Nevis	Ian Ward, Engineer ian.ward@nevlec.com
Department of Maritime Affairs	Strategic and planning unit for the maritime transport sector	Wayne Edmeade waynejrsm@gmail.com
Private Sector – New Era	Provider of RE products	Davian Trotman, Owner neweraskn@gmail.com

Annex II: Technology Factsheets for Short Listed Technologies – Water Sector

Technology: Leakage detection and repair	
Introduction	Worldwide, water losses are occurring at both the consumer / end user side and the utility's distribution side. It is a universal problem affecting in both developed and developing countries. There are two types of water losses (Thornton et al. 2008 p. 5): 1. Real losses – consists of water lost from the distribution system through leaky pipes, joints and fittings and leaky reservoirs (including overflows) 2. Apparent losses – consists of water that is not physically lost but does not generate revenue because of inaccuracies in customer metering / data handling errors or any form of theft or illegal use In 2012, the real losses on the island of St. Kitts were estimated to be over 37 million imperial gallons per month (Daniel and Daniel Engineering 2013). This factsheet will focus reduction of real losses and specifically on leakage detection and repair technologies.
Technology Characteristics/Highlights	Leak management methods can prevent or reduce leakage volume and leak detection technology can improve the ability of water utilities to respond quickly and repair leaks. The primary methods used for leak detection included acoustic, infrared thermography, chemical tracer, and mechanical methods. Among the acoustic methods were ground microphones, acoustic loggers on pipe fittings, and tethered in-line leak detectors. New and emerging technologies include ground penetrating radar (GPR), combined acoustic logger and leak noise correlators, digital correlators, and radio-frequency interferometers (Elliott et al. 2011). Acoustic methods have been used successfully for leak detection in metallic pipes for many years. However, their application in non-metallic piping is more challenging. The SK WSD has acoustic leakage detection equipment, but it is not widely used because of the predominance of PVC piping and the amount of time required to deploy the equipment. The Nevis Water Department does not have currently have any leakage detection equipment. Repairs to pipes with holes generally involve either covering the hole from outside the pipe or inserting a smaller pipe inside the one that is leaking. The complexity and time for repairs varies widely but the knowledge and experience for repairs exists inside of both utilities in the Federation of St. Kitts and Nevis.
Institutional and Organizational Requirements	
Scale of the application / Size of beneficiary group	All residents of St. Kitts and Nevis.

Operation and Maintenance	Leak detection and repair programs should include the following: • Update of water distribution system maps and record keeping of all inspection and repair works; • Use of leakage detection technology (including remote sensors) for ongoing monitoring and analysis of source, transmission, and distribution facilities. Remote sensors and monitoring software can alert operators to leaks, fluctuations in pressure, problems with equipment integrity, and other concerns; and • Regular inspection of pipes (and all elements of the distribution systems like meters, valves and hydrants), and other maintenance efforts (cleaning, lubricating, exercising of valves) to improve the distribution system and prevent leaks and ruptures from occurring.
Advantages and disadvantages (Is the technology endorsed by local experts? Is it adequate for local conditions?)	This technology is endorsed by local experts and adequate for local conditions especially for those methods suitable to PVC pipe. The main advantage is the ability to quickly detect leaks. The main disadvantage is the need for a dedicated specialized crew (sometimes working at night to identify more easily the leaks). Water systems with intermittent supply cannot benefit from many of the methods for leak management and detection covered here. High water pressure is required for leak detection equipment to be used effectively (Elliott et al. 2011). This is an issue especially since water rationing is now commonplace in St. Kitts and Nevis in the dry season.
Costs	
Cost to Implement Adaptation Technology Additional cost to implement adaptation option compared to "business as usual"	The costs of leak management, detection and repair include staff training, management, labor, and equipment. In the water conservation plan of 2013, it was estimated that over 2.25 million imperial gallons could be saved with a strategic focus on leakage detection and repair (reduction of 6% of real losses). A one-year program with a dedicated leakage detection and repair crew was estimated at about 150,000 XCD (team of 4 persons fulltime for 9 months, dedicated vehicle and equipment costs). The cost of training would also have to be included. These programs often pay for themselves through water conservation, reduced costs for treatment and distribution, and reduced maintenance and pipe replacement costs (Elliott et al. 2011)
Development Impacts - Direct and Indirect Benefits	
Reduction of vulnerability to climate change	Water demand management initiatives like leakage detection and repair lead to overall improved water use efficiency, reduction in environmental impact and improved sustainability. Reducing leakages and inefficient water use reduces strain on operations, making more water available to more customers in the dry season and under drought conditions. It can also offset the need for supply side infrastructure upgrades by reducing demand growth and the impacts of climate change. Climate change is expected to result in drier condition in the region, hence managing demand will help adapt to climate change (HR Wallingford 2021).

Economic benefits (including employment, investment, public and private expenditures) Social benefits (including income, education, health)	Minimizing leakage in water systems has many benefits for water customers and utilities. These benefits include: 1. Improved operational efficiency 2. Lowered water system operational costs 3. Reduced potential for contamination 4. Extended life of facilities 5. Reduced potential property damage and water system liability 6. Reduced water outage events 7. Improved public relations As a specific example in St. Kitts, reducing leakages could bring significant energy savings (where the annual energy cost is estimated at 4.5 million XCD, 30% of operating costs). A reduction in leakage by 30% could reduce total production by 10% and energy costs by 0.5 million XCD per year (HR Wallingford 2021)
Environmental Benefits (Indirect)	The main environmental benefit is related to water use efficiency and the preservation of water resources. Reducing abstraction from the environment will retain more water in aquifers and springs for ecosystems services (HR Wallingford 2021).
Gender aspects	The incremental increase in supply will promote equity in distribution and facilitate wider access to existing and potential users especially vulnerable persons.
Local Context	
Opportunities and Barriers	Opportunities for leakage management, detection and repair programs should abound when decision- makers are made aware that the economic benefits often outweigh the costs. The economic benefits of these programs are especially great when: (1) energy costs for transport, treatment and distribution are expensive; (2) infrastructure is aging and leakage is high; (3) high-profile water main breaks lead to media attention and political pressure; (4) under water stress or water scarcity conditions; and (5) water conservation is valued. On the other hand, motivation to prevent leakage may be low when water is inexpensive and abundant, and when water utilities are short-staffed or under-funded which is the case for St. Kitts and Nevis.
Market Potential	Equipment and suppliers available for the Caribbean Region
Status	Practiced
Timeframe for implementation	Short to medium term
Acceptability to local stakeholders	Acceptable
References Daniel and Daniel Engineering Inc. (2016) St. Kitts Water Conservation and Drought Management Project Water Auditing, Retrofitting, Pressure Management, and Identification of	

Additional Water Sources. Prepared for the OECS / EU Global Climate Change Alliance (GCCA) Project on Climate Change Adaptation and Sustainable Land Management. May 2016.

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Thornton, J. et al. 2008. Water Loss Control, McGraw-Hill, New York. 632 p.

Technology: Pressure management	
Introduction	Worldwide, water losses are occurring at both the consumer / end user side and the utility's distribution side. It is a universal problem affecting in both developed and developing countries. There are two types of water losses (Thornton et al. 2008 p. 5): 1. Real losses – consists of water lost from the distribution system through leaky pipes, joints and fittings and leaky reservoirs (including overflows) 2. Apparent losses – consists of water that is not physically lost but does not generate revenue because of inaccuracies in customer metering / data handling errors or any form of theft or illegal use In 2012, the real losses on the island of St. Kitts were estimated to be over 37 million imperial gallons per month (Daniel and Daniel Engineering 2013). There are four aspects to controlling real losses: pressure management, active leak control, speed and quality of repairs and infrastructure asset management (including replacement and renewal). This factsheet will focus on pressure management as a means of controlling real losses.
Technology Characteristics/Highlights	Pressure management can be defined as the practice of managing system pressures to the optimum levels of service while reducing unnecessary excess pressure and eliminating transients both of which cause distribution systems to leak (EU 2015). Years of research has shown leakage and pipe burst frequency increase with pressure thus wasting water (EU 2015, Fanner et al. 2007). The EU (2015) highlights three different levels of pressure management: Basic • Identify and reduce pressure transients and surges • Achieve continuous supply (24/7 policy) even if at low pressure • Strategic separation of transmission mains from distribution systems and zones • Monitor pressures (inlet, critical, average), flows, bursts/leaks/repairs, complaints. • Avoid overflows from service reservoirs; reduce outlet pressure whenever possible. Intermediate • Create sub-sectors (Pressure managed areas or zones) • Reduce pressure using fixed outlet PRVs or intelligent pumping Advanced • Introduce time and/or flow modulation, or feedback loop from a critical node, or remote control, for valves and pumps. • Introduce hydraulic flow modulation for valves Both utilities in St. Kitts and Nevis practice basic level pressure management with some limited use of pressure-reducing valves.

Institutional and Organizational Requirements	
Scale of the application / Size of beneficiary group	All residents of St. Kitts and Nevis
Operation and Maintenance	Operation and maintenance tasks are summarized above for three levels of pressure management (basic, intermediate, and advanced). These are underpinned by regular monitoring of the distribution system (operating pressures) especially for district metering areas. This includes analysis of all types of data (including length of main, number connections, metering data) to pinpoint areas where leakage could be occurring.
Advantages and disadvantages (Is the technology endorsed by local experts? Is it adequate for local conditions?)	The technology is endorsed by local experts and adequate for local conditions is not considered a high-tech solution and should be easily implemented with the proper training and dedication. The main deterrents to active pressure management in St. Kitts are the "spaghetti" configuration of the distribution system which makes setting up of district metering areas (DMA) and pressure zones quite difficult and the costs related to purchase of PRVs (Daniel and Daniel Engineering 2016).
Costs	
Cost to Implement Adaptation Technology Additional cost to implement adaptation option compared to "business as usual"	Under the OECS / EU GCCA project, it was estimated to cost about 73,000 XCD to set up two small DMAs (200-300 connections, 4" feeder main) in St. Kitts. This only includes the cost of the meters / PRV and installation (Daniel and Daniel Engineering 2016). Long term monitoring and data analysis would also have to be factored in.
Development Impacts - Direct and Indirect Benefits	
Reduction of vulnerability to climate change	Pressure management is the foundation for optimal management of water supply and distribution systems especially considering the negative impacts of climate change. There is no doubt that this type of proactive management of water systems is critical to increased resiliency and adaptation to climate change (Daniel and Daniel Engineering 2016).
Economic benefits (including employment, investment, public and private expenditures)	Pressure management reduces leak flow rates and frequency of leaks thus extending infrastructure life, reducing pipe failures, conserving water, and saving money.
Social benefits (including income, education, health)	Some of the benefits to water consumers from pressure management include less disruptions to the water supply and less issues related to damages caused to plumbing from transient pressure.
Environmental Benefits (Indirect)	The main environmental benefit is related to water use efficiency and the preservation of water resources. Reducing abstraction from the environment will retain more water in aquifers and springs for ecosystems services (HR Wallingford 2021).

Gender aspects	The incremental increase in supply will promote equity in distribution and facilitate wider access to existing and potential users especially vulnerable persons.
Local Context	
Opportunities and Barriers	The main opportunity is to reduce real losses in a cost-effective manner as it compares to high capital investment in finding new water sources. The main barriers for St. Kitts and Nevis including hilly topography, "spaghetti" configuration of distribution systems, lack of good quality data for water auditing exercises and establishment of NRW estimates, lack of financial resources dedicated to water loss control and overall reactive instead of proactive management of water systems.
Market Potential	Good
Status	Practiced at the basic level
Timeframe for implementation	Short to medium term
Acceptability to local stakeholders	Acceptable

References

Daniel and Daniel Engineering Inc. (2016) St. Kitts Water Conservation and Drought Management Project Water Auditing, Retrofitting, Pressure Management, and Identification of Additional Water Sources. Prepared for the OECS / EU Global Climate Change Alliance (GCCA) Project on Climate Change Adaptation and Sustainable Land Management. May 2016.

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Thornton, J. et al. 2008. Water Loss Control, McGraw-Hill, New York. 632 p.

<table>
<tr><th colspan="2">Technology: Non-revenue water and demand management programme</th></tr>
<tr><td>Introduction</td><td>
Worldwide, water losses are occurring at both the consumer / end user side and the utility's distribution side. It is a universal problem affecting in both developed and developing countries. There are two types of water losses (Thornton et al. 2008 p. 5):

Real losses – consists of water lost from the distribution system through leaky pipes, joints and fittings and leaky reservoirs (including overflows)
Apparent losses – consists of water that is not physically lost but does not generate revenue because of inaccuracies in customer metering / data handling errors or any form of theft or illegal use

This factsheet will focus on technologies and approaches to manage apparent losses but also an overall approach to manage water demand (apart from leakage detection and pressure management). In 2012, the apparent losses on the island of St. Kitts were estimated to be about 34 million imperial gallons per month (Daniel and Daniel Engineering 2013). The Non-Revenue water (NRW) (real + apparent losses) were estimated to represent 53% of total volume of water input. NRW for Nevis is estimated to be between 30-35%.
</td></tr>
<tr><td>Technology Characteristics/Highlights</td><td>
The first step in any water loss control program is a utility water balance (including water losses) as defined by the IWA/AWWA Water Audit methodology (Daniel and Daniel Engineering 2013). The exercise of a top-down water audit allows a utility to identify weaknesses in terms of data quality and to take steps to improve data quality and ultimately to set performance indicators and monitor progress of any water loss control measures interventions taken (as shown in the figure below).

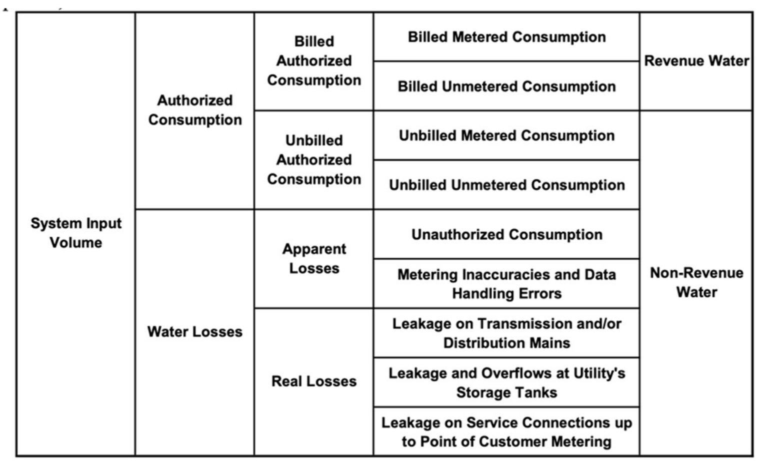


Figure 1: Standard IWA Water Balance
</td></tr>
<tr><th colspan="2">Institutional and Organizational Requirements</th></tr>
<tr><td>Scale of the application / Size of beneficiary group</td><td>All water users in St. Kitts and Nevis</td></tr>
</table>

Operation and Maintenance	The steps in a strategy to reduce NRW include continuous water accounting (as shown in Figure 1), identification and removal of illegal connections, audits of large-volume users and ensuring the integrity of the billing and customer information system. The other parts of a NRW reduction plan include universal metering and public awareness and outreach. Data collected can be tracked in a Management Information System (MIS) or Customer Relations Management System (CRM) or basic billing software. Universal metering includes activities such as installation of meters for all users (including public standpipes), retrofitting of old meters, fixed interval meter reading, meter accuracy analysis and meter testing, calibration, repair or replacement. Public awareness and outreach programs can include activities such as water bill inserts, social media education programmes and workshops (Daniel and Daniel Engineering 2013).
Advantages and disadvantages (Is the technology endorsed by local experts? Is it adequate for local conditions?)	These types of interventions to control water losses are endorsed by local experts and are adequate for local conditions. The technology is endorsed by local experts and adequate for local conditions is not considered a high-tech solution and should be easily implemented with the proper training and dedication. The main disadvantage is probably the expertise and human resources required to properly implement such a program with many data requirements over the long-term.
Costs	
Cost to Implement Adaptation Technology Additional cost to implement adaptation option compared to "business as usual"	Indicative costs to start up an NRW reduction program are outlined in the Water Utility Adaptation Plan of 2021.

Programme activities (St Kitts)	Indicative cost	Duration
St Kitts – NRW 1 – Phase 1 Water Audit and Revenue Enhancement • Review progress on water audits completed as part of the St Kitts Water Conservation Plan and expand, and recommend enhancements as necessary to determine actual NRW. • Ensure requisite in-house capacity and technology to continue to conduct Water Audits as an ongoing activity (particularly for government buildings which are not billed; and other high volume users) • Assess customer information and meter data base systems • Assess metering coverage and accuracy of readings (including of government facilities) to better understand the supply / demand deficits • Develop a NRW reduction road map for apparent and real losses • Commence revenue enhancement activity • Review public awareness programme and revise as needed • Review plan to increase the use of water saving devices for household, business and government facilities through incentives and concessions and revise as needed.	**USD 400,000**	**3 years**
Nevis – NRW 1 – Phase 1 Water Audit and Revenue Enhancement • Conduct Water Audit • Assess customer information and meter data base systems • Assess metering coverage and install meters for all water users • Assess accuracy of readings (including of government facilities) to better understand the supply / demand deficits • Reinstall meters on government premises • Develop a NRW reduction road map for apparent and real losses • Commence revenue enhancement activity • Develop a public awareness programme • Develop a plan to increase the use of water saving devices for household, business and government facilities through incentives and concessions	**USD 200,000**	**3 year**

Development Impacts - Direct and Indirect Benefits	
Reduction of vulnerability to climate change	Water demand management initiatives like water auditing and universal metering lead to overall improved water use efficiency, reduction in environmental impact and improved sustainability. Reducing water losses (all types) and inefficient water use reduces strain on operations, making more water available to more customers in the dry season and under drought conditions. It can also offset the need for supply side infrastructure upgrades by reducing demand growth and the impacts of climate change. Climate change is expected to result in drier condition in the region, hence managing demand will help adapt to climate change (HR Wallingford 2021).
Economic benefits (including employment, investment, public and private expenditures) Social benefits (including income, education, health)	Minimizing water losses in water systems has many benefits for water customers and utilities. These benefits include: 1. Improved operational efficiency 2. Lowered water system operational costs 3. Reduced potential for contamination 4. Extended life of facilities 5. Reduced potential property damage and water system liability 6. Reduced water outage events 7. Improved public health through a more regular and adequate water supply 8. Improved public relations
Environmental Benefits (Indirect)	The main environmental benefit is related to water use efficiency and the preservation of water resources. Reducing abstraction from the environment will retain more water in aquifers and springs for ecosystems services (HR Wallingford 2021).
Gender aspects	The incremental increase in supply will promote equity in distribution and facilitate wider access to existing and potential users especially vulnerable persons.
Local Context	
Opportunities and Barriers	There is a major opportunity to bring expertise into the water utilities thus creating skills that allows for future sustainability. It will be important that the multiple benefits of NRW reduction and water conservation measures be effectively communicated to decision-makers to facilitate continued funding. Generally, the main barrier is the fact the water utilities operate reactively instead of proactively and this type of program requires a lot of data monitoring / analysis in order to be effective.
Market Potential	Good
Status	Practiced
Timeframe for implementation	Medium to long term
Acceptability to local stakeholders	Acceptable

References

Daniel and Daniel Engineering Inc. (2013) St. Kitts: Water Sector Assessment, Auditing and Conservation. Water Conservation Plan for St. Kitts. OECS/USAID Reducing the Risk to Human and Natural Assets Resulting from Climate Change Project. April 2013.

HR Wallingford (2021) Vulnerability Assessment and Water Utility Adaptation Plans. St. Kitts and Nevis – Water Sector Adaptation Plan. Caribbean Community Climate Change Centre / EU GCCA+ Enhancing Climate Resilience in CARIFORUM Countries Programme. August 2021.
Thornton, J. et al. 2008. Water Loss Control, McGraw-Hill, New York. 632 p.

Technology: Smart metering	
Introduction	Worldwide, water losses are occurring at both the consumer / end user side and the utility's distribution side. It is a universal problem affecting in both developed and developing countries. There are two types of water losses (Thornton et al. 2008 p. 5): 1. Real losses – consists of water lost from the distribution system through leaky pipes, joints and fittings and leaky reservoirs (including overflows) 2. Apparent losses – consists of water that is not physically lost but does not generate revenue because of inaccuracies in customer metering / data handling errors or any form of theft or illegal use This factsheet focuses on one aspect of reduction of apparent losses related to universal metering relating to the use of smart meters (also referred to as automatic meter reading / infrastructure or AMR / AMI).
Technology Characteristics/Highlights	Smart water meters facilitate more frequent, higher resolution and remotely accessible water consumption data compared to analogue meters. Arniella (2017) provides a good overview of AMR / AMI. **2.1. SMART METERING (AMR/AMI)** Smart metering is a component of the smart grid that allows a utility to obtain meter readings on demand (daily, hourly or more frequently) without the need of manual meter readers to transmit information. There are two types: (1) automated meter reading (AMR), and (2) automated metering infrastructure (AMI). These two types of technologies are described below. Automated Meter Reading (AMR) includes the walk-by and drive-by methods as well as a fixed network, usually with only one-way communication from the meter to the billing system. The AMR technology includes: Drive-by metering: This resource-saving metering solution allows water meter data to be collected instantly on-the-go. After installing the reading device and software in a van or work truck, the meter reading crew can quickly obtain accurate meter readings simply by driving through a service area. Touch-read metering: For areas that are not conducive to vehicles, touch-read metering is an excellent meter reading solution. Touching a hand-held meter reading device directly to the water meter sends a radio signal that automatically transmits meter data and stores it in the hand-held device. Automated Metering Infrastructure (AMI) refers to a fixed network system, with smart meters providing two-way communications between the water meter and the utility. The use of AMI further improves the efficiency of water utilities and eliminates the costs of routine meter reading. When AMI is combined with geospatial meter data management, it increases the accuracy and precision of the meter read, reducing re-reads. This results in accurate and timely reads that are ready for billing, with an identification of failed and failing meters before actual billing, improving the utility's cash flow.
Institutional and Organizational Requirements	
Scale of the application / Size of beneficiary group	All water consumers in St. Kitts and Nevis.
Operation and Maintenance	Universal metering includes activities such as installation of meters (analogue and digital) for all users (including public standpipes), retrofitting of old meters, fixed interval meter reading, meter accuracy analysis and meter testing, calibration, repair or

	replacement. Smart metering increases the amount of specialized IT technicians required to process and analyze the data collected by the meters.
Advantages and disadvantages (Is the technology endorsed by local experts? Is it adequate for local conditions?)	Arniella (2017) summarizes the advantages and disadvantages of smart metering. ADVANTAGES OF SMART METERS Smart meters can benefit the water utility, the environment, and the utility's customers by: · Lowering the cost of meter reading by eliminating manual meter reading; · Enhancing employee safety by reducing the number of personnel on the road; · Reducing billing errors and disputes; · Monitoring the water system in a timely manner; · Enabling flexible reading schedules, reducing delays in billing of commercial accounts; · Providing useful data for balancing customer demand; · Enabling possible dynamic pricing (raising or lowering the cost of water based on demand, promotions, and customer incentives); · Benefitting the environment by reducing pollution from vehicles driven by meter readers; · Assessing Non-Revenue Water in real time or short intervals; · Facilitating the data to establish the night water consumption patterns, analyzing the minimum night flows (MNF), and offering a more detailed feedback on water use patterns; · Enabling customers to adjust their habits to lower water bills; · Providing real-time billing information, reducing estimated readings and re-billing costs; · Reducing customer complaint calls and increasing customer satisfaction; · Improving the monitoring of potential meter tampering and water theft; and · Detecting water line leaks sooner, so they can be repaired faster. DISADVANTAGES OF SMART METERS While smart meters have many benefits, they also present challenges to water utilities, customers, and the environment. They require: · Front-end capital investment; · Long-term financial commitment to the new metering technology and related software; · Ensuring the security of metering data and preventing cyber-attacks; · Transitioning to new technology and processes with proper training; · Managing public reaction and customer acceptance of the new meters; · Managing and storing vast quantities of metering data and; · Disposing of the old meters. Smart metering is suitable for local conditions and acceptable to local experts. There are several case studies of smart meter pilots in

the Caribbean. The St. Kitts Water Services Department has also installed smart meters as part of a pilot program in 2019.

Costs

Cost to Implement Adaptation Technology Additional cost to implement adaptation option compared to "business as usual"	The Water Utility Adaptation Plan of 2021 for St. Kitts and Nevis envisions the deployment of smart meters as part of a phased approach to NRW reduction. Smart metering is considered an advanced step of that process (last phase out of four phases of implementation). Indicative costs of an overall approach to NRW reduction are included below for both islands (also includes technologies described in other factsheets).

Programme activities (St Kitts)	Indicative cost	Duration
St Kitts – NRW 1 – Phase 1 Water Audit and Revenue Enhancement • Review progress on water audits completed as part of the St Kitts Water Conservation Plan and expand, and recommend enhancements as necessary to determine actual NRW. • Ensure requisite in-house capacity and technology to continue to conduct Water Audits as an ongoing activity (particularly for government buildings which are not billed; and other high volume users) • Assess customer information and meter data base systems • Assess metering coverage and accuracy of readings (including of government facilities) to better understand the supply / demand deficits • Develop a NRW reduction road map for apparent and real losses • Commence revenue enhancement activity • Review public awareness programme and revise as needed • Review plan to increase the use of water saving devices for household, business and government facilities through incentives and concessions and revise as needed.	**USD 400,000**	**3 years**
St Kitts – NRW 2 – Phase 2 Detailed Implementation Plans and Revenue Enhancement • Detailed implementation plans for apparent loss reduction • Detailed implementation plans for real loss reduction • Implementation of remedial work in high loss areas identified in water audit • Recommend upgrade of information systems where necessary • Continue revenue enhancement activity • Implement a public awareness programme • Trialling of incentive scheme for water saving devices	**USD 300,000**	**7 years**
St Kitts – NRW 3 – Phase 3 Implementation of NRW Reduction Plan • Implementation of apparent losses reduction programme • Implementation of real losses reduction programme • Continue public awareness programme • Rolling out incentive scheme for water saving devices	**USD 10,000,000**	**3 years**
St Kitts – NRW 4 – Information systems upgrades • Operationalise SCADA system and upgrade the systems that work with it to improve data collection, management and use in the effective and efficient collection of metering information (by expanding the use of smart meters to the entire island); and management of customer accounts, and supporting capacity development and staffing. Expanding the pilot phase of smart meters completed in 2019 would help to better quantify water loss and improve efficiency in how meters are read, and consequently improve the billing system. • Fully automate the operation of water supply equipment.	**USD 1,000,000**	**4 years**

Programme activities (Nevis)	Indicative cost	Duration
Nevis – NRW 1 – Phase 1 Water Audit and Revenue Enhancement • Conduct Water Audit • Assess customer information and meter data base systems • Assess metering coverage and install meters for all water users • Assess accuracy of readings (including of government facilities) to better understand the supply / demand deficits • Reinstall meters on government premises • Develop a NRW reduction road map for apparent and real losses • Commence revenue enhancement activity • Develop a public awareness programme • Develop a plan to increase the use of water saving devices for household, business and government facilities through incentives and concessions	USD 200,000	3 year
Nevis – NRW 2 – Phase 2 Detailed Implementation Plans and Revenue Enhancement • Detailed implementation plans for apparent loss reduction • Detailed implementation plans for real loss reduction • Implementation of remedial work in high loss areas identified in water audit • Recommend upgrade of information systems where necessary • Continue revenue enhancement activity • Implement a public awareness programme • Trialling of incentive scheme for water saving devices	USD 100,000	7 years
Nevis – NRW 3 – Phase 3 Implementation of NRW Reduction Plan • Implementation of apparent losses reduction programme (Phase 1) • Implementation of real losses reduction programme (Phase 2) • Continue public awareness programme • Rolling out incentive scheme for water saving devices	USD 1,000,000	3 years
Nevis – NRW 4 – Information systems upgrades • Completion of information systems upgrade to improve data collection, management and use in the effective and efficient collection of metering information and management of customer accounts, and supporting capacity development and staffing.	USD 300,000	4 years

Development Impacts - Direct and Indirect Benefits	
Reduction of vulnerability to climate change	Smart water metering increases resilience to climate change driven water scarcity by making better use of limited water resources.
Economic benefits (including employment, investment, public and private expenditures) Social benefits (including income, education, health)	Smart Water Metering (SWM) technology provides high resolution and frequent water consumption data which can be used to improve feedback to consumers and thus enhance water conservation and management. Other socio-economic benefits include reduced use of water restrictions and equity of water supply. Digital water metering and intelligent network devices can support the lessening of water restrictions by providing a range of alternative mechanisms to stimulate consumption reduction. This technology also provides the infrastructure and the information required to influence long-term water policy and vision, and thereby support the sustainable supply of water resources for future generations.
Environmental Benefits (Indirect)	The main environmental benefit is related to water use efficiency and the preservation of water resources. Reducing abstraction from the environment will retain more water in aquifers and springs for ecosystems services (HR Wallingford 2021). Smart water metering can also lead to reduced energy consumption and greenhouse gas emissions.
Gender aspects	The incremental increase in supply will promote equity in distribution and facilitate wider access to existing and potential users especially vulnerable persons.

Local Context	
Opportunities and Barriers	The main opportunity for smart metering is the fact this technology is evolved rapidly and new forms of communication standards such as the NarrowBand-Internet of Thing (NB-IoT) can allow a utility to leapfrog and avoid the costly issues related to more traditional communication modes such as cellular 3G/4G/5G. The main barrier is the need to implement a well-rounded NRW reduction plan including water accounting, audits, universal metering before diving into the installation of smart meters.
Market Potential	Good
Status	Practiced regionally
Timeframe for implementation	Medium to long term
Acceptability to local stakeholders	Acceptable

References

Arniella, E.F. (2017) Evaluation of Smart Water Infrastructure Technologies. Report for the Inter-American Bank (IDB).

HR Wallingford (2021) Vulnerability Assessment and Water Utility Adaptation Plans. St. Kitts and Nevis – Water Sector Adaptation Plan. Caribbean Community Climate Change Centre / EU GCCA+ Enhancing Climate Resilience in CARIFORUM Countries Programme. August 2021.

Thornton, J. et al. 2008. Water Loss Control, McGraw-Hill, New York. 632 p.

Technology: Real-time data monitoring	
Introduction	Worldwide, water losses are occurring at both the consumer / end user side and the utility's distribution side. It is a universal problem affecting in both developed and developing countries. There are two types of water losses (Thornton et al. 2008 p. 5): 1. Real losses – consists of water lost from the distribution system through leaky pipes, joints and fittings and leaky reservoirs (including overflows) 2. Apparent losses – consists of water that is not physically lost but does not generate revenue because of inaccuracies in customer metering / data handling errors or any form of theft or illegal use This factsheet focuses on one aspect of reduction of losses relating to the use of real-time monitoring which can include Geographical Information Systems (GIS) and Supervisory Control and Data Acquisition (SCADA) systems.
Technology Characteristics/Highlights	Arniella (2017) summarizes the tools available for real-time data monitoring as: GIS are a collection of computer hardware, software and geographic data, supported by technical staff to capture, store, update, manipulate, analyze and display all of forms of geographically referenced information. A SCADA system is a software application supported by electronic real time data gathering, capable of automation. This can include the addition of sensors that collect data on equipment such as pressure at a pump, tank levels, water quality etc. Some utilities may choose to have the data from the field sensors be tracked via a web application versus a custom-made software. The SK WSD has tank level controls installed which are tracked via a web app and the NWD has a SCADA system.
Institutional and Organizational Requirements	
Scale of the application / Size of beneficiary group	All water consumers in St. Kitts and Nevis.
Operation and Maintenance	GIS / SCADA and similar real time data monitoring tools require a dedicated program, funding, and staff to capture, view and update data collection via a digital platform. Sensors, software, and all related equipment require regular maintenance, calibration and monitoring to ensure proper functioning.
Advantages and disadvantages (Is the technology endorsed by local experts? Is it adequate for local conditions?)	Arniella (2017) summarizes the advantages and disadvantages of SCADA and similar systems:

	Advantages of SCADA · Water users do not have to manually read and record meter readings at regular intervals because data on water use is collected automatically; · Data can be downloaded at the user's convenience. Can generate instantly Preprogrammed reports; and · Can be rigged for telemetry access by radio, satellite, cell phone, or telephone landline GIS / SCADA is appropriate for local conditions and endorsed by local experts and practiced at both utilities in the Federation. The main disadvantage is the capital costs related to equipment and highly specialized technical staff required to run these systems effectively especially ICT experts.
Costs	
Cost to Implement Adaptation Technology Additional cost to implement adaptation option compared to "business as usual"	The Water Utility Adaptation Plan of 2021 for St. Kitts and Nevis envisions the installation and upgrade of SCADA / GIS systems as part of a phased approach to NRW reduction and water loss control. SCADA is considered an advanced step of that process (last phase out of four phases of implementation). Indicative costs of an overall approach to NRW reduction are included below for both islands (also includes technologies described in other factsheets).

Programme activities (St Kitts)	Indicative cost	Duration
St Kitts – NRW 1 – Phase 1 Water Audit and Revenue Enhancement • Review progress on water audits completed as part of the St Kitts Water Conservation Plan and expand, and recommend enhancements as necessary to determine actual NRW. • Ensure requisite in-house capacity and technology to continue to conduct Water Audits as an ongoing activity (particularly for government buildings which are not billed; and other high volume users) • Assess customer information and meter data base systems • Assess metering coverage and accuracy of readings (including of government facilities) to better understand the supply / demand deficits • Develop a NRW reduction road map for apparent and real losses • Commence revenue enhancement activity • Review public awareness programme and revise as needed • Review plan to increase the use of water saving devices for household, business and government facilities through incentives and concessions and revise as needed.	**USD 400,000**	**3 years**
St Kitts – NRW 2 – Phase 2 Detailed Implementation Plans and Revenue Enhancement • Detailed implementation plans for apparent loss reduction • Detailed implementation plans for real loss reduction • Implementation of remedial work in high loss areas identified in water audit • Recommend upgrade of information systems where necessary • Continue revenue enhancement activity • Implement a public awareness programme • Trialling of incentive scheme for water saving devices	**USD 300,000**	**7 years**
St Kitts – NRW 3 – Phase 3 Implementation of NRW Reduction Plan • Implementation of apparent losses reduction programme • Implementation of real losses reduction programme • Continue public awareness programme • Rolling out incentive scheme for water saving devices	**USD 10,000,000**	**3 years**
St Kitts – NRW 4 – Information systems upgrades • Operationalise SCADA system and upgrade the systems that work with it to improve data collection, management and use in the effective and efficient collection of metering information (by expanding the use of smart meters to the entire island); and management of customer accounts, and supporting capacity development and staffing. Expanding the pilot phase of smart meters completed in 2019 would help to better quantify water loss and improve efficiency in how meters are read, and consequently improve the billing system. • Fully automate the operation of water supply equipment.	**USD 1,000,000**	**4 years**

Programme activities (Nevis)	Indicative cost	Duration
Nevis – NRW 1 – Phase 1 Water Audit and Revenue Enhancement • Conduct Water Audit • Assess customer information and meter data base systems • Assess metering coverage and install meters for all water users • Assess accuracy of readings (including of government facilities) to better understand the supply / demand deficits • Reinstall meters on government premises • Develop a NRW reduction road map for apparent and real losses • Commence revenue enhancement activity • Develop a public awareness programme • Develop a plan to increase the use of water saving devices for household, business and government facilities through incentives and concessions	**USD 200,000**	**3 year**
Nevis – NRW 2 – Phase 2 Detailed Implementation Plans and Revenue Enhancement • Detailed implementation plans for apparent loss reduction • Detailed implementation plans for real loss reduction • Implementation of remedial work in high loss areas identified in water audit • Recommend upgrade of information systems where necessary • Continue revenue enhancement activity • Implement a public awareness programme • Trialling of incentive scheme for water saving devices	**USD 100,000**	**7 years**
Nevis – NRW 3 – Phase 3 Implementation of NRW Reduction Plan • Implementation of apparent losses reduction programme (Phase 1) • Implementation of real losses reduction programme (Phase 2) • Continue public awareness programme • Rolling out incentive scheme for water saving devices	**USD 1,000,000**	**3 years**
Nevis – NRW 4 – Information systems upgrades • Completion of information systems upgrade to improve data collection, management and use in the effective and efficient collection of metering information and management of customer accounts, and supporting capacity development and staffing.	**USD 300,000**	**4 years**

Development Impacts - Direct and Indirect Benefits	
Reduction of vulnerability to climate change	Real-time data monitoring increases resilience to climate change driven water scarcity by making better use of limited water resources.
Economic benefits (including employment, investment, public and private expenditures) Social benefits (including income, education, health)	Real-time data technology provides high resolution and frequent water consumption / production data which can be used to improve feedback to all stakeholders and thus enhance water conservation and management. Other socio-economic benefits include reduced use of water restrictions and equity of water supply. Intelligent network devices can support the lessening of water restrictions by providing a range of alternative mechanisms to stimulate consumption reduction. This technology also provides the infrastructure and the information required to influence long-term water policy and vision, and thereby support the sustainable supply of water resources for future generations.
Environmental Benefits (Indirect)	The main environmental benefit is related to water use efficiency and the preservation of water resources. Reducing abstraction from the environment will retain more water in aquifers and springs for ecosystems services (HR Wallingford 2021). Real-time data monitoring and automation can also lead to reduced energy consumption and greenhouse gas emissions.
Gender aspects	The incremental increase in supply will promote equity in distribution and facilitate wider access to existing and potential users especially vulnerable persons.

Local Context	
Opportunities and Barriers	The main opportunity for smart metering is the fact this technology is evolved rapidly and new forms of communication standards such as the NarrowBand-Internet of Thing (NB-IoT) can allow a utility to leapfrog and avoid the costly issues related to more traditional communication modes such as cellular 3G/4G/5G. The main barrier is the need to implement a well-rounded NRW reduction plan including water accounting, audits, universal metering before diving into the installation of intelligent network devices.
Market Potential	Good
Status	Practiced locally and regionally
Timeframe for implementation	Medium to long term
Acceptability to local stakeholders	Acceptable

References

Arniella, E.F. (2017) Evaluation of Smart Water Infrastructure Technologies. Report for the Inter-American Bank (IDB).

HR Wallingford (2021) Vulnerability Assessment and Water Utility Adaptation Plans. St. Kitts and Nevis – Water Sector Adaptation Plan. Caribbean Community Climate Change Centre / EU GCCA+ Enhancing Climate Resilience in CARIFORUM Countries Programme. August 2021.

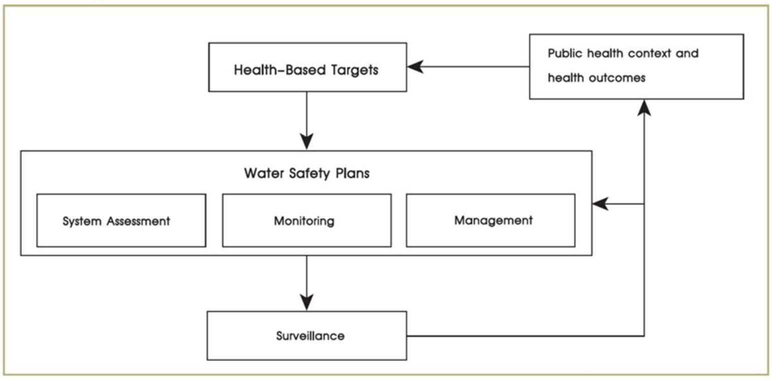
Thornton, J. et al. 2008. Water Loss Control, McGraw-Hill, New York. 632 p.

Technology: Groundwater assessment, mapping and modelling	
Introduction	To achieve sustainable groundwater management in the face of increasing demand for water resources in growing urban, industrial, and agricultural areas, a three-pronged approach of mapping, monitoring and management is required (DNR 2010).
Technology Characteristics/Highlights	Mapping provides the data and information needed to develop an accurate inventory of groundwater resources, including the classification of aquifers and other water resources; mapping also provides assessments of resource vulnerability (DNR 2010). Monitoring / Modelling provides critical data about system behavior throughout the monitoring network. These data support a variety of models that relate aquifer levels to the health and status of our drinking water supplies and other ecological systems. Management success depends upon accurate mapping and monitoring information at all scales.
Institutional and Organizational Requirements	
Scale of the application / Size of beneficiary group	Island wide
Operation and Maintenance	The backbone for most models and mapping tools is (DNR 2010): • a baseline understanding of the hydrogeology, • adequate data for modeling aquifer characteristics, understanding the flow pathways and rate of movement of water through the aquifers, and • methods and data for understanding both surface and groundwater components of management areas. In terms of operation and maintenance, this requires a dedicated team of technical staff monitoring and managing wells (both monitoring and production wells), regular data monitoring, troubleshooting, and updating of any models with new information as needed.
Advantages and disadvantages (Is the technology endorsed by local experts? Is it adequate for local conditions?)	The main advantage of these tools is to aid in effective decision-making in planning, designing, operating, and optimizing water resources. The main disadvantages are: • Requires specialized skills in GIS / groundwater modelling • Requires continuous upgrading • High capital costs
Costs	
Cost to Implement Adaptation Technology Additional cost to implement adaptation	*Implementation:* • High investment cost, which would include, drilling and development of observation wells, data logging equipment, computers, open source or software license, procurement of expert/consultancy services for training; and

option compared to "business as usual"	• Many of the software developed for ground, surface and water quality modelling, for example, MODFLOW are available for free download. *Operation/Maintenance:* • Training, ongoing data collection, security for observation wells/ equipment, procurement of software updates (Guyana TNA FS 2016).
Development Impacts - Direct and Indirect Benefits	
Reduction of vulnerability to climate change	Groundwater assessment, mapping, and modelling increases resilience to climate change driven water scarcity by making better use of limited water resources.
Economic benefits (including employment, investment, public and private expenditures) Social benefits (including income, education, health)	Groundwater assessment, mapping and modelling provide high resolution and frequent water resource and production data which can be used to improve feedback to all stakeholders and thus enhance water conservation and management. Other socio-economic benefits include reduced use of water restrictions and equity of water supply. This technology also provides the infrastructure and the information required to influence long-term water policy and vision, and thereby support the sustainable supply of water resources for future generations.
Environmental Benefits (Indirect)	Groundwater assessment, mapping and modelling promote water security, prevent groundwater contamination and excessive extraction, and promote ecosystems health.
Gender aspects	The incremental increase in supply will promote equity in distribution and facilitate wider access to existing and potential users especially vulnerable persons.
Local Context	
Opportunities and Barriers	The major opportunity from implementation of this technology includes strengthened capacity to monitor, plan and management groundwater effectively. The main barriers are lack of institutional skills to deploy the technology, high initial investment cost and the cost to retain the technical expertise required to sustain this technology.
Market Potential	Good
Status	Practiced
Timeframe for implementation	Medium to long term
Acceptability to local stakeholders	Acceptable
References	
DNR Ecological and Water Resources, State of Minnesota (2010) Evaluation of Models and Tools for Assessing Groundwater Availability and Sustainability. Groundwater Technical Workgroup. Accessed online on February 21, 2022 at https://files.dnr.state.mn.us/publications/waters/modelsandtools.pdf	

Elliott, R. et al (2011) Technologies for Climate Change Adaptation – Water. TNA Guidebook, April 2011.

Guyana TNA FS (2016). Factsheet on Groundwater Mapping and Modelling.

Technology: Water safety plans	
Introduction	Water safety plans (WSPs) were introduced by the World Health Organization in 2004, as a health-based, risk assessment approach to managing drinking water quality.
Technology Characteristics/Highlights	The components of a WSP are shown below (Elliott et al. 2011):  System assessment: Identification of potential threats to water quality at each step in the water supply chain for a specific drinking water system. Monitoring: Development of a prioritized and system-specific plan for monitoring and controlling hazards. Management: Implementation of best practices to mitigate potential threats and ensure drinking water quality.
Institutional and Organizational Requirements	
Scale of the application / Size of beneficiary group	All residents of St. Kitts and Nevis
Operation and Maintenance	To develop a WSP, a water supplier must (Elliott et al. 2011): • Assemble a team that understands the water supply system and its capability to meet the water quality targets • Identify where contamination could arise within the water supply, and how it could be controlled • Validate the methods employed to control hazards • Establish both a monitoring system to check that safe water is consistently supplied and agree to corrective actions in the case of deviation outside acceptable limits • Periodically verify that the WSP is being implemented correctly and is achieving the performance required to meet the water safety targets
Advantages and disadvantages (Is the technology endorsed by local experts? Is it adequate for local conditions?)	Water safety plans have been implemented throughout Latin America and the Caribbean especially in smaller communities. The main advantages of a WSP are (Elliott et al 2011): • Better understanding of the risks that may affect water quality and health and a focus on prevention • Improvement of day-to-day management and operation of water supply • Involves all stakeholders • Identification of improvement needs and opportunities

	Sone of the disadvantages: • Needs technical expertise in the WSP team which may not be available in all water supply systems particularly in rural areas • Requires additional training and capacity building initiatives • May require huge capital investment for large water supply systems • Need thorough and systematic monitoring, supervision and validation process which may be time consuming and tedious
Costs	
Cost to Implement Adaptation Technology Additional cost to implement adaptation option compared to "business as usual"	The implementation of a WSP will potentially require water suppliers to increase sampling frequency and number of locations where process indicators (such as turbidity, chlorine, residuals, pH, etc.) are monitored. It is likely that the cost of providing and distributing safe water from a risk-based approach will actually be less than from a traditional end-product monitoring approach (Elliott et al. 2011).
Development Impacts - Direct and Indirect Benefits	
Reduction of vulnerability to climate change	The water safety plan process offers a systematic framework to manage climate change risks (WHO 2017).
Economic benefits (including employment, investment, public and private expenditures) Social benefits (including income, education, health)	WSPs can make a significant contribution to economic development and sustainable livelihoods by reducing the burden of waterborne illness and enhancing water quality at every level of the water supply chain.
Environmental Benefits (Indirect)	Improved water quality can also bring ecosystems related benefits.
Gender aspects	Having a continuous and safe water supply is important especially where the burden of domestic activities and hygiene fall to women and children. Reducing the burden of waterborne illness opens up opportunities for employment, education etc.
Local Context	
Opportunities and Barriers	Opportunities for WSP implementation arise whenever the supplier is motivated to pursue a risk-based approach and when the personnel capacity exists to make the necessary changes (Elliott et al. 2011). The three most important success factors identified by Herschan et al. (2020) are the development of technical capacity, community engagement, and monitoring and verification. There are several barriers to implementation including: • Limited data availability • Unplanned development • Lack of sanitation infrastructure • Limited system knowledge • Limited equipment/human resource availability

Market Potential	Good
Status	Not currently practiced in the Federation
Timeframe for implementation	Medium to long term
Acceptability to local stakeholders	Acceptable

References

Elliott, R. et al (2011) Technologies for Climate Change Adaptation – Water. TNA Guidebook, April 2011.

Herschan, J. et al. (2020) Success Factors for Water Safety Plan Implementation in Small Drinking Water Supplies in Low- and Middle-Income Countries. Resources (9): 126. Accessed online on February 21, 2022 at https://www.mdpi.com/2079-9276/9/11/126/pdf.

WHO (2017) Climate-resilient water safety plans. Managing health risks associated with climate change. 92p.

Technology: Integrated water resources management

Introduction

The Global Water Partnership (GWP) defines Integrated Water Resources Management as a process which promotes the coordinated development and management of water, land and related resources in order to maximise economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems and the environment (GWP-C 2011). IWRM as a process in water resources management is infinitely more important and meaningful than simply having an IWRM plan.

Technology Characteristics/Highlights

The key components of the IWRM process are:

- Managing water resources at the lowest possible level
- Optimizing supply
- Managing demand
- Providing equitable access to water resources through participatory and transparent governance and management
- Establishing improved and integrated policy, regulatory and institutional frameworks
- Utilizing an inter-sectoral approach to decision-making

The table below provides an overview of IWRM implementation status in various Caribbean countries (GWP-C 2021).

Table 1: IWRM implementation status of participating countries

S.D.G Indicator 6.5.1 IWRM Implementation Status (score/100)		
Member/ Observe Country	**2017 Ranking (Baseline)**	**2020 Ranking**
Trinidad and Tobago	25 (Low)	34 (Medium Low)
Jamaica	43 (Medium Low)	50 (Medium Low)
Saint Vincent and the Grenadines	Not available	24 (Low)
Saint Kitts and Nevis	22 (Low)	23 (Low)
Antigua and Barbuda	30 (Low)	35 (Medium Low)
Dominican Republic	36 (Medium Low)	36 (Medium Low)
Cuba	80 (High)	82 (High)
Grenada	25 (Low)	31 (Medium Low)
Saint Lucia	40 (Medium Low)	40 (Medium Low)
Barbados	42 (Medium Low)	46 (Medium Low)

Source: UN IWRM Data Portal; SDG 6.5.1 summary

Institutional and Organizational Requirements

Scale of the application / Size of beneficiary group

All the residents of St. Kitts and Nevis

Operation and Maintenance

The operational tools of IWRM are (GWP-C 2011):

A. Enabling Environment
   a. Policies
   b. Legislative Framework
   c. Financing and Incentive Structures
B. Institutional Roles
   a. Institutional Framework
   b. Institutional Capacity Building
C. Management Instruments (many of these tools are described in more details in the other factsheets)
   a. Water Resources Assessments
   b. Planning for IWRM
   c. Demand Management
   d. Social Change Instruments
   e. Economic Instruments
   f. Information and Communications

Advantages and disadvantages (Is the technology endorsed by local experts? Is it adequate for local conditions?)	The rationale for IWRM is accepted by all water experts in the Federation and is suitable for local conditions. The main advantage of IWRM is that it is a wholistic paradigm which allows for an integrative, participatory approach to water management. A recent review of IWRM in the Caribbean found that there were deficiencies in the enabling environment such as bureaucratic processes that stymie effective policy development for an IWRM framework, overlap of responsibilities, resulting in duplication of effort and inefficient use of limited financial resources, inadequate legal and regulatory frameworks for managing the resources; the absence of a credible policy framework for involving civil society in the management process and engendering a proper understanding and awareness of the principles of IWRM or institutional arrangements for IWRM are weak/non-existent; limited stakeholder participation in IWRM processes including the participation of women, limited public awareness and education, lack of political will, the need for gender mainstreaming; poor land use planning, limited data collection and data sharing, limited monitoring and assessment, national investment policies and programmes do not reflect the inter-relationships between quality and quantity (GWP-C 2021).
Costs	
Cost to Implement Adaptation Technology Additional cost to implement adaptation option compared to "business as usual"	It is difficult to find documented costs for implementation of IWRM as it is very much a management process / paradigm with many components. The overall costs could be significant depending on the operational tools needed to effectively implement IWRM. In the Water Utility Adaptation Plan of 2021 (HR Wallingford 2021), the indicative costs for the preparation and upgrade of master plans for both islands were estimated at 800,000 USD. A lot of effort is involved in coordinating the IWRM process which requires dedicated staff and funding.
Development Impacts - Direct and Indirect Benefits	
Reduction of vulnerability to climate change	Through management of the resource at the most adequate level, the organization of participation in management practices and policy development, and assuring that the most vulnerable groups are considered, IWRM instruments directly assist communities to cope with climate variability (UNDP Cap-Net 2009).
Economic benefits (including employment, investment, public and private expenditures) Social benefits (including income, education, health)	IWRM is a flexible participatory approach which can improve feedback to all stakeholders and thus enhance water conservation and management. Other socio-economic benefits include reduced use of water restrictions and equity of water supply. This technology also provides the information required to influence long-term water policy and vision, and thereby support the sustainable supply of water resources for future generations.

Environmental Benefits (Indirect)	Ecosystems can benefit from applying an integrated approach to water management by giving environmental needs a voice in the water allocation debate. IWRM can assist the sector by raising awareness among other users of the needs of ecosystems and the benefits these generate for them. Often these are undervalued and not incorporated into planning and decision-making (Elliott et al. 2011).
Gender aspects	There are three basic linkages between gender and IWRM issues (UNDP Cap-Net 2009): 1. Gender and environmental sustainability linkages • Women and men affect environmental sustainability in different proportions and by different means, as they have different access, control and interests. • Flood and drought events weigh heaviest on women because they lack the means to cope with disasters. 2. Gender and economic efficiency linkages • Technology choice affects affordability. Consulting female and male users may result in a more acceptable, user-friendly and sustainable service. (Water supply) 3. Gender and social equity linkages • Women rarely have equal access to water for productive use an are the first to be affected in times of water shortage. (Agriculture) • Women and children are the most susceptible to waterborne disease due to their roles in water collection, clothes washing and other domestic activities (Sanitation)
Local Context	
Opportunities and Barriers	The main opportunity is the collaborative and participatory management of water resources. The main barrier is the time required to coordinate the effort over the long-term.
Market Potential	N/A
Status	Not practiced effectively
Timeframe for implementation	Medium to long term
Acceptability to local stakeholders	Acceptable
References Elliott, R. et al (2011) Technologies for Climate Change Adaptation – Water. TNA Guidebook, April 2011. Global Water Partnership Caribbean (2011) About IWRM. Accessed online on February 21, **2022 at https://www.gwp.org/en/GWP-Caribbean/WE-ACT/About-IWRM/.** Global Water Partnership Caribbean (2021) Draft Conceptual Integrated Water Resources Management (IWRM) Framework for the CARICOM Region. September 2021.	

HR Wallingford (2021) Vulnerability Assessment and Water Utility Adaptation Plans. St. Kitts and Nevis – Water Sector Adaptation Plan. Caribbean Community Climate Change Centre / EU GCCA+ Enhancing Climate Resilience in CARIFORUM Countries Programme. August 2021.

UNDP Cap-Net (2009) IWRM as a Tool for Adaptation to Climate Change. Training Manual. Accessed on February 21, 2022 at https://www.gwp.org/globalassets/global/toolbox/references/iwrm-as-a-tool-for-adaptation-to-climate-change-cap-netundp-2009.pdf

Technology: Enhanced potable water storage	
Introduction	Vessels or tanks for storing potable water are critical to the efficient operation of any water distribution system. Storage tanks serve two major purposes. One is to provide storage volume and the other is to provide pressure to the distribution system. A particular tank can serve one or both purposes depending on its location within the system and its type of configuration. It is best practice to have at least three days of water supply in storage to provide security thus reducing the impacts of outages due to drought or extreme weather events or any other type of emergency.
Technology Characteristics/Highlights	Ground storage tanks can be installed either below or above ground. They are fabricated of concrete or steel. In St. Kitts, reinforced concrete storage tanks are common. In more recent time, in Nevis, glass-fused to steel tanks have been installed. They generally have the function of providing large volumes of storage for peak-day demand when the capacity of the source of supply is less than the maximum daily volume the specific system may need. It is usually necessary to pump water from a ground storage tank to an elevated storage tank to provide uniform pressure to a distribution system. Ground storage tanks can provide system pressure if they are located on hills within or near the distribution system area which is generally the case in St. Kitts and Nevis. Such situations are ideal since ground storage tanks are usually less expensive to construct than elevated storage tanks.
Institutional and Organizational Requirements	
Scale of the application / Size of beneficiary group	Islandwide
Operation and Maintenance	Dedicated technical staff are required to routinely inspect and maintain storage tanks. This includes inspection of tank integrity and cleaning of the tank periodically.
Advantages and disadvantages (Is the technology endorsed by local experts? Is it adequate for local conditions?)	This technology is commonplace in the Federation and widely accepted. The main advantage of enhanced water storage is increased reliability of the water supply and reduced impacts from service disruptions or emergencies. There are no major disadvantages. It is important to select the right construction material for the local conditions.
Costs	
Cost to Implement Adaptation Technology Additional cost to implement adaptation option compared to "business as usual"	The Water Utility Adaptation Plan (HR Wallingford 2021) estimated the cost of increasing potable water storage on both islands –

<table>
<tr><td></td><td>
<table>
<tr><td>St Kitts – CRW4 – Increasing treated water storage volume. Activities will include increasing water supply system storage to allow three days' supply across the island (increasing current island-wide storage from 7 million Gallons to the target of 13 million Gallons), and upgrading fibreglass tanks at high risk of failure
• Construction of additional storage reservoirs to increase treated water storage volume from 7 to 13 million Gallons across all supply systems, providing additional resilience to planned and unplanned outages
• Replacement of two vulnerable and deteriorating fibreglass tanks (half million gallon capacity each) with appropriately resilient new tanks. Proposal to be prepared for submission to the PSIP.
• Install resilient water tanks at government facilities and emergency shelters.</td><td>USD 15,000,000 (approximate cost)</td><td>5 years</td></tr>
<tr><td>Nevis – CRW4 – Additional water storage. – Activities will include
• Conduct detailed design studies and construct additional storage reservoirs to provide three days' supply for present day demand.</td><td>USD 6,000,000 (approximate)</td><td>3 years</td></tr>
</table>
Also in 2020, eighteen (18) educational institutions were equipped with emergency onsite water storage tanks and delivery systems with a total storage capacity of eighty-two thousand, four hundred (82,400) gallons of water. This project was funded by USAID for approximately 200,000 USD.</td></tr>
<tr><td colspan="2">Development Impacts - Direct and Indirect Benefits</td></tr>
<tr><td>Reduction of vulnerability to climate change</td><td>Enhancing potable water storage allows for more resilience during droughts or extreme weather events.</td></tr>
<tr><td>Economic benefits (including employment, investment, public and private expenditures)</td><td>The economic benefits of a more resilient water supply include the avoided losses associated with supply interruptions to all sectors and increasing the continuity of operation of water dependent economic activities during drought events (HR Wallingford 2021).</td></tr>
<tr><td>Social benefits (including income, education, health)</td><td>Increased water storage especially in the dry season for households and small farms which use public supplies for hygiene, watering and irrigation will lead to improve food security, health and livelihoods.</td></tr>
<tr><td>Environmental Benefits (Indirect)</td><td>The main environmental benefit is related to water use efficiency and the preservation of water resources.</td></tr>
<tr><td>Gender aspects</td><td>Reduced rationing and interruptions reduce disruption to households in accessing and using water for basic needs, often impacting women disproportionately.</td></tr>
<tr><td colspan="2">Local Context</td></tr>
<tr><td>Opportunities and Barriers</td><td>Long term sustainability will depend on the ability of the water utilities in St. Kitts and Nevis to plan strategically for security of water supplies during drought periods. This will require sustainable financing and a high level of political support and awareness of the levels of service benefits which investment will bring (HR Wallingford 2021).</td></tr>
<tr><td>Market Potential</td><td>Good</td></tr>
<tr><td>Status</td><td>Practiced</td></tr>
<tr><td>Timeframe for implementation</td><td>Medium term</td></tr>
</table>

Acceptability to local stakeholders	Acceptable

References

Elliott, R. et al (2011) Technologies for Climate Change Adaptation – Water. TNA Guidebook, April 2011.

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Technology: Stormwater harvesting (small reservoirs and micro-catchments)	
Introduction	Stormwater harvesting is the collection, accumulation, treatment, and storage of stormwater for its eventual reuse. While rainwater harvesting collects precipitation primarily from rooftops, stormwater harvesting deals with collection of runoff from creeks, gullies, ephemeral streams, and other ground conveyances. It can also include catchment areas from developed surfaces, such as roads or parking lots, or other urban environments such as parks, gardens and playing fields.
Technology Characteristics/Highlights	This factsheet covers collection, storage and use of rainfall that lands on the ground (runoff). The two broad categories are (Elliot et al. 2011): • Collecting rainfall from ground surfaces utilizing “micro-catchments” to divert or slow runoff so that it can be stored before it can evaporate or enter watercourses; and • Collecting flows from a river, stream or other natural watercourse such as ghaut (sometimes called floodwater harvesting). This technique often includes an earthen or other structure to dam the watercourse and form “small reservoirs.” There are many different best management practices (BMPs) for stormwater collection, storage, treatment, and reuse. Some of these BMPs include traditional pond /pipe typically designed to attenuate flooding and for infiltration (and irrigation but to a lesser extent in the Caribbean) or multi-purpose basins / ponds / wetlands which provide more than storage and often include a sediment forebay to prevent clogging and a grass filter to help remove pollutants. More recently, focus has shifted to Low Impact Development (LID) practices (sometimes called green infrastructure) which reduce runoff using smaller, distributed BMPs such as rain gardens, linear bioretention, cisterns, green roofs and permeable pavements (Horsley Witten et al. 2014). This type of approach to stormwater management is not widely practiced in the Federation of St. Kitts and Nevis. There are examples of retaining walls / weirs constructed inside of ghauts (natural drainage channels) to retain soil runoff that can negatively impact the nearshore environment (i.e. inside the College Street Ghaut in St. Kitts). This has been effective in the past but needs regular maintenance for long-term sustainability. There are also small-scale stormwater retention ponds utilized for irrigation in Nevis. Nevis has a more clayey soil structure, and this impermeable layer makes it easier to design ponds for retention versus infiltration. These have been less effective in St. Kitts due to the need for liners to avoid infiltration, high evaporation rates and design flaws. This factsheet will focus on the use of stormwater catchment to supplement water supply to the agricultural sector and not so much for aquifer recharge.
Institutional and Organizational Requirements	
Scale of the application / Size of beneficiary group	Islandwide

<table>
<tr><td>Operation and Maintenance</td><td>Maintenance is required for the cleaning of the BMPs and inspection of the gutters, pipes and taps and typically consists of the removal of sediments, leaves and other accumulated materials. Such cleaning should take place annually before the start of the major rainfall season with regular inspections.</td></tr>
<tr><td>Advantages and disadvantages
(Is the technology endorsed by local experts? Is it adequate for local conditions?)</td><td>Some of the advantages of stormwater harvesting are reduced risk of flooding, aquifer recharge, channel protection and better water quality for receiving bodies of water.

Major concerns for stormwater harvesting projects include cost effectiveness as well as quality, quantity, and reliability of the reclamation, as well as existing water management infrastructure and soil characteristics. Many different factors need to be considered to design an effective solution including an in-depth analysis of rainfall, soils, slope and land use in the catchment area being considered.</td></tr>
<tr><td colspan="2">Costs</td></tr>
<tr><td>Cost to Implement Adaptation Technology

Additional cost to implement adaptation option compared to "business as usual"</td><td>The Water Utility Adaptation Plan (HR Wallingford 2021) estimated the feasibility and design cost of securing alternative water sources for agriculture on both islands –
<table>
<tr><td>St Kitts – CRW3 – Feasibility and development of alternative water sources for agricultural use. – Activities will include surveys and feasibility studies with the aim of securing affordable and reliable water for agricultural development:
• Survey of water use for agriculture to quantify the extent and distribution of agricultural water demand from the potable supply system, including an inventory of major water users
• Feasibility study for securing affordable and reliable water supplies for agricultural development. This would include feasibility and design for irrigation schemes using redundant surface water sources (as WSD moves increasingly towards groundwater), taking into consideration lessons learned from previous projects (for e.g. avoiding excessive evaporation and damage to new equipment).
• Continued promotion of small scale RWH systems for farmers to reduce pressure on potable water supplies. This could include education on water management for farmers, promotion of RWH and subsidies for purchase of RWH and efficient irrigation systems.
• Investigation of the feasibility of utilising check dams in ghauts for managed aquifer recharge and irrigation use, and small scale RWH ponds for agriculture.</td><td>USD 200,000for feasibility studies and design</td><td>2 years</td></tr>
<tr><td>Nevis – CRW3 – Scoping study for alternative water sources for agricultural use. – Activities will include
• Scoping study on the feasibility of utilising existing spring sources for supplementary irrigation to support food security, livelihood opportunities and economic development</td><td>USD 40,000</td><td>1 year</td></tr>
</table></td></tr>
<tr><td colspan="2">Development Impacts - Direct and Indirect Benefits</td></tr>
<tr><td>Reduction of vulnerability to climate change</td><td>Collection and storage of stormwater can provide a convenient and reliable water supply during seasonal dry periods and droughts. Additionally, widespread stormwater storage capacity can greatly reduce land erosion. Stormwater collection and infiltration can also contribute greatly to the stabilization of declining groundwater tables (Elliott et al. 2011).</td></tr>
</table>

Economic benefits (including employment, investment, public and private expenditures) Social benefits (including income, education, health)	Lack of adequate water supply during drought and seasonal dry periods can halt economic development and hinder human health and well-being. Access to a convenient supply of stored stormwater can decrease the domestic water demand, increase agricultural productivity, and reduce depletion of groundwater resources. Increasing the availability of irrigation water during the dry season and even during short dry spells can yield increases in agricultural production and associated livelihoods (Elliott et al. 2011).
Environmental Benefits (Indirect)	The main benefits to the environment are reduced soil erosion and enhanced water quality in receiving water bodies for aquatic life such as coral reefs.
Gender aspects	The incremental increase in supply especially for agriculture will promote equity in distribution and facilitate wider access to existing and potential users especially vulnerable persons.
Local Context	
Opportunities and Barriers	The main opportunity related to stormwater harvesting is related to finding an alternative supply for agriculture especially as domestic and commercial water demand increase and taking advantage of surface runoff which generally is not effectively captured. A detailed feasibility assessment looking at all factors especially soils, rainfall variability, land space and topography, access / location / proximity to agricultural areas is critical.
Market Potential	Good
Status	Practiced
Timeframe for implementation	Medium to long term
Acceptability to local stakeholders	Acceptable
References	

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Annex III: Technology Factsheets for Short Listed Technologies – Agriculture Sector

Technology: Integrated Pest Management	
Introduction	Integrated Pest Management (IPM) is an ecosystem-based strategy that focuses on long-term prevention of pests or their damage through a combination of techniques such as biological control, habitat manipulation, modification of cultural practices, and use of resistant varieties. Pesticides are used only after monitoring indicates they are needed according to established guidelines, and treatments are made with the goal of removing only the target organism. Pest control materials are selected and applied in a manner that minimizes risks to human health, beneficial and nontarget organisms, and the environment.
Technology Characteristics/Highlights	The key components of an IPM approach are (Clements et al, 2011): **Crop Management:** Selecting appropriate crops for local climate and soil conditions including - • Selection of pest-resistant well adapted cultivars • Use of legume-based crop rotations to increase soil nitrate availability thereby improving soil fertility and favourable conditions for robust plants that better face pests and diseases • Use of cover crops • Integration of intercropping and agro-forestry systems • Use of crop spacing, intercropping and pruning to create conditions unfavourable to the pests **Soil Management:** maintaining soil nutrition and pH levels to provide the best possible chemical, physical, and biological soil habitat for crops. • Building a healthy soil structure • Using longer crop rotations to enhance soil microbial populations and break disease, insect and weed cycles • Applying organic manures to help maintain balanced pH and nutrient levels • Reducing soil disturbance (tillage) – undisturbed soil with sufficient supply of organic matter provides a good habitat for soil fauna • Keeping soil covered with crop residue or living plants. **Pest Management:** using beneficial organisms that behave as parasitoids and predators. • Releasing beneficial insects and providing them with a suitable habitat • Managing plant density and structure to deter diseases • Cultivating for weed control based on knowledge of the critical competition period • Managing field boundaries and in-field habitats to attract beneficial insects, and trap or confuse insect pests.

Institutional and Organizational Requirements	
Scale of the application / Size of beneficiary group	All farmers are potential beneficiaries as IPM can be applied to all crop types.
Operation and Maintenance	For successful implementation of IPM, collaborative action is required involving farmers, extension services, research organizations (such as CARDI and IICA) and the government. As such, the operation and maintenance aspect of IPM are of utmost importance and required well-trained farmers and extension officers. Monitoring entails keeping track of pest population and field conditions and continuous pest risk analyses.
Advantages and disadvantages (Is the technology endorsed by local experts? Is it adequate for local conditions?)	The IPM approach has been applied in the Caribbean with success and is adequate for local conditions. With the IPM approach, farmers can avoid the costs of pesticides as well as the fuel, equipment and labour used to apply them. A sweet potato IPM program, developed under IPM CRSP (Collaborative Research Support Program) and tested in Jamaica, demonstrated a 2-3-fold reduction in pest damage (Jackson et al. 2002). CARDI 2018 assisted farmers in St. Vincent and the Grenadines by establishing a demonstration plot in an affected area, to show by comparison the effectiveness of IPM towards reducing damage caused by the Sweet Potato weevil. A combination of cultural, mechanical and chemical tactics was found to be very effective in controlling the beetle. Similar work was also done in St. Kitts and Nevis (CARDI 2010). IPM is not easy to implement and requires substantial knowledge, time and monitoring for the combined components of the system to produce success (Clements et al 2011). Pests, diseases and weeds continue to evolve and move making the IPM challenge ever changing.
Costs	
Cost to Implement Adaptation Technology Additional cost to implement adaptation option compared to "business as usual"	The cost varies according to the scale of implementation. A major component of the total cost is the training for farmers and extension officers. Additional costs include the costs of traps, pheromones, selective pesticides, pest resistant / tolerant varieties. However, research has shown that the cost of these could outweighed by the savings from reduced pesticides use.
Development Impacts - Direct and Indirect Benefits	
Reduction of vulnerability to climate change	IPM contributes to climate change adaptation by providing a healthy and balanced ecosystem in which the vulnerability of plants to pests and diseases is decreased. By promoting a diversified farming system, the practice of EPM builds farmers' resilience to potential risks posed by climate change, such as damage to crop yields caused by newly emerging pests and diseases (Clements et al 2011).

Economic benefits (including employment, investment, public and private expenditures)	Reduction in pesticide and labour costs. Depending on the crop, one review study of IPM programs in Asia and Africa found that at least 50% of pesticide use is not needed in most agroecosystems (Pretty and Bharucha 2015)
Social benefits (including income, education, health)	IPM is known to reduce the cost of production, thus increasing the income of farmers. There is marked improvement in the safety of the farmer as reduction of pesticide usage provides a major reduction of health hazards to farmers. IPM requires a farmer to improve their overall knowledge base to properly implement IPM as such the educational opportunities for farmers should increase.
Environmental Benefits (Indirect)	Clements et al 2011 note that IPM requires less fossil energy and thus less GHG emissions. IPM fosters an integrated approach to agriculture promoting diverse crop, soil and pest management techniques which preserve agro-biodiversity, maintain beneficial insects, enhanced soil fertility and decreased pollution from pesticides.
Gender aspects	In the Caribbean region, women accounts for 22-30 percent of registered farmers (FAO 2019). Case studies from Sub Saharan Africa and Asia (Kawarazuka et al. 2020) from the field have shown that adopting a gender perspective while conducting agronomic research and extension work has a great potential to provide more efficient approaches to managing pests and diseases and practices by women and men farmers according to their roles, knowledge, and capacities.
Local Context	
Opportunities and Barriers	IPM is an opportunity for collaboration between farmers, extension officers, research institutes and others and to promote more environmentally friendly agricultural practices. The major barrier for widespread implementation of IPM is funding, expert knowledge and organization and coordination amongst all of the key stakeholders.
Market Potential	Locally, there is a slowly growing demand for produce that is organic especially as the adverse impacts of pesticides on human and environmental health are becoming more mainstream. There is no doubt that farmer adopting IPM are likely to produce better quality crops.
Status	St. Kitts and Nevis is a participating country in a GEF-FAO project termed "Caribbean Pesticides Management Project" which includes an aspect of development of guidelines for IPM in the Caribbean. CARDI and IIAC have also researched IPM over the years in SKN.
Timeframe for implementation	Medium to Long Term

Acceptability to local stakeholders	The long-standing myth that higher yields = generous spraying of pesticides is still widely held. Also, it is known that IPM takes a lot more time to implement and requires active monitoring and corrective action by the farmers.

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Technology: Crop Diversification and New Varieties	
Introduction	Crop diversification means growing more than one crop in an area. Diversification can be accomplished by adding a new crop species or different variety, or by changing the cropping system currently in use. According to Clements et al (2011), the introduction of new cultivated species and improved varieties of crop is a technology aimed at enhancing plant productivity, quality, health and nutritional value and/or building crop resilience to diseases, pest organisms and environmental stresses such as water and heat stress and water salinity. Current strategies in the Caribbean include conservation of existing local varieties (both landraces and crop wild relatives), breeding new varieties and making them available to farmers, and exchanges of plant genetic resources with other regions whose current climate closely resembles the conditions we expect in the future (CARDI 2013).
Technology Characteristics/Highlights	New and improved crop species can be introduced though two different processes (Clements et al. 2011): 1. Farmer experimentation with new varieties, and 2. The introduction of new crop species to diversify the crop production systems. In a comprehensive review of crop diversification methods worldwide, Hufnagel et al. (2020) define crop diversification as 'a process that makes a simplified cropping systems more diverse in time and space by adding additional crops'. Crop diversification can lead to greater genetic and/or structural diversity in time and/or space. Common examples for crop diversification are crop rotations, double cropping or intercropping, bee crops, nurse crops or variety mixtures.
Institutional and Organizational Requirements	
Scale of the application / Size of beneficiary group	All farmers are potential beneficiaries as crop diversification can be applied to most farms.
Operation and Maintenance	For successful implementation of crop diversification, collaborative action is required involving farmers, extension services, research organizations (such as CARDI and IICA) and the government. Plant breeding requires specialized know-how and investment. As such, the operation and maintenance aspect of crop diversification are of utmost importance and required well-trained farmers and extension officers. Monitoring entails keeping track of crop yields and field conditions to ensure the new varieties have adapted. Also, it can take a time for a new variety to be taken up by farmers and subsequently properly introduced to market (Clements et al. 2011)
Advantages and disadvantages	This technology is endorsed by local experts and has been practiced in the Federation with some success.

(Is the technology endorsed by local experts? Is it adequate for local conditions?)	The main advantages of the introduction of adapted and accepted varieties to strengthen farmers' cropping systems are increased yields, improved drought resilience, enhanced resistance to pests and diseases and new market opportunities. The main disadvantages can be time and financial outlays to conduct the research required to introduce new varieties. Preliminary feasibility studies and market research are necessary for success, and this may be out of reach to a small farmer.
Costs	
Cost to Implement Adaptation Technology Additional cost to implement adaptation option compared to "business as usual"	Costs of farmer experimentation are generally low, but results may only have local applicability. Capital investment will relate to the purchase of new seed varieties and labor time. Where farmers are implementing a project initiated by an external agency, capital costs for training, technical experts, field staff and on farm trial equipment should be considered (Clements et al. 2011).
Development Impacts - Direct and Indirect Benefits	
Reduction of vulnerability to climate change	Crop diversification is effective climate change adaptation technology because it protects natural biodiversity, strengthens the ability of the agroecosystem to respond to environmental stresses, minimizes environmental pollution, reduces the risk of total crop failure and incidence of pests and diseases and improves food security (Lakharan et al. 2017).
Economic benefits (including employment, investment, public and private expenditures)	As noted above, the economic benefits stem mostly from introduction of new varieties into the market (both locally and for export) and thus increased income generation for farmers.
Social benefits (including income, education, health)	Crop diversification is also a cost-effective way of reducing uncertainties in farmer's income and increase in employment opportunities (Feliciano 2019). As a result, this allows for poverty alleviation and associated social benefits.
Environmental Benefits (Indirect)	Feliciano (2019) lists some of the environmental benefits of crop diversification include: • Avoids soil exploitation and reduces soil erosion; • Provides habitat; • Greater nutrient uptake and cycling that sustains production on existing plots; • Maintaining biodiverse vegetation cover that provides environmental services; and, • Avoiding the need for forest clearing and the consequent environmental impacts.
Gender aspects	Diversification empowers women farmers and allows for more employment opportunities (Joshi et al. 2004).
Local Context	
Opportunities and Barriers	A comprehensive review by Feliciano (2019) found that six main factors were found to influence the implementation of crop

	diversification, namely, access to roads and markets, access to irrigation, land size, land and water rights, chronic poverty, and policy interventions.
Market Potential	Market potential would have to be properly assessed but it seems there is a demand for newer varieties especially in the tourism sector and for export.
Status	Not widely practiced
Timeframe for implementation	Medium to long term
Acceptability to local stakeholders	Acceptable to local stakeholders

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Technology: Plant tissue culture	
Introduction	Plant tissue culture is the cultivation of plant cells, tissues, or organs on specially formulated nutrient media. Tissue culture is seen as an important technology to produce disease-free, high quality planting material and the rapid production of many uniform plants which facilitates distribution and large-scale planting (ISAAA 2004).
Technology Characteristics/Highlights	Hussain et al. (2012) describe the basics of plant tissue culture as plant tissues and organs are grown in vitro on artificial media, under aseptic and controlled environment. Plant tissue culture medium contains all the nutrients required for the normal growth and development of plants. It is mainly composed of macronutrients, micronutrients, vitamins, other organic components, plant growth regulators, carbon source and some gelling agents in case of solid medium.
Institutional and Organizational Requirements	
Scale of the application / Size of beneficiary group	Islandwide
Operation and Maintenance	This technology requires a sterile workplace, nursery, and green house, and trained manpower. There are a few examples of plant tissue laboratories in the Caribbean (Taiwan ICDF 2013, Barbados 2022). The Taiwan International Cooperation and Development Fund supported establishment of a lab in St. Lucia in 2011-2013. The government of Barbados also has a plant tissue culture laboratory aiming to facilitate the national food security programme by micro-propagation of root and other food crops. This lab also works on ornamental plants. There is also a lab in Jamaica.
Advantages and disadvantages (Is the technology endorsed by local experts? Is it adequate for local conditions?)	The main advantage of tissue culture technology lies in the production of high quality and uniform planting material that can be multiplied on a year-round basis under disease-free conditions anywhere irrespective of the season and weather. Tissue culture is labor and energy intensive, time consuming, and costly. This technology is not currently utilized in the Federation of St. Kitts and Nevis. It could be adequate for local conditions but would require significant capital outlay and training.
Costs	
Cost to Implement Adaptation Technology Additional cost to implement adaptation option compared to "business as usual"	High. There is a need to set up a dedicated laboratory with specialized rooms/ area. Aseptic technique is required as well. Equipment for lab set up are commercially available. No indicative costs could be found online.

Development Impacts - Direct and Indirect Benefits	
Reduction of vulnerability to climate change	Clements et al. (2011) highlight that plant tissue culture can confer tolerance to drought and salt to crops rapidly as compared to conventional breeding techniques which clearly reduces vulnerability to climate change. They provide examples of research performed on rice and corn in India, Brazil and China. Ko, Kong and McDonald (2008) document successful micropropagation of white dasheen in St. Vincent and the Grenadines, an important crop in the Caribbean.
Economic benefits (including employment, investment, public and private expenditures)	By producing plantlets locally, the cost of importation of important varieties can be greatly reduced. Also important local varieties can be better preserved. There are also opportunities to be able to run a plant culture lab as a commercial venture. A plant tissue laboratory will create employment opportunities as well.
Social benefits (including income, education, health)	Preservation of important varieties as well as being able to propagate plants with tolerance to drought or salt can increase food security. In addition, a cadre of well-trained technicians is required and thus can provide educational opportunities and associate income benefits.
Environmental Benefits (Indirect)	Plant tissue culture is an important agricultural biotechnological tool that contributes in the production of crops with improved and more efficient food, fiber, fuel, and feed. In addition, plant tissue culture enables some rare and nearly extinct plant species to be rescued and propagated.
Gender aspects	In the Caribbean region, women accounts for 22-30 percent of registered farmers (FAO 2019). There is no doubt that adopting a gender perspective coupled with a participatory approach while conducting agronomic research and extension work has a great potential to provide more efficient approaches to agricultural diversification including plant tissue culture.
Local Context	
Opportunities and Barriers	Plant tissue culture provides an opportunity for a small island Federation like St. Kitts and Nevis to be better placed to control and propagate important local varieties and experiment with newer varieties that are more tolerant to environmental stresses. There is a successful example of set up of plant tissue culture lab in the Eastern Caribbean in St. Lucia over a two-year period with funding from an external donor. The main barriers are the need for specialized equipment, space, trained staff and quality assurance and control.

Market Potential	Market potential would have to be properly assessed but it seems there is a demand for plantlets especially for newer varieties or for crops that are heavily imported.
Status	No plant tissue culture laboratory in the Federation.
Timeframe for implementation	Medium term A plant tissue laboratory was implemented in St. Lucia with funding from the Taiwan International Cooperation and Development Fund in 2011. The lab was up and running in two years (Taiwan ICDF 2013)
Acceptability to local stakeholders	Acceptable

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<table>
<tr><th colspan="2">Technology: Livestock disease management including selective livestock breeding</th></tr>
<tr><td>Introduction</td><td>Livestock diseases contribute to an important set of problems within livestock production systems. These include animal welfare, productivity losses, uncertain food security, loss of income and negative impacts on human health. Livestock disease management can reduce disease through improved animal husbandry practices. These include controlled breeding, controlling entry to farm lots, and quarantining sick animals and through developing and improving antibiotics, vaccines and diagnostic tools, evaluation of ethnotherapeutic options, and vector control techniques (Clements et al. 2011).

Genetic make-up influences fitness and adaptation and determines an animal's tolerance to shocks such as temperature extremes, drought, flooding, pests and diseases. Adaptation to harsh environments includes heat tolerance and an animal's ability to survive, grow and reproduce in the presence of poor seasonal nutrition as well as parasites and diseases. Selective breeding is a technology that aims to improve the value of animal genetic diversity (Clements et al. 2011)</td></tr>
<tr><td>Technology Characteristics/Highlights</td><td>The two fundamental components of animal disease emergency preparedness planning are the development of capabilities for:
early warning, and
early reaction to disease epidemics and other animal health emergencies.
These require advance preparation of both generic and disease-specific written contingency plans and operating procedures, the testing of such plans and training of staff; the development of capabilities at national, provincial and local veterinary headquarters, including field and laboratory services; development of mechanisms to involve other necessary government and private sector services and farming communities in the emergency response; development of the capacity to apply all the necessary resources to counter the disease or other animal health emergency in the most efficient way (including equipment, personnel and finances); and, finally, advance establishment of the appropriate legal and administrative structures to deal with an emergency (Geering et al. 1999).

As it related to selective breeding, there are three main approaches:
Outcrossing: Mating two animals that are unrelated for at least 4 to 6 generations back is called an outcross.
Linebreeding: Mating related animals like half-brother/half-sister, cousins, aunt/nephew, and other more distant relationships.
Inbreeding: Mating directly related animals, like mother/son, father/daughter, and full brother/full sister (full siblings).</td></tr>
</table>

	This type of management is ongoing in St. Kitts and Nevis. According to the 2020 Director's Report (DOA SK, 2020), the prevalent livestock disease in the Federation is Dermatophilosis which is transmitted by the Tropical Bont Tick (which was introduced in the 1980s). Since then, the established programme of disease surveillance has been successful with no other new introduction of exotic livestock disease in the Federation.
Institutional and Organizational Requirements	
Scale of the application / Size of beneficiary group	Islandwide
Operation and Maintenance	The basic principles of any livestock disease management program, which dictate operations and maintenance requirements on the farm, are (Berry 2017): 1. Select a well-known, reliable source from which to purchase animals, one that can supply healthy stock, inherently vigorous and developed for a specific purpose. 2. Keep animals separate according to source and age groups. To mix animals is an invitation to trouble. 3. Follow an "all-in, all-out" program. 4. Select a reliable commercial feed, or if farm mixing is done, mix carefully according to a dependable formula. 5. Provide an adequate supply of wholesome water. Avoid watering from surface tanks, streams, or ponds. 6. Carry out a precise vaccination schedule for each herd or flock. Work out the vaccination program with disease authorities in each state or local area. 7. Discourage persons other than the caretaker or essential personnel from visiting the barns and lots. This would include vehicular traffic. 8. Observe animals frequently for signs of disease, and if a disease problem develops, obtain an early, reliable diagnosis and apply the best treatment, control, and eradication measures for that specific disease. 9. Dispose of all dead animals by burning, deep burying, or disposal pit. This phase of management often is overlooked. 10. Maintain good records relative to flock or herd health. These should include vaccination history, disease problems and medication.
Advantages and disadvantages (Is the technology endorsed by local experts? Is it adequate for local conditions?)	Yes, livestock disease management is practiced in the Federation with success. It is adequate for local conditions. According to Clements et al. (2011), the benefits of livestock disease prevention and control include: higher production (as morbidity is lowered and mortality or early culling is reduced), and avoided future control costs. When farmers mitigate disease through prevention or control, they benefit not just themselves but any others at risk of adverse outcomes from the presence of disease on that operation. The main disadvantages is that disease management options may interact, so the use of one option may diminish the effectiveness of another. Another critical issue is the long-term sustainability of currently used strategies.

	In the 2020 Annual Director's Report for the DOA SK, details about a goat breeding programme are given. The specific advantages of selective breeding through controlled mating include low input and maintenance costs once the strategy is established, and permanence and consistency of effect. In addition, controlled mating can preserve local and rare breeds that could be lost as a result of climate change-related disease epidemics. One of the main limitations of this technology is that selective breeding of certain genes can run the risk of reducing or removing other genes from the overall pool, a process which is irreversible. This can create new weaknesses amongst animals, particularly with the emergence of a new pest or disease. Also, this process is time consuming.
Costs	
Cost to Implement Adaptation Technology Additional cost to implement adaptation option compared to "business as usual"	Livestock disease management costs include: testing and screening, veterinary services, vaccines, training of livestock keepers and veterinary staff, and perhaps changes to practices and facilities to reflect movement restrictions and quarantines when animals are added to the herd. Venereo and Hermosillo (2014) speak to importance of livestock producers to be trained to keep records, identify females on heat, identify key traits amongst animals, secure good quality water and feed for their livestock and build infrastructure for controlled mating. As such most of the upfront costs are associated to infrastructure and training of farmers. An example of indicative costs, in 2020, the Department of Agriculture in St. Kitts spent over ECD 200,000 for supplies utilized in their tick control program and saw a decrease in the number of cases of Dermatophilosis from 1289 in 2019 to 821 in 2020.
Development Impacts - Direct and Indirect Benefits	
Reduction of vulnerability to climate change	The major impacts of climate change on livestock diseases have been on diseases that are vector-borne. Increasing temperatures have supported the expansion of vector populations into cooler areas. Changes in rainfall patterns can also influence an expansion of vectors during wetter years and can lead to large outbreaks. Climate changes could also influence disease distribution indirectly through changes in the distribution of livestock. Improving livestock disease control is therefore an effective technology for climate change adaptation (Clements et al. 2011). Key breeding traits associated with climate change resilience and adaptation include thermal tolerance, low quality feed, high kid survival rate, disease resistance, good body condition and animal morphology.

Economic benefits (including employment, investment, public and private expenditures)	Control of livestock diseases can contribute to reduced economic losses via decreased mortality, increased productivity, gain in trade, increased market value, and food security (Barratt et al. 2019)
Social benefits (including income, education, health)	Improved levels of animal health deliver better animal welfare, more efficient livestock production, safer animal -sources foods and thus healthier, improved livelihoods.
Environmental Benefits (Indirect)	The beneficiaries might also include at-risk wildlife populations surrounding the area that may have direct or indirect contact with livestock or livestock-related material (Clements et al. 2011). Controlled mating makes it easier for unproductive animals to be identified and culled. It is a useful tool to maximise production while matching grazing pressure to carrying capacity which leads to healthier and more productive pastures, better ground cover, reduced sediment loss and better water quality (DAF, 2019)
Gender aspects	In the Caribbean region, women accounts for 22-30 percent of registered farmers (FAO 2019). There is no doubt that adopting a gender perspective coupled with a participatory approach while conducting agronomic research and extension work has a great potential to provide more efficient approaches to agricultural diversification including livestock disease management.
Local Context	
Opportunities and Barriers	A system of livestock disease management already exists in the Federation and could be improved to ensure better knowledge transfer to farmers and to ensure the program can adapt as challenges due to climate change increase.
Market Potential	Good
Status	Good but can be improved
Timeframe for implementation	Short to medium term
Acceptability to local stakeholders	Acceptable

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Technology: Livestock feed production	
Introduction	To reduce poverty, fight hunger and ensure food security, there is a need to increase livestock production in sustainable ways in the Federation of St. Kitts and Nevis. Currently, one main constraint to livestock production systems is feed shortage and associated nutrient deficiency. Livestock feed is mostly composed of forages and grain/oilseed crop product. Production of these items is affected by climate change, as are water supplies, both through irrigation and soil moisture. Commercial feed is imported and subject to fluctuating prices due to the price of oil and climate change impacts.
Technology Characteristics/Highlights	Feed shortage is one of the most frequent problems that the livestock division faces in the Federation. In, October - November 2021, poultry animals died because of feed shortage. This factsheet will focus on the construction of a feed mill and the production of supplemental feed source (fodder). To make production of alternate feed source (fodder) more efficient and effective, it is advised that it is done hydroponically. Feed manufacturing refers to the process of producing animal feed from raw agricultural products. Fodder produced by manufacturing is formulated to meet specific animal nutrition requirements for different species of animals at different life stages. Feed milling is the process of grinding and processing feed ingredients into a form that is suitable for animal consumption. The feed milling process can be divided into five main stages: raw material handling, grinding, mixing, pelleting, and cooling. Feed milling is a critical step in the production of animal feed, as it creates a uniform mixture that is easy for animals to digest. According to the American Feed Industry Association (AFIA 2018), there are four basic steps: 1. Receive raw ingredients: Feed mills receive raw ingredients from suppliers. Upon arrival, the ingredients are weighed, tested and analyzed for various nutrients and to ensure their quality and safety. 2. Create a formula: Nutritionists work side by side with scientists to formulate nutritionally sound and balanced diets for livestock, poultry etc. This is a complex process, as every species has different nutritional requirements. 3. Mix ingredients: Once the formula is determined, the mill mixes the ingredients to create a finished product. 4. Package, label and distribute locally. For times when raw ingredients may be scarce and to ensure resilience of the overall supply of livestock feed, it is proposed that supplemental fodder be grown hydroponically (the factsheet on soilless agriculture highlights all the characteristics of hydroponics).
Institutional and Organizational Requirements	
Scale of the application / Size of beneficiary group	Islandwide

Operation and Maintenance	The main operation and maintenance tasks relate to the equipment requirements for the feed mill, the greenhouse for the hydroponically grown supplemental feed and laboratory testing of the final feed product to ensure food safety and quality control. The equipment required for a feed mill can include grinder, crusher or hammermill, mixer, pelletizer, heat extractors, dust collectors, pallets and more. Each of these require specialized labour to operate and maintain. In addition, there is a need for quality assurance and control and laboratory testing of the feed material to ensure food safety.
Advantages and disadvantages (Is the technology endorsed by local experts? Is it adequate for local conditions?)	Livestock feed production in not currently practiced in the Federation. It is adequate for local conditions. The specific advantage of producing feed locally is the ability to produce feed to meet the specific needs of the animals on the island and in sufficient quantities to meet the local demand. In addition, having a supplemental source of fodder increases the resilience of the feed production system. One of the main limitations of this technology is the reliance on raw materials which are not available locally. In addition, the feed mill generally requires a high upfront capital cost along with the recurrent cost of energy to power the mill.
Costs	
Cost to Implement Adaptation Technology Additional cost to implement adaptation option compared to "business as usual"	Livestock feed production costs include testing and screening of raw materials and final feed product, operation and maintenance of the feed mill and hydroponics fodder production including ongoing energy and raw materials costs and training of feed mill operators and extension officers.
Development Impacts - Direct and Indirect Benefits	
Reduction of vulnerability to climate change	The major impacts of climate change on livestock production systems are feed availability and quality. Improving livestock feed production locally is therefore an effective technology for climate change adaptation (Clements et al. 2011).
Economic benefits (including employment, investment, public and private expenditures)	A reliable, local source of animal feed can contribute to reduced economic losses via decreased mortality, increased productivity, gain in trade, increased market value, and food security (Barratt et al. 2019).
Social benefits (including income, education, health) Environmental Benefits (Indirect)	Improved levels of animal health via reliable feed supply deliver better animal welfare, more efficient livestock production, safer animal -sources foods and thus healthier, improved livelihoods.

Gender aspects	In the Caribbean region, women accounts for 22-30 percent of registered farmers (FAO 2019). There is no doubt that adopting a gender perspective coupled with a participatory approach while conducting agronomic research and extension work has a great potential to provide more efficient approaches to agricultural diversification including livestock feed production.
Local Context	
Opportunities and Barriers	The main opportunity is the start-up of a local feed mill (whether run publicly or privately) which can meet the local demand for feed for various types of livestock. The main barrier is the capital cost of start-up of the mill especially this has never been done locally.
Market Potential	Good
Status	Not currently practiced
Timeframe for implementation	Short to medium term
Acceptability to local stakeholders	Acceptable

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Technology: Agrosilviculture	
Introduction	Agro-forestry is an integrated approach to the production of trees and of non-tree crops or animals on the same piece of land. The crops can be grown together at the same time, in rotation, or in separate plots when materials from one are used to benefit another (Clements et al. 2011).
Technology Characteristics/Highlights	Agro-forestry systems can be categorised into three broad types: agrosilviculture (trees with crops), agrisilvipasture (trees with crops and livestocks) and silvopastoral (trees with pasture and livestock) systems. Some of the most common uses of trees in agro-forestry systems are: • Alley cropping: growing annual crops between rows of trees • Boundary plantings/living fences: trees planted along boundaries or property lines to mark them well • Multi-strata: including home gardens and agroforests that combine multiple species • Scattered farm trees: increasing the number of trees, shrubs or shaded perennial crops (such as coffee and cocoa) scattered among crops or pastures and along farm boundaries. There are many examples of successful agroforestry programs in the Caribbean including cocoa-based agroforestry in St. Lucia (https://www.caribbeanclimate.bz/blog/2017/12/01/the-saint-lucia-agroforestry-project/) and long standing programs in Cuba and the US Virgin Islands (https://www.uvi.edu/research/agricultural-experiment-station/agroforestry/default.aspx). This factsheet will focus on agrosilviculture the planting of tree crops to establish different industry (cocoa, coconut plantation etc.) This technology can be used to preserve some of local fruits /varieties that are endangered or on the verge of extinction (sapodilla, ghaut plum, dog apple, shaddock, manciport, etc.).
Institutional and Organizational Requirements	
Scale of the application / Size of beneficiary group	Islandwide
Operation and Maintenance	To plan for the use of trees in agro-forestry systems, considerable knowledge of their properties is necessary. Desirable information includes the uses: the climatic adaptations of the species, including adaptations to various soils and stresses; the size and form of the canopy as well as the root system; and the suitability for various agro-forestry practices (Clements et al. 2011).
Advantages and disadvantages (Is the technology endorsed by local experts? Is it adequate for local conditions?)	Agro-forestry has a broad application potential and provides a range of advantages, including increased land-use efficiency, enhanced land productivity as the trees provide forage, firewood and other organic materials that are recycled and used as natural fertilisers and increased yields. Agro-forestry systems require substantial management. Incorporating trees and crops into one system can create competition for space, light water and nutrients and can impede the mechanisation of agricultural production.

	Yields of cultivated crops can also be smaller than in alternative production systems, however agro-forestry can reduce the risk of harvest failure.
Costs	
Cost to Implement Adaptation Technology Additional cost to implement adaptation option compared to "business as usual"	Agroforestry is a low-input system which combines trees with crops in various combinations or sequences. It is an alternative to intensive cropping systems, which rely on large inputs of manufactured fertilizers and other external inputs to sustain production. Current et al. (1995) highlight that many agroforestry practices are profitable under a broad range of conditions in the Caribbean. Demonstration plots and the use of technicians have been low-cost and effective means of technology transfer and research to identify the practices best suited to the region. Disincentives to adoption of agroforestry include government regulation of tree harvesting and insecurity of land tenure.
Development Impacts - Direct and Indirect Benefits	
Reduction of vulnerability to climate change	Agro-forestry can improve the resilience of agricultural production to current climate variability as well as long-term climate change through the use of trees for intensification, diversification and buffering of farming systems. Trees have an important role in reducing vulnerability, increasing resilience of farming systems and buffering agricultural production against climate-related risks (Clements et al. 2011).
Economic benefits (including employment, investment, public and private expenditures)	Agro-forestry promotes year-round and long-term production and thus employment creation and enhanced diversity of products and livelihoods. Specific to the Caribbean, products that can be generated from agroforestry include fruits such as citrus, tamarind, custard apple, sugar apple, hog plum, west Indian cherry, guava, guavaberry, soursop, genip, mango, avocado, papaya; cut flowers such as Heliconia, Anthurium, Frangipani; medicinal plants such as marjoram, aloe vera, and spices such as oregano, cilantro, rosemary; raw materials for crafts such as: wood for carving, seeds for jewelry, vetiver grass for baskets, mats, palm fronds for brooms, baskets, sculptures, coconut husks for purses, hummingbird feeders, arts & crafts; forages; syrups and honey; recreation areas, photography and bird watching (USDA-NRCS 2015).
Social benefits (including income, education, health)	Cultural uses of forest products include food, crafts, medicines, tools, furniture and musical instruments.
Environmental Benefits (Indirect)	Agro-forestry systems take advantage of trees for many uses: to hold the soil; to increase fertility through nitrogen fixation, or through bringing minerals from deep in the soil and depositing them by leaf-fall; and to provide shade, construction materials, foods and fuel (Clements et al. 2011). Other advantages of agroforestry are increasing biodiversity, reducing soil erosion and sedimentation, reduced nutrient leaching

	to groundwater and improving soil and water quality and use efficiency (USDA NRCS 2015, FOA/IAEA 2008).
Gender aspects	Adopting a gender perspective coupled with a participatory approach while conducting agronomic research and extension work has a great potential to provide more efficient approaches to agricultural diversification including agroforestry.
Local Context	
Opportunities and Barriers	Benefits of agroforestry outweigh the costs and local farmers can adopt this method of farming. Support programmes would be required to provide capital and knowledge to help farmers adapt to climate change using this technology.
Market Potential	Market potential is high because agroforestry systems are applicable for almost any size of farm. It is particularly suitable for the subsistence farmer who has a greater variety of crops to harvest and market throughout the year.
Status	Practiced
Timeframe for implementation	Medium term
Acceptability to local stakeholders	Acceptable

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Technology: Soilless Agriculture / Aquaponics / Hydroponics	
Introduction	Soilless cultivation generally refers to any method of growing plants without soil as a rooting medium.
Technology Characteristics/Highlights	Soilless production can be done in several ways. Sometimes plants are grown in a substrate (simply meaning the material where the plant roots live) that mimics the physical support and water and nutrient supplying roles of native soil but is not actually soil. These plants are watered, fertilized and managed to optimize growth through management of physical properties of the substrate and providing water and nutrition for the plant (Bumgarner and Hochmuth 2019). There are three types of soilless farming: 1. Hydroponics: plants are grown in a water-based, nutrient-rich solution. 2. Aeroponics: plant roots are suspended in the air and plants grow in a humid environment without soil. 3. Aquaponics: a system that combines hydroponics and aquaculture (the cultivation of aquatic organisms in controlled aquatic environments) within a closed system. This technology has been adopted in the Caribbean with examples in most islands including Barbados and St. Lucia (https://spore.cta.int/en/innovation/all/article/caribbean-soilless-solutions-boost-smart-production-sid035bd1708-3154-4564-b60c-79957f9700b8), Jamaica (https://www.jamaicaobserver.com/news/inmed-caribbean-empowering-women-through-agriculture_224670) and the Federation of St. Kitts and Nevis (https://www.facebook.com/MontravilleFarms/ and https://www.facebook.com/parisleafygreens/).
Institutional and Organizational Requirements	
Scale of the application / Size of beneficiary group	Islandwide
Operation and Maintenance	Soilless agriculture requires a controlled environment (a greenhouse) and specialized equipment and inputs (such as fertilizers and substrate) and a high-quality reliable water supply (Van Os et al. 2008). Specialized equipment include monitoring equipment, fertigation unit, injection pumps, nutrient solution mixing tank, irrigation unit and benches and troughs.
Advantages and disadvantages (Is the technology endorsed by local experts? Is it adequate for local conditions?)	Soilless cultivation is advantageous for year-round agricultural production, especially in areas characterized by severe soil degradation and limited water availability (Paolo et al. 2019). These systems use water efficiently and allow for agriculture in areas where land is expensive, or soils are degraded. It also allows for land use efficiency with less labour. The controlled

	environment is also resilient against environmental stressors such as heat and drought. The main disadvantages include high capital costs, energy intensive and the need for highly trained technicians. Also, the process is not amenable to all types of crops and any introduced soilborne disease can spread quickly. The technology is endorsed by local experts and adequate for local conditions.
Costs	
Cost to Implement Adaptation Technology Additional cost to implement adaptation option compared to "business as usual"	The upfront capital costs are high related to construction of a greenhouse and purchase of specialized equipment and inputs. In addition, although the systems utilize water efficiently, the quality of the water must be tightly controlled.
Development Impacts - Direct and Indirect Benefits	
Reduction of vulnerability to climate change	Since soilless agriculture is a controlled system which is protected by a greenhouse, production is not hindered by to sudden or long-term environmental stressors which makes it resilient in terms of climate change.
Economic benefits (including employment, investment, public and private expenditures)	Soilless cultivation systems can allow for additional employment of highly skilled labour. In addition, the private sector may be more easily involved in this type of endeavour.
Social benefits (including income, education, health)	The introduction of these types of system could expose persons to valuable training and educational opportunities.
Environmental Benefits (Indirect)	These systems utilize water much more efficiently and avoid land degradation from unsustainable farming practices. Also, these systems allow for farming at the urban level, allowing access to high quality produce utilizing much less land space.
Gender aspects	Adopting a gender perspective coupled with a participatory approach while conducting agronomic research and extension work has a great potential to provide more efficient approaches to agricultural diversification including soilless agriculture.
Local Context	
Opportunities and Barriers	Using hydroponic culture in St. Kitts and Nevis will offer different opportunities particularly through addressing production inefficiencies and gaps and improving food security under future climate uncertainty. Barriers are mainly attributed to the absence of agriculture credits and loan facilities, the capital cost, energy requirement, and the lack of specialized expertise in this field.

Market Potential	Medium - High
Status	Practiced in the Federation
Timeframe for implementation	Short to Medium Term
Acceptability to local stakeholders	Acceptable

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Technology: Soil moisture conservation monitoring and techniques	
Introduction	The main objective of soil moisture conservation is to minimize the amount of water lost from the soils through evaporation (water loss directly from the soil) and transpiration (water loss occurring through the plants) – or combined, the evapotranspiration. Preserving soil moisture is important means to maintain the necessary water for agricultural production, and also helps minimize irrigation needs of the crops. This is especially important in areas where rainwater and/or groundwater resources for irrigation are scarce or decreasing due to climate change or other causes (CTCN 2022).
Technology Characteristics/Highlights	Soil moisture conservation measures can be categorized as biological (agroforestry and agricultural) and mechanical measures (terracing, bunding, trenching, check dams, etc.). Generally, most methods used for soil quality improvement and conservation, will also yield benefits to soil moisture conservation. Examples of methods for reducing excess soil moisture loss include following: • Spreading manure or compost over the soil – this minimizes evapotranspiration and also provides valuable nutrients to the soil through processes of decomposition • Mulching – mulch is a layer of organic (or inorganic) material that is placed on the root zone of the plants. Mulching is most suited for low to medium rainfall areas, and less suited for areas with very wet conditions. • Conservation tillage – reducing or eliminating the tillage to maintain healthy soil organic levels which increases the soils capacity to absorb and retain water. • Crop rotation – growing different types of crops every season helps improve soil structure and thus water holding capacity. • Green manuring – growing of plant materials with the sole purpose of adding to the soil for improved organic matter and nutrients. • Deep tillage – suited for some areas and soils, deep tillage can help increase porosity and permeability of the soil to increase its water absorption capacity. • Mixed cropping and interplanting - cultivating a combination of crops with different planting times and different length of growth periods. • Contour ploughing – by ploughing the soil along the contour instead of up- and downward slopes, the velocity of runoff is reduced, creating even barriers, and more water is retained in the soils and distributed more equally across the cropland. • Strip cropping - growing erosion permitting crops and erosion resisting crops in alternate strips. It is important for the effectiveness of these techniques to be evaluated and measured in the field. Such data provide real-time information and the ability to make adjustments to increase soil moisture. Various tools are available to measure soil moisture including tensiometers, electrical resistance blocks, granular matrix sensors and time domain reflectometry (Kujawski 2011).

Institutional and Organizational Requirements	
Scale of the application / Size of beneficiary group	Islandwide
Operation and Maintenance	The operation and maintenance can be relatively easy once farmers are trained in these techniques and use of tools for measuring soil moisture in-situ and have access to any equipment needed to help in land preparation and preparation of mulches.
Advantages and disadvantages (Is the technology endorsed by local experts? Is it adequate for local conditions?)	Soil moisture conservation techniques reduce runoff, soil erosion and to improve soil quality, water quality and overall crop productivity in a sustainable way (Kumawat et al. 2020).
Costs	
Cost to Implement Adaptation Technology Additional cost to implement adaptation option compared to "business as usual"	Most of these soil moisture conservation techniques are relatively low cost and low complexity approaches, primarily relying on the presence of required materials and technical capacity locally. Most of the upfront cost would be for procurement of equipment such as shredders and cutters, soil moisture monitoring probes and training all of the farmers.
Development Impacts - Direct and Indirect Benefits	
Reduction of vulnerability to climate change	This technology facilitates adaptation to climate change by optimizing water use and enhancing soil quality. This is particularly relevant in areas that depend on seasonal rainfall for production and where there is uncertainty about future rainfall patterns.
Economic benefits (including employment, investment, public and private expenditures) Social benefits (including income, education, health)	Improved soil moisture goes hand in hand with improved soil quality and reduced irrigation needs thus potentially improving harvest and income / employment generated by the activity. Opportunities for using existing waste materials may considerably reduce costs and needs for waste handling. As such, application of these techniques may create new income and synergies between different crop variety farmers.
Environmental Benefits (Indirect)	The benefits of many soil conservation methods, depending on the material used, may also include better control of weeds, provision of additional nutrients to the soil, soil temperature control and protection of soil surface from the impacts of heavy rain and wind. Active reuse of waste organic materials also reduces waste management needs, returning the residue crops and plants to the soil through decomposition (CTCN 2022).

Gender aspects	Adopting a gender perspective coupled with a participatory approach while conducting agronomic research and extension work has a great potential to provide more efficient approaches to agricultural diversification including soil moisture conservation.
Local Context	
Opportunities and Barriers	The main opportunity is the availability of labour and machinery locally without any needs for specialized equipment. The technology can be promoted using existing research, extension and farmer linkages for technology dissemination. This however needs to be supported by effective capacity building and training at various levels to support operations at the farmer level.
Market Potential	Medium
Status	Practiced
Timeframe for implementation	Short to medium term
Acceptability to local stakeholders	Acceptable

References

Clements, R. et al (2011) Technologies for Climate Change Adaptation – Agriculture. TNA Guidebook, August 2011.

Climate Technology Centre and Network (CTCN) (2022). Factsheet on soil moisture conservation techniques. Accessed on February 9, 2022 at: https://www.ctc-n.org/technologies/soil-moisture-conservation-techniques

Kujawski, Jennifer (2011) Measuring soil moisture. Center for Agriculture, Food and the Environment. UMass Amherst. Access on March 15, 2022 at: https://ag.umass.edu/print/9572

Kumawat, A., Yadav, D., Samadharmam, K., & Rashmi, I. (2020). Soil and Water Conservation Measures for Agricultural Sustainability. In R. S. Meena, & R. Datta (Eds.), Soil Moisture Importance. IntechOpen. https://doi.org/10.5772/intechopen.92895

Nova Scotia Federation of Agriculture (NSCA), 2011: Soil Moisture Conservation Factsheet. Accessed on February 9, 2022 at: https://nsefp.ca/wp-content/uploads/2014/07/NSCA-2001-Soil-Moisture-Conservation.pdf

Technology: Integrated soil nutrient management	
Introduction	Integrated Nutrient Management is an approach to the management of plant nutrients for maintaining and enhancing soil, where both natural and man-made sources of plant nutrients are used (Gruhn et al. 2000). Fertilizers are typically classified as organic or mineral. Organic fertilizers are derived from substances of plant or animal origin, such as manure, compost, seaweed and cereal straw. Organic fertilizers generally contain lower levels of plant nutrients as they are combined with organic matter that improves the soils physical and biological characteristics. The most widely-used mineral fertilizers are based on nitrogen, potassium and phosphate (Clements et al. 2011).
Technology Characteristics/Highlights	Key components of the INM approach include (Clements et al. 2011): 1. Testing procedures to determine nutrient availability and deficiencies in plants and soils including plant symptom analysis and tissue analysis and soil testing. 2. Systematic appraisal of constraints and opportunities in the current soil fertility management practices and how these relate to the nutrient diagnosis, for example insufficient or excessive use of fertilisers. 3. Assessment of productivity and sustainability of farming systems. Different climates, soil types, crops, farming practices, and technologies dictate the correct balance of nutrients necessary. 4. Participatory farmer-led INM technology experimentation and development. The need for locally appropriate technologies means that farmer involvement in the testing and analysis of any INM technology is essential.
Institutional and Organizational Requirements	
Scale of the application / Size of beneficiary group	Islandwide
Operation and Maintenance	INM can be executed with locally available materials (except for inorganic fertilizers) and labour. However, INM requires knowledge of what is required by plants for optimum level of production — in what different forms and at what different timings and how these requirements can be integrated to obtain highest productivity levels within acceptable economic and environmental limits. Determining this information will require localised research. Extension staff who can translate research data into practical recommendations will need to take account of both farmers' expertise and applicable research results (Clements et al. 2011).
Advantages and disadvantages (Is the technology endorsed by local experts? Is it	Urmi et al. (2022) in a recent study of INM on rice yields found the addition of organic fertilizer significantly influenced the organic carbon, total carbon, total nitrogen, ammonium nitrogen, nitrate nitrogen, soil pH, phosphorus, potassium, sulfur, calcium,

adequate for local conditions?)	and magnesium contents in post-harvest soil, which indicated enhancement of soil fertility compared to use of inorganic fertilizers alone.
Costs	
Cost to Implement Adaptation Technology Additional cost to implement adaptation option compared to "business as usual"	The main cost associated with Integrated Nutrient Management relates to the purchase and distribution of inorganic fertilizers which are affected by a range of factors. Organic fertilizers provide a low-to-no-cost technology for improving soil fertility if they can be produced and used within a relatively close distance (Clements et al. 2011). Training and capacity building for farmers and extension staff will be critical and will present an upfront and ongoing cost.
Development Impacts - Direct and Indirect Benefits	
Reduction of vulnerability to climate change	INM contributes to reduction of vulnerability to climate change through improvements in soil resources and increases in crop productivity and soil fertility.
Economic benefits (including employment, investment, public and private expenditures)	The technology can contribute to generation of employment at the community level from sales of organic fertilizer sources such as compost. It also requires relatively low investment in tools and equipment, and training of farmers for transforming organic sources into easily usable forms. Also, it reduces public and private expenditures in terms of expenditure on the use of inorganic soil nutrients.
Social benefits (including income, education, health)	This technology could provide a source of extra income for individuals and groups from sales of transformed organic materials into organic soil nutrients and creates opportunity for increased group and individual learning at group and community level.
Environmental Benefits (Indirect)	Reliance on inorganic fertilizers with less or no use of organic fertilizers has impaired the productivity of soils worldwide (Urmi et al. 2022). Integrated Soil Nutrient Management can contribute to reduction in the use of inorganic fertilizers hence reduced incidences of water pollution and soil degradation from poor handling and overuse of chemical fertilizers.
Gender aspects	Adopting a gender perspective coupled with a participatory approach while conducting agronomic research and extension work has a great potential to provide more efficient approaches to agricultural diversification including INM.
Local Context	
Opportunities and Barriers	The main opportunity is the availability of organic inputs / materials locally to enhance INM. The main barrier is the introduction of new and best practices for nutrient management and ongoing farmer-led research for continuous and sustainable improvement in the way nutrients are managed and enhanced soil fertility achieved.

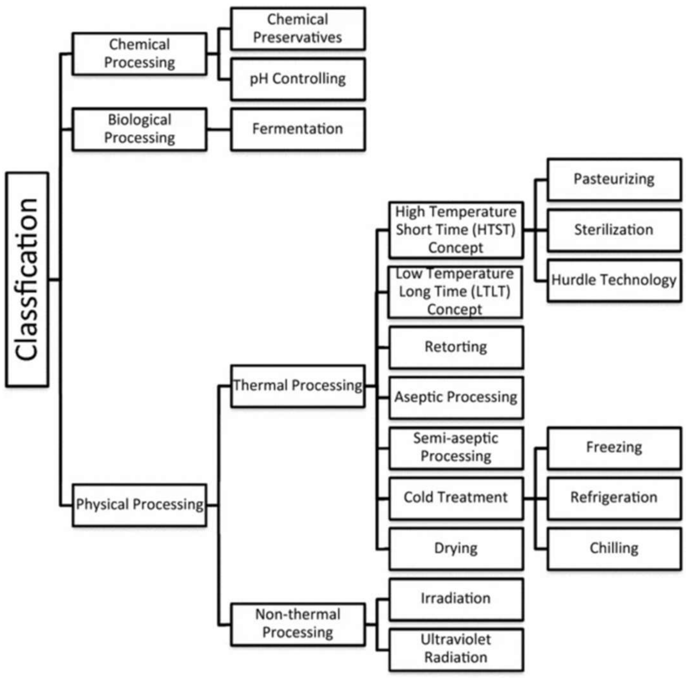
Market Potential	Medium to high
Status	Not widely practiced
Timeframe for implementation	Medium to long term
Acceptability to local stakeholders	Acceptable

References

Clements, R. et al (2011) Technologies for Climate Change Adaptation – Agriculture. TNA Guidebook, August 2011.

Gruhn, P., Goletti, F., and M. Yudelman (2000) Integrated Nutrient Management, Soil Fertility, and Sustainable Agriculture: Current Issues and Future Challenges. International Food Policy Research Institute (IFPRI). Washington, D.C. Accessed on February 10, 2022 at: https://ebrary.ifpri.org/digital/collection/p15738coll2/id/125397

Urmi, T.A., Rahman, M.M., Islam, M.M.;, Islam, M.A., Jahan, N.A., Mia, M.A.B., Akhter, S., Siddiqui, M.H. and Kalaji, H.M. (2022) Integrated Nutrient Management forRice Yield, Soil Fertility, and Carbon Sequestration. Plants 2022, 11, 138. https://doi.org/10.3390/plants

Technology: Food storage, preservation, and processing	
Introduction	Food storage includes techniques to store food (including seeds) to ensure domestic food security and maintaining value prior to sale. Food preservation and processing techniques combines science-based knowledge with technologies, to prevent spoilage and extend shelf-life and prevent foodborne illness while maintaining nutritional value, texture and flavour.
Technology Characteristics/Highlights	In order to reduce the amount of food lost, food storage needs to be controlled so as to lower the possibility of: • Biological damage by insects, rodents and micro-organisms • Chemical damage through acidity development and flavour changes • Physical damage through crushing and breaking. Good storage thus involves controlling the following factors: temperature, moisture, light, pests and hygiene. Conventional food preservation techniques like drying, freezing, chilling, pasteurization, and chemical preservation are being used comprehensively throughout the world. Scientific advancements and progresses are contributing to the evolution of existing technologies and innovation of the new ones, such as irradiation, high-pressure technology, and hurdle technology (Amit et al. 2017) and shown in a summary figure below. 
Institutional and Organizational Requirements	
Scale of the application / Size of beneficiary group	Islandwide
Operation and Maintenance	The specific elements of operation and maintenance of any food storage and preservation technique will differ depending on the type of food and a

	There are examples of studies done in the Caribbean by the FAO to measure the magnitude of post-harvest losses in the cassava, mango and tomato crops in Guyana, Saint Lucia and Trinidad and Tobago (FAO 2015). The main causes of food spoilage were found to be physical damage, deterioration, high temperatures and drying. The main interventions needed to improve food storage and processing to avoid such losses include: • Invest in equipment and supplies • Intensify training in post-harvest practices • Promote the use of packaging technology • Encourage supply-chain workers and service providers to strengthen their skills • Carry out guided interventions • Disseminate the appropriate technology and approaches
Advantages and disadvantages (Is the technology endorsed by local experts? Is it adequate for local conditions?)	This technology is endorsed by local experts and many of the traditional techniques of food processing are widely practiced. It is suitable for local conditions. The main advantage of preservation is the reduction of food losses and increase in food security. Many of the techniques are low cost. Traditional preservation techniques such as drying, roasting, smoking etc. can lead to low productivity, poor and non-uniform quality of products, poor shelf-life of products (Adeyeye, 2017).
Costs	
Cost to Implement Adaptation Technology Additional cost to implement adaptation option compared to "business as usual"	The main cost of this technology would be for a thorough assessment of current food storage and processing practices in the Federation to identify the specific techniques which are most appropriate for local conditions. Afterwards, investment would be required for any new equipment and for wide ranging training and capacity building.
Development Impacts - Direct and Indirect Benefits	
Reduction of vulnerability to climate change	Technologies for reducing waste of agricultural produce reduce vulnerability to climate change by improving food security (Clements et al. 2011).
Economic benefits (including employment, investment, public and private expenditures)	Agricultural practices and technology, as well as the establishment of small-scale agro-processing industries, can significantly increase employment and income-generating opportunities and thus positively affect household access to food.
Social benefits (including income, education, health)	Food safety and quality, secured through effective food quality control at all stages of production, processing and handling, also influence nutritional well-being (Adeyeye 2017).
Environmental Benefits (Indirect)	Overall, reducing food wastage has significant environmental benefits by ensuring efficient use of land and water resources for food production.

Gender aspects	Adopting a gender perspective coupled with a participatory approach while conducting agronomic research and extension work has a great potential to provide more efficient approaches to agricultural diversification including controlled breeding. Generally, women are the main players in agro-processing in St. Kitts and Nevis.
Local Context	
Opportunities and Barriers	The main opportunity is to build on already existing programmes and knowledge base for food processing and to pinpoint where guided interventions can be most beneficial. The main barrier is the need for extensive training to ensure the best practices are understood and implemented in the long-run.
Market Potential	High
Status	Widely practiced
Timeframe for implementation	Short to medium term
Acceptability to local stakeholders	Acceptable

References

Adeyeye, S. (2017) The role of food processing and appropriate storage technologies in ensuring food security and food availability in Africa. Nutrition & Food Science (47). Accessed online on February 10, 2022 at: https://www.researchgate.net/publication/311144278_The_role_of_food_processing_and_appropriate_storage_technologies_in_ensuring_food_security_and_food_availability_in_Africa

Amit, S.K., Uddin, M.M., Rahman, R. *et al.* (2017) A review on mechanisms and commercial aspects of food preservation and processing. *Agric & Food Secur* 6, 51 (2017). https://doi.org/10.1186/s40066-017-0130-8

Clements, R. et al (2011) Technologies for Climate Change Adaptation – Agriculture. TNA Guidebook, August 2011.

FAO (2015). Food Losses and Waste in Latin America and the Caribbean. Bulletin No. 2 (2015). Accessed on February 10, 2022 at: https://www.fao.org/3/i4655e/I4655E.pdf

Annex IV: Technology Factsheets for Short Listed Technologies – Energy Sector

<table>
<tr><td colspan="2">Technology Category: Energy Demand
Technology: Energy Efficient Water Heating (Solar)</td></tr>
<tr><td>Introduction</td><td>Energy demand incorporates the end-use consumption of energy in SKN. This comprises energy demand for residential buildings, commercial buildings (public buildings, schools, churches, restaurants, hotels), industry and street light use. Mitigation actions for energy demand primarily relate to the affected changes in the end-use of electricity and fossil fuels. These actions are normally related to changes in fuel and/or equipment used for lighting, cooling, refrigeration, cooking, water heating and other appliances (SKN TNC 2022).

This factsheet focuses on changes in equipment used for water heating with special focus on solar water heating across all sectors in St. Kitts and Nevis.</td></tr>
<tr><td>Technology Characteristics/Highlights</td><td>Solar water heating systems include storage tanks and solar collectors. A sun-facing collector heats a working fluid that passes into a storage system for later use. SWH are active (pumped) and passive (convection-driven). They use water only, or both water and a working fluid. They are heated directly or via light-concentrating mirrors. They operate independently or as hybrids with electric or gas heaters (Belize TNA factsheet 2017).

Solar water heating was identified as a mitigation action under the TNC and BUR in 2021. Various assumptions regarding adoption of the technology were as follows:

- Public awareness and incentives for solar water heaters will increase penetration.
- Water heaters are either solar or electric
- Ownership rate for residential water heaters is assumed to grow from 15% in 2020 to 30% in 2030 and 50% in 2050.
- Fraction of solar water is expected to increase from 2.5% in 2020 to 40% in 2030 and 70% in 2050.
- Ownership of commercial water heaters is assumed to be 10% and remains constant through the years.
- Approximately 1% of these water heaters are solar in 2020, and this is expected to increase to 40% by 2030 and 70% by 2050 (SKN TNC 2022).

The estimated GHG emission reduction related to the implementation (when implemented alone) is 5.54 ktCO2-eq compared to the baseline.</td></tr>
<tr><td colspan="2">Institutional and Organizational Requirements</td></tr>
<tr><td>Scale of the application / Size of beneficiary group</td><td>All residents of St. Kitts and Nevis.</td></tr>
</table>

Operation and Maintenance	Currently, mostly plumbers and some electricians are familiar with the installation of SWH in the Federation which can take a team of two persons one or two days to install. Maintenance is minimal and mainly requires the cleaning of the glazed panel or tubes to ensure efficiencies are maintained. Maintenance also includes regular checks for leaks on the plumbing and occasional flushing of the system.
Advantages and disadvantages (Is the technology endorsed by local experts? Is it adequate for local conditions?)	This technology is endorsed by local experts and is adequate for local conditions. Advantages include major energy savings and easy operation and maintenance. The main disadvantage is the upfront cost compared to a conventional electric water heater.
Costs	
Cost to Implement Mitigation Technology Additional cost to implement mitigation option compared to "business as usual"	Currently, the cost of a 50-gallon unit is about 6,000 ECD for units coming out of Barbados to SKN.
Development Impacts - Direct and Indirect Benefits	
Reduction of vulnerability to climate change	SKN total GHG emissions increased by 19.7% or approximately 60 $ktCO_2eq$ in 2018 compared to the 2010 levels (excluding emissions/removals from LULUCF) according to the latest NIR. The energy sector represented 77% and 81% of total GHG emissions in 2010 and 2018, respectively in St. Kitts and Nevis (TNC 2022). Demand-side EE is achieved when less energy input is used to deliver the same service or when the same amount of energy input delivers more services. This concept is relevant considering climate change challenges in two ways: (i) the less energy used, the fewer emissions produced, and (ii) cost effective EE achieves environmental benefits at low cost, and thus could reduce the economic costs of achieving climate change policy goals (e.g., CO2 emission reduction, resilience enhancement) (Flores and Peralta Quesada 2020).
Economic benefits (including employment, investment, public and private expenditures) Social benefits (including income, education, health)	Electrical water heating can take up to 30% of a household electrical bill in the Caribbean (Lapillone 2019). Energy savings frees up income for other household needs. Energy efficiency is one of the fastest and most affordable practices to mitigate climate change, prevent excess demand of electricity, avoid electricity rationing (blackouts), reduce the investment in power generation, and reduce the cost of energy subsidies. Further, the use of efficient solar water heating provides savings at country and citizen levels, in financial, environmental and energy terms. These reduce the value of electricity bills as well as imports of fossil fuels, improve consumer welfare and reduce carbon dioxide emissions (UNEP / CLASP 2015).

Environmental Benefits (Indirect)	SWH is a clean technology and has the following additional environmental benefits (Belize TNA factsheet 2017): - Solar water heating systems require no fuel or any inputs during operation and electricity production and does not contaminate any water since there are no waste products. - SWH systems are noise and vibration free which can be considered environmentally friendly. - SWH systems have a service life of over 20 years with minimal
Gender aspects	The incremental increase in supply will promote equity in distribution and facilitate wider access to existing and potential users especially vulnerable persons.
Local Context	
Opportunities and Barriers	Demand-side EE measures and other energy saving measures are crucial, as they consist of the least costly and fastest way to lessen the environmental and socioeconomic costs associated with energy systems. Some barriers that need to be overcome include: lack of adequate EE standards, policies and legislation to provide frameworks, roadmap and incentives for EE. Water heating is mainly done through electrical water heaters; although the current penetration is low, it is expected that with an increased GDP as projected, these numbers will increase. The promotion of solar water heaters will assist in the increased adoption of this technology on the islands. This can be achieved through education, awareness campaigns, as well as the introduction of incentives for solar water heaters. The energy unit for SKN participates in CARICOM energy awareness month activities in November each year.
Market Potential	Equipment and suppliers available for the Caribbean Region
Status	Practiced
Timeframe for implementation	Short to medium term
Acceptability to local stakeholders	Acceptable

References

Lapillone, B. (2019) "Study on trends in energy efficiency in selected Caribbean countries" Santiago, Economic Commission for Latin America and the Caribbean (ECLAC). https://d1owejb4br3l12.cloudfront.net/about-us/case-study/cepal-study-trends-in-energy-efficiency-caribbean-countries.pdf Accessed on January 12, 2023.

UNEP / CLASP (2015) Energy Efficient Cooling Products in Latin America and the Caribbean. https://c2e2.unepccc.org/wp-content/uploads/sites/3/2016/04/2015-02-energy-efficient-cooling-products-in-lac-english.pdf. Accessed on January 11, 2023

Technology Category: Energy Demand **Technology: Energy Efficient HVAC Systems (Efficient air conditioning systems)**	
Introduction	Energy demand incorporates the end-use consumption of energy in SKN. This comprises energy demand for residential buildings, commercial buildings (public buildings, schools, churches, restaurants, hotels), industry and street light use. Mitigation actions for energy demand primarily relate to the affected changes in the end-use of electricity and fossil fuels. These actions are normally related to changes in fuel and/or equipment used for lighting, cooling, refrigeration, cooking, water heating and other appliances (SKN TNC 2022). This factsheet focuses on changes in equipment used for air conditioning (AC) across all sectors in St. Kitts and Nevis.
Technology Characteristics/Highlights	Air conditioning systems can be applied in numerous sectors, namely buildings, industry, and transport. An air conditioner cools the building or transport space with a cold indoor coil called the evaporator. The condenser, a hot outdoor coil, releases the collected heat outside. The evaporator and condenser coils are serpentine tubing surrounded by aluminum fins. Generally, the compressor moves a heat transfer fluid (or refrigerant) between the evaporator and the condenser. The pump forces the refrigerant through the circuit of tubing and fins in the coils. The liquid refrigerant evaporates in the indoor evaporator coil, pulling heat out of indoor air and thereby cooling the home. The hot refrigerant gas is pumped outdoors into the condenser where it reverts to a liquid giving up its heat to the air flowing over the condenser's metal tubing and fins. Air conditioning systems are distinguished in two main categories, room air conditioners and central air conditioners. In the Caribbean region, at the household level with cooling systems, room air conditioners are generally utilized and are also called split or wall mounted AC units. In more recent times, AC units have become more EE by using a compressor that has variable speeds (inverters) that can adjust or modulate based on the demand of the system. This means that if you need to use less power based on the conditions, temperature or area of operation, they can wind down to meet that demand (CTCN 2017). Each air conditioner has an energy-efficiency rating that lists how many Btu per hour are removed for each watt of power it draws. For room air conditioners, this efficiency rating is the Energy Efficiency Ratio (EER). Room air conditioners generally range from 5,500 Btu per hour to 14,000 Btu per hour. There are several appliance standards worldwide, which require a minimum EER for room air conditioners. For milder climates an efficient air conditioning system could have a minimum 9, while for hotter climates this should be over 10 (CTCN 2017).
Institutional and Organizational Requirements	
Scale of the application / Size of beneficiary group	All residents of St. Kitts and Nevis.

<table>
<tr><td>Operation and Maintenance</td><td>Operation and maintenance of energy efficient AC units are similar to the conventional type. In terms of energy efficiency, it is very important to properly size the system and to understand the type of refrigerant used (low global warming potential (GWP)) and proper use, storage, transportation and disposal. A training needs analysis of the RAC sector in SKN done in 2020 suggests that there is a great need for training to ensure all RAC technicians in the Federation are fully updated as to low GWP refrigerants and their proper usage as well as energy efficient refrigeration and cooling systems (Hanley 2020).</td></tr>
<tr><td>Advantages and disadvantages
(Is the technology endorsed by local experts? Is it adequate for local conditions?)</td><td>This technology is endorsed by local experts and adequate for local conditions. The main advantage is the vast improvement in energy efficient of the new inverter-type AC units. The main disadvantage is the need for a cadre of trained technicians that fully understand how to properly size the systems, operate, and maintain them. There is also a need to standardize these across the Caribbean region.</td></tr>
<tr><td colspan="2">Costs</td></tr>
<tr><td>Cost to Implement Mitigation Technology

Additional cost to implement mitigation option compared to "business as usual"</td><td>The initial upfront cost of the inverter AC units will be more, but this can easily be offset by the energy savings over the lifetime of the unit. In 2023, for example, the price differential between a conventional and inverter type 12,000 BTU unit is only 500 ECD in SKN.</td></tr>
<tr><td colspan="2">Development Impacts - Direct and Indirect Benefits</td></tr>
<tr><td>Reduction of vulnerability to climate change</td><td>SKN total GHG emissions increased by 19.7% or approximately 60 ktCO$_2$eq in 2018 compared to the 2010 levels (excluding emissions/removals from LULUCF) according to the latest NIR. The energy sector represented 77% and 81% of total GHG emissions in 2010 and 2018, respectively in St. Kitts and Nevis (TNC 2022). Demand-side EE is achieved when less energy input is used to deliver the same service or when the same amount of energy input delivers more services. This concept is relevant considering climate change challenges in two ways: (i) the less energy used, the fewer emissions produced, and (ii) cost effective EE achieves environmental benefits at low cost, and thus could reduce the economic costs of achieving climate change policy goals (e.g., CO2 emission reduction, resilience enhancement) (Flores and Peralta Quesada 2020).

In a study done by UNEP and CLASP in 2015, the following energy and GHG savings were estimated for implementation of efficient cooling products for SKN.

<table>
<tr><th>COUNTRIES</th><th>PRODUCT</th><th>ENERGY SAVINGS (GWh)</th><th>GHG EMISSION REDUCTION (kTon CO$_2$)</th><th>REDUCTION IN END-USERS' ELECTRICITY BILLS (In thousands of dollars)</th></tr>
<tr><td rowspan="4">Saint Kitt and Nevis</td><td>Refrigerators</td><td>3.64</td><td>2.8</td><td>877.0</td></tr>
<tr><td>Air conditioners</td><td>10.02</td><td>7.8</td><td>2,412.4</td></tr>
<tr><td>Fans</td><td>1.09</td><td>0.8</td><td>261.4</td></tr>
<tr><td>Total savings</td><td>14.75</td><td>11.4</td><td>3,550.7</td></tr>
</table>
</td></tr>
<tr><td>Economic benefits (including employment, investment, public and private expenditures)</td><td>Energy efficiency is one of the fastest and most affordable practices to mitigate climate change, prevent excess demand of electricity, avoid electricity rationing (blackouts), reduce the investment in power generation, and reduce the cost of energy subsidies. Further,</td></tr>
</table>

Social benefits (including income, education, health)	the use of efficient cooling products provides savings at country and citizen levels, in financial, environmental and energy terms. These reduce the value of electricity bills as well as imports of fossil fuels, improve consumer welfare and reduce carbon dioxide emissions (UNEP / CLASP 2015). No recent studies with local data to show energy and GHG savings.
Environmental Benefits (Indirect)	Use of low GWP refrigerants allows for less GHG emissions as well as phase out of refrigerants that cause ozone depletion.
Gender aspects	The incremental increase in supply will promote equity in distribution and facilitate wider access to existing and potential users especially vulnerable persons.
Local Context	
Opportunities and Barriers	Demand-side EE measures and other energy saving measures are crucial, as they consist of the least costly and fastest way to lessen the environmental and socioeconomic costs associated with energy systems. Some barriers that need to be overcome include: lack of adequate EE standards, policies and legislation to provide frameworks, roadmap and incentives for EE.
Market Potential	Equipment and suppliers available for the Caribbean Region
Status	Practiced
Timeframe for implementation	Short to medium term
Acceptability to local stakeholders	Acceptable

References

Hanley, T. (2020). Assessment of the Refrigeration and Air Conditioning Sector on Training and Equipment Needs. Department of Environment. St. Kitts and Nevis.

UN Climate Technology and Network (CTCN) (2017) Efficient Air Conditioning Systems Factsheet. https://www.ctc-n.org/technologies/efficient-air-conditioning-systems. Accessed on January 12, 2023

UNEP / CLASP (2015) Energy Efficient Cooling Products in Latin America and the Caribbean. https://c2e2.unepccc.org/wp-content/uploads/sites/3/2016/04/2015-02-energy-efficient-cooling-products-in-lac-english.pdf. Accessed on January 11, 2023

Technology Category: Energy Demand **Technology: Energy Efficient Water Pumping (Solar)**	
Introduction	Energy demand incorporates the end-use consumption of energy in SKN. This comprises energy demand for residential buildings, commercial buildings (public buildings, schools, churches, restaurants, hotels), industry and street light use. Mitigation actions for energy demand primarily relate to the affected changes in the end-use of electricity and fossil fuels. These actions are normally related to changes in fuel and/or equipment used for lighting, cooling, refrigeration, cooking, water heating and other appliances (SKN TNC 2022). This factsheet focuses on changes in equipment used for solar water pumping in St. Kitts and Nevis.
Technology Characteristics/Highlights	A solar water pump system is essentially an electrical pump system in which the electricity is provided by one or several photovoltaic panels. A typical solar powered pumping system consists of a solar panel array that powers an electric motor, which in turn powers a bore or surface pump. The water is often pumped from the ground or stream into a storage tank. Newer generation pumps can reach deeper wells (500 meters (m), compared to the previous 200 m) and push larger volumes of water (1,500 m3/day, compared to the previous 500 m3/day at low head). Efficiencies have also increased considerably. New pump and motor designs have increased water outputs over the entire pump range (World Bank 2018).
Institutional and Organizational Requirements	
Scale of the application / Size of beneficiary group	All residents of St. Kitts and Nevis.
Operation and Maintenance	Operation and maintenance would be like that of a conventional pump except for minimal maintenance required for the solar panels.
Advantages and disadvantages (Is the technology endorsed by local experts? Is it adequate for local conditions?)	This technology is endorsed by local experts and is adequate for local conditions. Advantages include major energy savings and easy operation and maintenance. The main disadvantage is the upfront cost compared to a conventional pump and lower output in cloudy weather if there is no storage of the solar energy or no battery back-up. Also there needs to be enough land near to the well for the PV panels.

	Advantages of solar pumping • SWP systems consume little to no fuel. By using freely available sunlight, they avoid the constraints of weak or expensive rural fuel supply networks. • Unlike diesel-based systems (i.e., where a diesel generator powers the pump), solar pumping produces clean energy with zero or much reduced exhaust gases and pollutants. • Solar pumping systems are durable and reliable. PV panels have a design life of over 20 years, and solar pumps have few moving parts and require little maintenance (unlike diesel pumps). • Solar pumping systems are modular so can be tailored to current power needs and easily expanded by adding PV panels and accessories. • Properly installed solar systems are safe and low risk due to low system voltage. Adequate protection minimizes fire risk. **Possible disadvantages and mitigation** • Solar pumping systems have high initial capital costs, which can be discouraging. However, component prices are dropping substantially and investment payback is quick thanks to vast reductions in fuel usage (as detailed in Chapter 2). • Water tank storage is preferable to batteries, but still expensive. Hybrid solar/diesel pumping can reduce the need for storage and hence costs. • Solar pumps still require some servicing, and specialized technicians/providers may be difficult to access in some areas. This is gradually improving. • Panel theft can be circumvented by sensitizing communities and providing simple antitheft measures. • SWP can lead to excessive groundwater extraction because operators face near zero marginal-cost of pumping groundwater. From World Bank 2018.
Costs	
Cost to Implement Mitigation Technology Additional cost to implement mitigation option compared to "business as usual"	While the initial acquisition of equipment can be more costly than other pumping alternatives, the operation and maintenance costs are low. Particularly compared with diesel pumping, solar is not only more energy efficient, but with a lifespan of over 20 years, the financial benefits vastly outweigh the costs (World Bank 2018). Recently, a solar water pump was purchased for an application in Nevis with a dynamic head over 500 feet (approximately 30-40 gpm). The cost of the pump was approximately 5000 USD.
Development Impacts - Direct and Indirect Benefits	
Reduction of vulnerability to climate change	SKN total GHG emissions increased by 19.7% or approximately 60 $ktCO_2eq$ in 2018 compared to the 2010 levels (excluding emissions/removals from LULUCF) according to the latest NIR. The energy sector represented 77% and 81% of total GHG emissions in 2010 and 2018, respectively in St. Kitts and Nevis (TNC 2022). Demand-side EE is achieved when less energy input is used to deliver the same service or when the same amount of energy input delivers more services. This concept is relevant considering climate change challenges in two ways: (i) the less energy used, the fewer emissions produced, and (ii) cost effective EE achieves environmental benefits at low cost, and thus could reduce the economic costs of achieving climate change policy goals (e.g., CO2 emission reduction, resilience enhancement) (Flores and Peralta Quesada 2020).
Economic benefits (including employment, investment, public and private expenditures) Social benefits (including income, education, health)	The water utilities in St. Kitts and Nevis are one of the largest users of energy of all government departments. Energy savings frees up funds for critical infrastructural improvements. Energy efficiency is one of the fastest and most affordable practices to mitigate climate change, prevent excess demand of electricity, avoid electricity rationing (blackouts), reduce the investment in power and water generation, and reduce the cost of energy subsidies. Further, the use of efficient solar water pumping provides savings at country and citizen levels, in financial, environmental and energy terms. These reduce the value of electricity bills as well as imports

	of fossil fuels, improve consumer welfare and reduce carbon dioxide emissions (UNEP / CLASP 2015).
Environmental Benefits (Indirect)	Solar water pumping is a clean technology and has the following additional environmental benefits: - Solar water pumping systems require no fuel or any inputs during operation and electricity production and does not contaminate any water since there are no waste products. - Solar water pumping systems are noise and vibration free - Solar panels utilized for water pumping systems have a service life of over 20 years with minimal maintenance.
Gender aspects	The incremental increase in energy and water supply will promote equity in distribution of energy and water and facilitate wider access to existing and potential users especially vulnerable persons.
Local Context	
Opportunities and Barriers	Demand-side EE measures and other energy saving measures are crucial, as they consist of the least costly and fastest way to lessen the environmental and socioeconomic costs associated with energy systems. Some barriers that need to be overcome include: lack of adequate EE standards, policies and legislation to provide frameworks, roadmap and incentives for EE.
Market Potential	Equipment and suppliers available for the Caribbean Region
Status	Practiced
Timeframe for implementation	Short to medium term
Acceptability to local stakeholders	Acceptable
References UNEP / CLASP (2015) Energy Efficient Cooling Products in Latin America and the Caribbean. https://c2e2.unepccc.org/wp-content/uploads/sites/3/2016/04/2015-02-energy-efficient-cooling-products-in-lac-english.pdf. Accessed on January 11, 2023 World Bank (2018) Solar Pumping: The Basics. World Bank, Washington, DC. https://documents.worldbank.org/en/publication/documents-reports/documentdetail/880931517231654485/solar-pumping-the-basics Accessed February 7, 2023.	

Technology Category: Electricity Generation **Technology: Utility Scale Geothermal**	
Introduction	Saint Kitts and Nevis' energy mix is currently dominated by fossil fuels. Saint Kitts and Nevis has declared a 61% CO2 emission reduction target by 2030, based on 2010 levels. Transitioning to 100% renewable energy in power generation by 2030 can help the islands achieve their overall targets. The twin-island Federation has set a goal to reach 100% renewable energy generation through the following renewable energy projects: 5. 35.7 MW utility-scale solar PV capacity with 44.2 MWh lithium-ion battery storage facility by 2025 6. 10 MW geothermal power in Nevis by 2030 7. 6.6 MW wind power in St. Kitts by 2030 8. 15 MW geothermal power capacity in St. Kitts by 2035 The estimated GHG emission reduction related to the implementation of RE in the Federation as outlined above (when implemented alone) is 129.15 ktCO2-eq compared to the baseline. Geothermal Power has potential on both St. Kitts and Nevis. Exploring the potential for geothermal will provide base load supply to the island.
Technology Characteristics/Highlights	Geothermal energy is thermal energy (heat) generated and stored in the earth. Whenever hot matter comes close to the surface - less than 4,000 m – it can be used to produce steam, which generates electricity in a turbine. To produce steam, wells have to be drilled to reach the resource. These drillings are large infrastructure developments that require access roads and water supply to the drilling site. Due to its complexity a geothermal development takes several years to be executed. Once operational, a geothermal power plant can deliver base load energy, meaning that it produces electricity on a continuous basis. On the island of Nevis, there are already plans in place to develop 10 MW of geothermal power. The first phase (10 MW) drilling campaign will include drilling five geothermal wells (1 vertical and 4 directional) to approx. 4,500-5,000 feet measured depth.
Institutional and Organizational Requirements	
Scale of the application / Size of beneficiary group	All residents of St. Kitts and Nevis.
Operation and Maintenance	Very high, requires specialized human resources to be able to operate and maintain.
Advantages and disadvantages (Is the technology endorsed by local experts? Is it	**Advantage(s)** • Proven, mature and reliable technology • Baseload technology • Job opportunities for technically skilled (tertiary education) people in the field of operation and maintenance

adequate for local conditions?)	• Hurricane resilient **Disadvantage(s)** • Environmental and health concerns due to hazardous gases • Limited human capacity and expertise in SKN increasing the risk of malfunctioning systems • Very high upfront costs • Potential sites in virgin territory • Major infrastructure development (roads and water supply) required
Costs	
Cost to Implement Mitigation Technology Additional cost to implement mitigation option compared to "business as usual"	The projected cost to develop 10 MW geothermal power in Nevis by 2030 and 15 MW geothermal power capacity in St. Kitts by 2035 is estimated to be 88 Million USD and 98 Million USD respectively.
Development Impacts - Direct and Indirect Benefits	
Reduction of vulnerability to climate change	Successful implementation of the geothermal power in SKN would increase the proportion of clean renewable energy in the national energy mix; lower and stabilize energy prices; reduce reliance on imported fossil fuels; reduce carbon emissions; increase energy independence; and promote economic development (ERM 2022).
Economic benefits (including employment, investment, public and private expenditures) Social benefits (including income, education, health)	Wide array of possible economic benefits including employment and investment by local and foreign entities and the possibility for economic diversification that comes with cheaper and abundant energy supply. With a more affordable energy supply, there is more income available to each household to spend on education, health, wellness and leisure.
Environmental Benefits (Indirect)	Furthermore, in addition to steam, other gases like carbon dioxide (CO_2), hydrogen sulfide, methane and ammonia could be released. Additionally, the brine, which is the waste fluid from the separator in a geothermal power plant system, can contain trace amounts of toxics like mercury, arsenic, boron and antimony. However, these environmental risks can be mitigated against in modern plants.
Gender aspects	The incremental increase in supply will promote equity in distribution and facilitate wider access to existing and potential users especially vulnerable persons.
Local Context	
Opportunities and Barriers	Various opportunities are available including interconnection between both islands as well as other neighboring islands which want to invest in renewables. The main barrier is the large upfront capital cost of exploration, drilling and establishment of the power plant.

Market Potential	Equipment and suppliers available but not regionally.
Status	Not widely practiced in the Caribbean
Timeframe for implementation	Medium to long term
Acceptability to local stakeholders	Acceptable

References

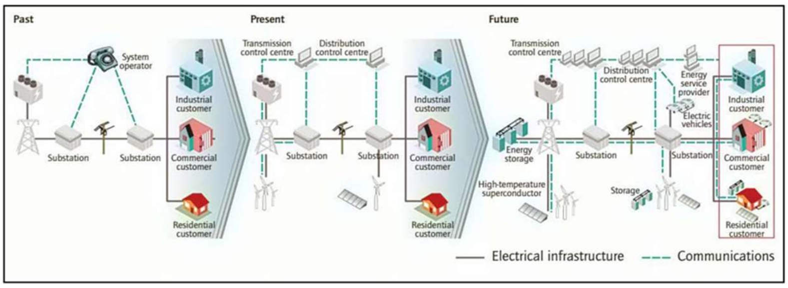
Environmental Resources Management Group (ERM) (2022) Supplemental Environmental and Social Impact Analysis. Nevis Geothermal Well Drilling Project. https://nia.gov.kn/documents/geothermal-energy/ Accessed on January 13, 2023.

Technology Category: Electricity Generation Technology: Residential grid-tied solar	
Introduction	Saint Kitts and Nevis' energy mix is currently dominated by fossil fuels. Saint Kitts and Nevis has declared a 61% CO_2 emission reduction target by 2030, based on 2010 levels. Transitioning to 100% renewable energy in power generation by 2030 can help the islands achieve their overall targets. Residential grid-tied solar (stand-alone systems or rooftop) as a technology was listed in the NDC Implementation Plan of 2022 for SKN but not included as a prioritized mitigation action in the Mitigation Assessment Chapters of the BUR and TNC.
Technology Characteristics/Highlights	Solar photovoltaic refers to the technology of using solar cells to convert solar radiation directly into electricity. A solar cell works based on the photovoltaic effect which can be briefly summarized as sunlight striking a semiconductor and causing electrons to be excited due to energy in the sunlight (photons). Grid-connected PV systems do not require energy storage but instead use an inverter to convert electricity from direct current (DC) to alternating current (AC) and the generated electricity is then fed into the grid distribution network to consumers. Grid-connected distributed PV systems are installed on residential, commercial or public buildings and generate electricity which is consumed by the customer and the excess is sent/sold to the grid to be consumed by other users. Most distributed systems range between 1-5 kW in power generation (Belize TNA factsheet, 2017).
Institutional and Organizational Requirements	
Scale of the application / Size of beneficiary group	All residents of St. Kitts and Nevis.
Operation and Maintenance	Operation and maintenance are straightforward but there is a lack of local companies / technicians to provide these services locally. Annual maintenance costs for on-grid systems is approximately 2-5% of system cost (Belize TNA factsheet, 2017).
Advantages and disadvantages (Is the technology endorsed by local experts? Is it adequate for local conditions?)	The technology is endorsed by local experts and adequate for local conditions. There are examples of rooftop solar for various commercial and households in SKN. **Advantage(s)** • Proven, mature and reliable technology • Very good scalability • Job opportunities for technically skilled in installation, operation and maintenance • Very low health and environmental risks • Capital and O+M costs decreasing as PV is being widely adopted worldwide **Disadvantage(s)**

	• Variable source of energy increasing the demand for storage and/or backup capacities • Limited human capacity and expertise in SKN increasing the risk of malfunctioning systems • High upfront costs • Increases the risk of social inequality – medium to high income households can bear the upfront cost and enjoy lower electricity costs while low-income households will be threatened by high non-fuel costs from the utility
Costs	
Cost to Implement Mitigation Technology Additional cost to implement mitigation option compared to "business as usual"	The cost of rooftop PV systems can be easily found online. For example, 4 kW grid-tied systems can be found for 7000-8000 USD. Currently, there are no incentives and with high shipping and duties, the upfront costs of these systems is high for households in the Federation. There are no regulations / framework for net metering which inhibits the adoption of this technology locally. Feasibility studies are now being conducted.
Development Impacts - Direct and Indirect Benefits	
Reduction of vulnerability to climate change	Adoption of rooftop solar systems would increase the proportion of clean renewable energy in the national energy mix; lower and stabilize energy prices; reduce reliance on imported fossil fuels; reduce carbon emissions; increase energy independence; and promote economic development.
Economic benefits (including employment, investment, public and private expenditures) Social benefits (including income, education, health)	Wide array of possible economic benefits including employment and investment by local and foreign entities and the possibility for economic diversification that comes with cheaper and abundant energy supply. With a more affordable energy supply, there is more income available to each household to spend on education, health, wellness and leisure.
Environmental Benefits (Indirect)	Solar PV is a clean technology and has the following additional environmental benefits: (i) Grid connected-distributed PV systems that are roof-mounted and do not require additional land usage for its installation. (ii) Solar PV systems are considered ‘closed’ systems and hence require no fuel or any inputs during operation and electricity production. It also does not contaminate water. (iii) Solar PV systems cause no noise or vibration and hence considered environmentally friendly.

	(iv) Predictions are that upwards of 80% of the bulk material in solar panels will be recyclable; recycling of solar panels is already economically viable.
Gender aspects	The incremental increase in supply will promote equity in distribution and facilitate wider access to existing and potential users especially vulnerable persons.
Local Context	
Opportunities and Barriers	Solar PV systems are very well suited to the tropical environment of the Caribbean but in the absence of a framework for net metering and incentives for importing systems manufactured elsewhere, the technology has not seen wide penetration in the Federation.
Market Potential	Equipment and suppliers available for the Caribbean Region
Status	Practiced
Timeframe for implementation	Medium term
Acceptability to local stakeholders	Acceptable
References	

<table>
<tr><td colspan="2">Technology Category: Electricity Generation
Technology: Improved efficiency in transmission and distribution (smart grids)</td></tr>
<tr><td>Introduction</td><td>A smart grid is an electrical grid which includes a variety of operational and energy measures including smart meters, smart appliances, renewable energy resources, and energy efficient resources. Electronic power conditioning and control of the production and distribution of electricity are important aspects of the smart grid (CTCN 2017).</td></tr>
<tr><td>Technology Characteristics/Highlights</td><td>A smart grid is an electricity network that uses digital and other advanced technologies to monitor and manage the transport of electricity from all generation sources to meet the varying electricity demands of end users (IEA 2022).



The smart grid is a combination of technologies that can include: home energy management, advanced metering infrastructure, distribution and substation automation communications, asset management and condition monitoring, demand response, software solutions, and analytics (Sooknanan et al. 2016). One of the main characteristics of the smart grid is the deployment of renewable and distributed resources, thus leading to a reduction in GHG emissions. Renewables have been discussed in other factsheets but it is noted that these go hand in hand with smart grid technologies.

The NDC implementation plan of 2022 for SKN speaks to reduction of losses from transmission and distribution which surely should include smart grid technologies although not explicitly stated. It is estimated that upgrades to transmission lines could cost upwards 391 Million USD.</td></tr>
<tr><td colspan="2">Institutional and Organizational Requirements</td></tr>
<tr><td>Scale of the application / Size of beneficiary group</td><td>All residents of St. Kitts and Nevis.</td></tr>
<tr><td>Operation and Maintenance</td><td>Operation and maintenance require a cadre of highly skilled technician across various fields such as ICT and power generation.</td></tr>
<tr><td>Advantages and disadvantages
(Is the technology endorsed by local experts? Is it adequate for local conditions?)</td><td>Advantages

- Designed to reroute power to where it is needed thus minimizing outages</td></tr>
</table>

	• Limit inefficiencies by allowing more automatic processes and user controls • Monitor usage trends and turn off when not in use • Makes it easier to incorporate more renewable energy resources **Disadvantages** • High upfront costs • Continuous data usage / privacy issue related to use of consumer's personal data • Vulnerable to cyber attacks
Costs	
Cost to Implement Mitigation Technology Additional cost to implement mitigation option compared to "business as usual"	Very capital intensive. No studies have quantified the costs for SKN. Broadly speaking, the investment in transmission and distribution alone could be as high as 391 Million USD (NDC Implementation Plan 2022)
Development Impacts - Direct and Indirect Benefits	
Reduction of vulnerability to climate change	Adoption of smart grid technologies would increase the proportion of clean renewable energy in the national energy mix; lower and stabilize energy prices; reduce reliance on imported fossil fuels; reduce carbon emissions; increase energy independence; and promote economic development.
Economic benefits (including employment, investment, public and private expenditures) Social benefits (including income, education, health)	Wide array of possible economic benefits including employment and investment by local and foreign entities and the possibility for economic diversification that comes with cheaper and abundant energy supply. With a more affordable energy supply, there is more income available to each household to spend on education, health, wellness and leisure.
Environmental Benefits (Indirect)	Main benefit of smart grid technologies are related to wider distribution of renewables, energy efficiency and reduction of greenhouse emisions.
Gender aspects	The incremental increase in supply will promote equity in distribution and facilitate wider access to existing and potential users especially vulnerable persons.
Local Context	
Opportunities and Barriers	Utilities must determine and select relevant business objectives; select the appropriate smart grid technologies to match these objectives, while avoiding total investment in any one technology without proper evaluation; invest in and deploy renewable and

	alternative energy sources; find and promote local and regional smart grid markets; implement legislation and regulation frameworks, while adhering to worldwide standards; and foster and promote an energy conservative, eco-friendly culture (Sooknanan et al. 2016).
Market Potential	Equipment and suppliers available for the Caribbean Region
Status	Smart meters installed in SKN in recent times
Timeframe for implementation	Medium to long term
Acceptability to local stakeholders	Acceptable

References

UN Climate Technology and Network (CTCN) (2017) Smart grids factsheet. https://www.ctc-n.org/technologies/smart-grid. Accessed on January 18, 2023

International Energy Agency (IEA) (2022), Smart Grids, IEA, Paris https://www.iea.org/reports/smart-grids, License: CC BY 4.0

Sooknanan, D., Bahadoorsingh, S., Joshi, A. and Sharma, D. (2016) Smart Grid Analysis for the Caribbean Region. West Indian Journal of Engineering 38(2): 24-32.

Annex V: Technology Factsheets for Short Listed Technologies – Transport Sector

Technology Category: Shift towards public transport, cycling and walking **Technology: Improved facilities for cycling and walking (sidewalks, cycles ways and lanes and cycle parking)**	
Introduction	SKN total GHG emissions increased by 19.7% or approximately 60 ktCO_2eq in 2018 compared to the 2010 levels (excluding emissions/removals from LULUCF) according to the latest National Inventory Report. This increase corresponds to an increase in GHG emissions of 26% in the energy sector over the same period, mainly attributed to the transport sector, with an increase of approximately 91% in 2018 from 2010 levels. The energy sector represented 77% and 81% of total GHG emissions in 2010 and 2018, respectively (TNC 2021). The transport sector is the second largest emitter in the Federation of SKN. An important part of the equation in trying to reform the transportation section is a revival of non-motorized transport (NMT), more specifically promotion of walking and cycling to move around for short distances.
Technology Characteristics/Highlights	The key to reversing the trend towards more private vehicle use is making walking and cycling attractive, together with improving public transport. This can be done by a range of activities including construction of sidewalks and bike lanes, bike sharing programmes, urban planning and pedestrian-oriented development. NMT is a highly cost-effective transportation strategy and brings about large health, economic and social co-benefits, particularly for the urban poor (CTCN 2016). Specific ways to improve non-motorised transportation (CTCN 2016) are: • Improve sidewalks, crosswalks, paths, bicycle lanes and networks. • Public bicycle systems (automated bicycle rental systems designed to provide efficient mobility for short, utilitarian urban trips). • Develop pedestrian oriented land use and building design. • Increase road and path connectivity, with special non motorised shortcuts • Traffic calming, streetscape improvements, traffic speed reductions, vehicle restrictions and road space reallocation. • Safety education, law enforcement and encouragement programs. • Bicycle parking. • Bicycle integration in transit systems (e.g. racks in metro or on bus) • Address security concerns of pedestrians and cyclists. • Congestion pricing • Vehicle parking policies • Fuel taxes

	The focus on this factsheet is on improved sidewalks, crosswalks, paths, bicycle lanes and parking and overall public education and awareness to promote more walking and biking.
Institutional and Organizational Requirements	
Scale of the application / Size of beneficiary group	All residents of St. Kitts and Nevis.
Operation and Maintenance	Very straightforward similar to operation and maintenance of road infrastructure which is already taking place.
Advantages and disadvantages (Is the technology endorsed by local experts? Is it adequate for local conditions?)	NMT is adequate for local conditions and endorsed by local experts. There are major advantages related to costs as it is generally more cost effective to develop sidewalks and cycling routes relative to the cost of other transport infrastructure (CTCN 2017). It is will well suited to short to medium travel distances which are common in SIDS. The main disadvantage is related to spatial planning and whether or not there is enough space to improve walking and cycling routes.
Costs	
Cost to Implement Mitigation Technology Additional cost to implement mitigation option compared to "business as usual"	NMT policies and investments have a positive benefits-cost ratio (often larger than 5), particularly when co-benefits for health, safety and quality of life are taken into account (CTCN 2016) but no specific studies have been conducted for SKN. The cost of bicycle paths, including construction, maintenance and awareness campaigns, has been estimated at being $ 200,000 per km (CTCN 2016). Upgrades to road infrastructure could be substantial.
Development Impacts - Direct and Indirect Benefits	
Reduction of vulnerability to climate change	Overall, NMT can displace use of transport options which are high emitters of GHG thus reducing vulnerability to climate change.
Economic benefits (including employment, investment, public and private expenditures) Social benefits (including income, education, health)	Economic • NMT, particularly cycling, is easy, flexible, cheap and fast • More attractive cities for tourists and residents, particularly if car-free zones are included • Reduced travel times due to improved traffic flow • Energy security due to lower vehicle energy use • Greater economic inclusion Social • Congestion reduction • Health benefits due to exercise. • Diverts income from car and gas expenditure to other priorities. • Improved safety

<table>
<tr><td>Environmental Benefits (Indirect)</td><td>Environmental benefits include air quality improvement, noise reduction and GHG emissions reduction.</td></tr>
<tr><td>Gender aspects</td><td>Vulnerable persons have increased access to non-motorized transport with social equality and poverty reduction as associated benefits.</td></tr>
<tr><td colspan="2">Local Context</td></tr>
<tr><td>Opportunities and Barriers</td><td>Technology is widely available and practiced and generally lower cost compared to other technologies. Issues related to spatial planning would be the main barrier.

Some of the other barriers towards implementing a successful NMT policy are (CTCN 2016):

• Private-vehicle-oriented transport and spatial planning,
• Public perception and status: walking, cycling (and public transport) is perceived as the transportation mode for the poor.
• Safety: pedestrians and particularly cyclist are vulnerable,
• Lack of convenient public transport, which is required to make NMT a good option for multi-modal trip (i.e. the combination of cycling and rapid bus or rail systems).
• Lack of overall long-term, integrated vision and planning.</td></tr>
<tr><td>Market Potential</td><td>Equipment and suppliers available for the Caribbean Region</td></tr>
<tr><td>Status</td><td>Practiced</td></tr>
<tr><td>Timeframe for implementation</td><td>Short to medium term</td></tr>
<tr><td>Acceptability to local stakeholders</td><td>Acceptable</td></tr>
<tr><td colspan="2">References

CTCN (2017) and (2016) Promotion of non-motorized transport. https://www.ctc-n.org/technologies/promotion-non-motorised-transport-0 and https://www.ctc-n.org/technologies/promotion-non-motorised-transport
Accessed on January 23, 2023.</td></tr>
</table>

Technology Category: Shift towards public transport, cycling and walking (smart mobility) **Technology: Intelligent transport systems**	
Introduction	SKN total GHG emissions increased by 19.7% or approximately 60 ktCO_2eq in 2018 compared to the 2010 levels (excluding emissions/removals from LULUCF) according to the latest National Inventory Report. This increase corresponds to an increase in GHG emissions of 26% in the energy sector over the same period, mainly attributed to the transport sector, with an increase of approximately 91% in 2018 from 2010 levels. The energy sector represented 77% and 81% of total GHG emissions in 2010 and 2018, respectively (TNC 2021). The transport sector is the second largest emitter in the Federation of SKN. This factsheet will focus on smart mobility specifically intelligent transport systems (akin to smart grids for the energy sector).
Technology Characteristics/Highlights	Intelligent Transport System (ITS) basically refers to the application of information and communication technologies to vehicles and to transport infrastructure. Some examples of transport management systems include GPS based optimization of public transport, computerized traffic signaling, information systems such as e-ticketing, e-information etc. Such systems increase the reliability, safety, efficiency and quality of transport systems. An increase in the efficiency of the transport system also leads to a reduction in associated GHG emissions.
Institutional and Organizational Requirements	
Scale of the application / Size of beneficiary group	All residents of St. Kitts and Nevis.
Operation and Maintenance	High. May require cadre of highly skilled ICT professionals which may not be available.
Advantages and disadvantages (Is the technology endorsed by local experts? Is it adequate for local conditions?)	The technology is new and not practiced locally but suitable to a certain extent to SKN. A study by Alonso et al. 2022 in the Dominican Republic suggests that opinions, intentions, and usage willingness of ITSs could be rather split, especially among users who currently have little information about them. ITSs contribute to improving users' safety, traffic flows, and trip-related decisions. In practical terms, this means minimizing congestion, reducing pollution, and (equally important) enhancing mobility as a potentially positive and safe experience (Alonso et al. 2022). Smart mobility solutions rely heavily on technology for solutions. Thus, given the very high reliance on digital technology solutions, smart mobility solutions face increased cyber-security risks (UNEP CCC 2021).
Costs	
Cost to Implement Mitigation Technology	Costs for the various ITS applications may include (CTCN 2016):

Additional cost to implement mitigation option compared to "business as usual"	• Investments in infrastructure, e.g. toll gantries, traffic detectors, road-side information displays and communication systems • Investments in vehicles, such as on-board electronic meters, GPS systems • Investments in travel time information systems • Policy implementation, including awareness campaigns • Operation and maintenance of the systems
Development Impacts - Direct and Indirect Benefits	
Reduction of vulnerability to climate change	ITS will allow for a more efficient transport system will emit less GHG emissions.
Economic benefits (including employment, investment, public and private expenditures) Social benefits (including income, education, health)	More efficient transport management system directly results in fuel savings thereby reducing dependence on import of fuel, fewer costs to health from pollution and accidents and cost savings by not having to invest in new road infrastructure. Social benefits include increased safety and health of residents thus increasing the quality of living.
Environmental Benefits (Indirect)	Environmental benefits include less noise, less traffic congestion, and less air pollution.
Gender aspects	ITS can provide for a more balanced and sociable use of public spaces which will positively impact vulnerable groups.
Local Context	
Opportunities and Barriers	With the rollout of different types of vehicles such as EVs, ITS will play an important supporting role and it can work is a variety of situations. ITS are often technologically complex which requires careful planning and public consultation and monitoring (CTCN 2016). Barriers to implementation include: • High initial investments • Complex implementation process due to roll-out to large numbers of end-users • Technological complexity • Uncertainty regarding costs, benefits and public acceptance • Protection of privacy, security and legal issues • High data requirement for ITS operations
Market Potential	Equipment and suppliers not available for the Caribbean Region
Status	Not practices

Timeframe for implementation	Medium to long term
Acceptability to local stakeholders	Acceptable

References

Alonso, F. et al. (2022) Could Technology and Intelligent Transport Systems Help Improve Mobility in an Emerging Country? Challenges, Opportunities, Gaps and Other Evidence from the Caribbean. *Applied Science* 12(9), 4759; https://doi.org/10.3390/app12094759

CTCN (2016) Intelligent Transport Systems. https://www.ctc-n.org/technologies/intelligent-transport-systems. Accessed on January 23, 2023.

UNEP CCC (2021) TNA Guidebook: Climate Technologies in an Urban Context. https://tech-action.unepccc.org/new-guidebook-climate-tech-in-an-urban-context/. Accessed on January 23, 2023.

Technology Category: Increase share of clean and low-carbon vehicles Technology: Hybrid and Battery electric vehicles	
Introduction	SKN total GHG emissions increased by 19.7% or approximately 60 ktCO_2eq in 2018 compared to the 2010 levels (excluding emissions/removals from LULUCF) according to the latest National Inventory Report. This increase corresponds to an increase in GHG emissions of 26% in the energy sector over the same period, mainly attributed to the transport sector, with an increase of approximately 91% in 2018 from 2010 levels. The energy sector represented 77% and 81% of total GHG emissions in 2010 and 2018, respectively (TNC 2021). The transport sector is the second largest emitter in the Federation of SKN. This factsheet will focus on battery electric vehicles (EVs) and hybrids.
Technology Characteristics/Highlights	Generally, electric vehicles use electricity to change a battery and transform that energy to mechanical energy to drive the wheels of the vehicle (CTCN 2017). There are many types of electric vehicles, these include: • Hydrogen fuel cell vehicles (see attached factsheet) • Battery electric vehicles • Hybrid electric vehicles The battery electric vehicle also gets it power from the power grid, which changes a battery. The power from the battery is used to propel the vehicle. The hybrid electric vehicle has a small internal combustion engine. This vehicle also obtains its power from the grid, but the internal combustion engine is used to recharge the battery, if needed, thus extending the range of the vehicle.
Institutional and Organizational Requirements	
Scale of the application / Size of beneficiary group	All residents of St. Kitts and Nevis.
Operation and Maintenance	All-electric vehicles typically require less maintenance than conventional vehicles because (US DOE 2023): • The battery, motor, and associated electronics require little to no regular maintenance • There are fewer fluids, such as engine oil, that require regular maintenance • Brake wear is significantly reduced due to regenerative braking • There are far fewer moving parts relative to a conventional fuel engine.
Advantages and disadvantages	There are very few battery plug-in EVs in SKN. The technology is endorsed by local experts and is adequate for local conditions. For example, Barbados is the top user of electric vehicles per capita in

(Is the technology endorsed by local experts? Is it adequate for local conditions?)	the Caribbean of EVs, with over 430 on the island's road generally powered by solar car ports (IADB 2021). **Advantage(s)** • Reduced carbon dioxide emissions • Greater fuel efficiency • Lower maintenance costs compared to the combustion engine • Opportunity to create new jobs and build new skill sets • High public interests **Disadvantage(s)** • Higher capital cost compared to the conventional combustion engine vehicle • Lack of charging infrastructure (powered by renewable energy sources or even fossil fuel sources) • Lack of local dealer support • Concerns with battery life and replacement costs
Costs	
Cost to Implement Mitigation Technology Additional cost to implement mitigation option compared to "business as usual"	In SKN's NDC Implementation Plan of 2022, one major mitigation option is to aim for 2% EV and 2% hybrid vehicle penetration by 2030 with a stated target of 624 EVs, 25 level 2 charging station and 3 level 3 charging stations estimated to cost 14.8 Million USD (GOSKN 2022). Various actions would have to be taken to achieve this target including: • Establishment of vehicle electrification target for privately owned vehicles and for the government vehicle fleet. • Conduct fuel consumption level study to inform reduction measures. • Conduct a CBA of transitioning to EV • Design and implement financial and regulatory incentives to encourage EVs uptake. • Raise public awareness of the benefits of EVs and dispel common myths. • Proffer Incentives for EV owners to install charging points at home. Conduct feasibility analysis of establishing charging stations for electrical vehicles in public facilities. • Development of an EV charging infrastructure plan. • Implement pilot/demonstration projects at major public facilities on both St. Kitts and Nevis. • Private sector partnerships to roll out charging infrastructure. • Feasibility analysis of establishing charging stations for electrical vehicles in public facilities. • Establish a pilot project at a major facility in both St. Kitts and Nevis. • Establish procurement policies to ensure EVs replace ICEVs.
Development Impacts - Direct and Indirect Benefits	
Reduction of vulnerability to climate change	The energy efficiency of electric cars is at least 2.5 times better than their fossil fuel counterparts (CTCN 2016) and can lead to considerable reduction in GHG emissions especially if the electricity is generated from renewables.

Economic benefits (including employment, investment, public and private expenditures) Social benefits (including income, education, health)	With progressive incentives and policies, the economic benefits of EVs include greater public / private partnerships and ultimately expenditure (with proven examples in Barbados, the Dominican Republic and Jamaica, IADB 2021). By ultimately reducing dependence on fossil fuels and associated air pollution and GHG emissions, EVs can promote greater health and more available income assuming the electricity powering the battery is from renewables.
Environmental Benefits (Indirect)	Electric vehicles have no tail-pipe emission of air pollutants and assuming they are powered by renewables little GHG emissions. They produce very little noise compared to conventional vehicles.
Gender aspects	The incremental increase in energy supply since EVs are more energy efficient will promote equity in distribution and facilitate wider access to existing and potential users especially vulnerable persons.
Local Context	
Opportunities and Barriers	Since SKN is a small island, the range issues associated with the EV can be mitigated as distances between points are generally short which is a major opportunity related to EVs. Combined with the emerging potential for renewables, there is a great opportunity to reduce SKN's dependence on fossil fuels. The main barriers for a wider user of electric vehicles are related to the batteries and to the recharging infrastructure.
Market Potential	Equipment and suppliers available for the Caribbean Region
Status	Practiced
Timeframe for implementation	Medium to long term
Acceptability to local stakeholders	Acceptable

References

CTCN (2016) Electric Vehicles factsheet. https://www.ctc-n.org/technologies/electric-vehicles. Accessed on January 24, 2023.

IADB (2021) Electrifying the Caribbean: Plugging in Electric Vehicles https://blogs.iadb.org/energia/en/electrifying-the-caribbean-plugging-in-electric-vehicles/ Accessed on January 24, 2023

GOSKN (2022) NDC Implementation Plan. https://ndcpartnershipplans.com/public/view/e0948d8c-705c-4a9a-9d48-3287d1428701. Accessed on January 24, 2023.

US Department of Energy (Energy Efficiency and Renewable Energy) (2023) Maintenance and Safety of Electric Vehicles. https://afdc.energy.gov/vehicles/electric_maintenance.html. Accessed on January 24, 2023

Technology Category: Increase share of clean and low-carbon vehicles **Technology: Fuel-cell hydrogen vehicles**	
Introduction	SKN total GHG emissions increased by 19.7% or approximately 60 ktCO_2eq in 2018 compared to the 2010 levels (excluding emissions/removals from LULUCF) according to the latest National Inventory Report. This increase corresponds to an increase in GHG emissions of 26% in the energy sector over the same period, mainly attributed to the transport sector, with an increase of approximately 91% in 2018 from 2010 levels. The energy sector represented 77% and 81% of total GHG emissions in 2010 and 2018, respectively (TNC 2021). The transport sector is the second largest emitter in the Federation of SKN. This factsheet will focus on fuel cell hydrogen vehicles.
Technology Characteristics/Highlights	Generally, electric vehicles (EVs) use electricity to change a battery and transform that energy to mechanical energy to drive the wheels of the vehicle. There are many types of electric vehicles, these include: • Hydrogen fuel cell vehicles (FCEVs) • Battery electric vehicles (BEVs) (see attached factsheet) • Hybrid electric vehicles (HEVs) (see attached factsheet) The fuel cell electric vehicle obtains its power from the power grid or any other power source generally hydrogen fuel. However, the vehicle has a fuel cell built into it that stores energy that can be used to recharge the battery when needed. This will extend the range of the vehicle. FCEVs use a propulsion system like that of electric vehicles, where energy stored as hydrogen is converted to electricity by the fuel cell (US DOE 2023). FCEVs are fueled with pure hydrogen gas stored in a tank on the vehicle. FCEVs are equipped with other advanced technologies to increase efficiency, such as regenerative braking systems that capture the energy lost during braking and store it in a battery.
Institutional and Organizational Requirements	
Scale of the application / Size of beneficiary group	All residents of St. Kitts and Nevis.
Operation and Maintenance	All-electric vehicles including FCEVs typically require less maintenance than conventional vehicles because (US DOE 2023): • The fuel cell, battery, motor, and associated electronics require little to no regular maintenance • There are fewer fluids, such as engine oil, that require regular maintenance • Brake wear is significantly reduced due to regenerative braking

	There are far fewer moving parts relative to a conventional fuel engine.
Advantages and disadvantages (Is the technology endorsed by local experts? Is it adequate for local conditions?)	1.1.1 **Advantages** • Efficiency • Zero tailpipe emissions • Short fueling time **Disadvantages** • Vehicles are expensive • Filling stations are limited or non-existent • Fuel is expensive and costs more than charging an electric car or filling up a combustion engine. • Fuel may come from non eco-friendly sources
Costs	
Cost to Implement Mitigation Technology Additional cost to implement mitigation option compared to "business as usual"	FCEVs are currently still more expensive than their other EV counterparts. Unlike a battery, where most of the cost comes from the raw materials used to make it, the most expensive part of a fuel cell is manufacturing the fuel cell stack itself—not the materials to produce it. The cost to build and maintain hydrogen stations also needs to decrease for the market to support a hydrogen economy (US DOE 2023). Currently, there is no real hydrogen economy anywhere in the Caribbean.
Development Impacts - Direct and Indirect Benefits	
Reduction of vulnerability to climate change	The energy efficiency of electric cars is at least 2.5 times better than their fossil fuel counterparts (CTCN 2016) and can lead to considerable reduction in GHG emissions especially if the hydrogen fuel is readily available.
Economic benefits (including employment, investment, public and private expenditures) Social benefits (including income, education, health)	With progressive incentives and policies, the economic benefits of EVs include greater public / private partnerships and ultimately expenditure (with proven examples in Barbados, the Dominican Republic and Jamaica, IADB 2021). By ultimately reducing dependence on fossil fuels and associated air pollution and GHG emissions, EVs can promote greater health and more available income.
Environmental Benefits (Indirect)	Electric vehicles have no tail-pipe emission of air pollutants or GHG emissions (only warm air and water vapour are emitted). They produce very little noise compared to conventional vehicles.
Gender aspects	The incremental increase in energy supply since EVs are more energy efficient will promote equity in distribution and facilitate wider access to existing and potential users especially vulnerable persons.
Local Context	
Opportunities and Barriers	The main barrier is the availability of hydrogen to fuel these vehicles. However, with the increase in renewables across the Federation, it should be a good opportunity to be able to produce hydrogen locally.

Market Potential	Equipment and suppliers available for the Caribbean Region
Status	Not Practiced
Timeframe for implementation	Medium to long term
Acceptability to local stakeholders	Acceptable

References

CTCN (2016) Electric Vehicles factsheet. https://www.ctc-n.org/technologies/electric-vehicles. Accessed on January 24, 2023.

IADB (2021) Electrifying the Caribbean: Plugging in Electric Vehicles https://blogs.iadb.org/energia/en/electrifying-the-caribbean-plugging-in-electric-vehicles/ Accessed on January 24, 2023

US Department of Energy (Energy Efficiency and Renewable Energy) (2023). Fuel Cell Electric Vehicles. https://afdc.energy.gov/vehicles/fuel_cell.html. Accessed on January 24, 2023

Annex VI: MCA Matrix – Water Sector

Scoring Matrix									
								Other	
	Costs		Economic	Social		Environmental	Climate related	Institutional/Implementation	
	Capital Costs	**O+M Costs**	**Improve economic performance**	**Build technical capacity**	**Improve health**	**Protect Environmental (Water) Resources**	**Reduce vulnerability to climate change impacts**	**Ease of implementation / Replicability / Appropriateness**	
Leakage detection and repair and pressure management	50	40	90	100	60	90	90	70	
Non-revenue water and demand management programme and smart metering	60	50	100	100	60	90	90	80	
Real-time data monitoring / SCADA / GIS	60	50	60	100	60	90	90	70	
Groudwater assessment, mapping, modelling and development	20	10	80	70	80	50	50	50	
Water safety plans / Water quality control	100	60	50	90	100	70	70	60	
Integrated Water Resources Management	80	60	70	90	90	80	80	60	
Enhanced potable water storage	30	100	50	50	50	50	50	100	
Stormwater harvesting (small reservoirs and micro-catchments)	40	30	80	70	70	70	70	50	
Desalination	0	0	80	70	80	50	50	90	
Scoring scale	0=very high cost --> 100=very low cost	0=very high cost --> 100=very low cost	0= Very low --> 100= Very high	0= Very low --> 100= Very high	0= Very low --> 100= Very high	0= Very low --> 100= Very high	0= Very low --> 100= Very high	0=Very Difficult --> 100=Very Easy	
Criterion weight	0.1	0.1	0.2	0.1	0.1	0.15	0.15	0.1	1

Decision Matrix: Weighted Scores									
								Other	
	Costs			Social			Climate related	Institutional/Implementation	
	Capital Costs	**O+M Costs**	**Improve economic performance**	**Build technical capacity**	**Improve health**	**Protect Environmental (Water) Resources**	**Reduce vulnerability to climate change impacts**	**Ease of implementation / Replicability / Appropriateness**	**Total Weighted Score**
Leakage detection and repair and pressure management	5	4	18	10	6	13.5	13.5	7	77
Non-revenue water and demand management programme and smart metering	6	5	20	10	6	13.5	13.5	8	82
Real-time data monitoring / SCADA / GIS	6	5	12	10	6	13.5	13.5	7	73
Groudwater assessment, mapping, modelling and development	2	1	16	7	8	7.5	7.5	5	54
Water safety plans / Water quality control	10	6	10	9	10	10.5	10.5	6	72
Integrated Water Resources Management	8	6	14	9	9	12	12	6	76
Enhanced potable water storage	3	10	10	5	5	7.5	7.5	10	58
Stormwater harvesting (small reservoirs and micro-catchments)	4	3	16	7	7	10.5	10.5	5	63
Desalination	0	0	16	7	8	7.5	7.5	9	55
Criterion weight	0.1	0.1	0.2	0.1	0.1	0.15	0.15	0.1	1

Annex VII: MCA Matrix – Agriculture Sector

Scoring Matrix									
	Costs		Benefits					**Other**	
			Economic	**Social**		**Environmental**	**Climate related**	**Institutional/ Implementation**	
	Capital Costs	**O+M Costs**	**Improve economic performance**	**Build technical capacity**	**Improve health**	**Supports Ecosystems Services**	**Reduce vulnerability to climate change impacts**	**Ease of implementation / Replicability / Appropriateness**	
Integrated Pest Management	65	72.5	57.5	80	42.5	65	37.5	80	
Crop diversification and new varieties	55	75	45	52.5	42.5	62.5	72.5	85	
Plant tissue culture	15	20	60	80	29	30	47.5	22.5	
Livestock disease management including selective livestock breeding	45	55	57.5	60	42.5	27.5	25	57.5	
Livestock feed production	47.5	48.75	63.75	47.5	46.25	38.75	50	58.75	
Agrosilviculture	62.5	62.5	45	45	47.5	77.5	76.25	66.25	
Soilless Agriculture / Aquaponics / Hydroponics	28.5	31	72.5	72.5	52.5	57.5	75	53.5	
Soil moisture conservation monitoring and techniques	52.5	61.25	56.25	52.5	51.25	68.75	72.5	63.75	
Integrated soil nutrient management	55	55	60	48.75	53.25	63.75	56.25	60	
Food storage, preservation and processing	22.5	42.5	82.5	67.5	45	20	50	47.5	
Scoring scale	0=very high cost --> 100=very low cost	0=very high cost --> 100=very low cost	0= Very low --> 100= Very high	0= Very low --> 100= Very high	0= Very low --> 100= Very high	0= Very low --> 100= Very high	0= Very low --> 100= Very high	0=Very Difficult --> 100=Very Easy	
Criterion weight	0.1	0.1	0.2	0.1	0.1	0.15	0.15	0.1	1

Decision Matrix: Weighted Scores									
	Costs		Benefits					Other	
			Economic	Social		Environment	Climate	Institutional/Implementation	
	Capital Costs	O+M Costs	Improve economic performance	Build technical capacity	Improve health	Supports Ecosystems Services	Reduce vulnerability to climate change impacts	Ease of implementation / Replicability / Appropriateness	Total Weighted Score
Integrated Pest Management	6.5	7.3	11.5	8.0	4.3	9.8	5.6	8.0	**60.9**
Crop diversification and new varieties	5.5	7.5	9.0	5.3	4.3	9.4	10.9	8.5	**60.3**
Plant tissue culture	1.5	2.0	12.0	8.0	2.9	4.5	7.1	2.3	**40.3**
Livestock disease management including selective livestock breeding	4.5	5.5	11.5	6.0	4.3	4.1	3.8	5.8	**45.4**
Livestock feed production	4.8	4.9	12.8	4.8	4.6	5.8	7.5	5.9	**50.9**
Agrosilviculture	6.3	6.3	9.0	4.5	4.8	11.6	11.4	6.6	**60.4**
Soilless Agriculture / Aquaponics / Hydroponics	2.9	3.1	14.5	7.3	5.3	8.6	11.3	5.4	**58.2**
Soil moisture conservation monitoring and techniques	5.3	6.1	11.3	5.3	5.1	10.3	10.9	6.4	**60.6**
Integrated soil nutrient management	5.5	5.5	12.0	4.9	5.3	9.6	8.4	6.0	**57.2**
Food storage, preservation and processing	2.3	4.3	16.5	6.8	4.5	3.0	7.5	4.8	**49.5**
Criterion weight	0.1	0.1	0.2	0.1	0.1	0.15	0.15	0.1	1

Annex VIII: MCA Matrix – Energy Sector

Scoring Matrix									
								Other	
	Costs		**Economic**	**Social**		**Environmental**	**Climate related**	**Institutional / Implementation**	
	Capital Costs	**O+M Costs**	**Improve economic performance (including job creation)**	**Build technical capacity**	**Improve health**	**Protect Environmental Resources**	**Reduce GHG emissions**	**Ease of implementation / Replicability / Appropriateness**	
Solar water heating	25	100	60	80	50	50	50	80	
Energy efficient HVAC systems	85	90	40	20	40	40	40	80	
Energy efficient water pumping systems (solar)	75	75	70	20	40	40	40	80	
Utility scale geothermal	10	60	90	70	80	30	80	10	
Residential grid-tied solar	15	90	70	80	50	50	50	40	
Improve efficiency in transmission and distribution (smart grid)	50	70	50	50	30	50	50	25	
Scoring scale	0=very high cost --> 100=very low cost	0=very high cost --> 100=very low cost	0= Very low --> 100= Very high	0= Very low --> 100= Very high	0= Very low --> 100= Very high	0= Very low --> 100= Very high	0= Very low --> 100= Very high	0=Very Difficult --> 100=Very Easy	
Criterion weight	0.1	0.1	0.2	0.1	0.1	0.15	0.15	0.1	1

Decision Matrix: Weighted Scores									
	Costs			Social			Climate related	Other Institutional / Implementation	
	Capital Costs	O+M Costs	Improve economic performance (including job creation)	Build technical capacity	Improve health	Protect Environmental Resources	Reduce GHG emissions	Ease of implementation / Replicability / Appropriateness	Total Weighted Score
Solar water heating	2.5	10	12	8	5	7.5	7.5	8	60.5
Energy efficient HVAC systems	8.5	9	8	2	4	6	6	8	51.5
Energy efficient water pumping systems (solar)	7.5	7.5	14	2	4	6	6	8	55
Utility scale geothermal	1	6	18	7	8	4.5	12	1	57.5
Residential grid-tied solar	1.5	9	14	8	5	7.5	7.5	4	56.5
Improve efficiency in transmission and distribution (smart grid)	5	7	10	5	3	7.5	7.5	2.5	47.5
Criterion weight	0.1	0.1	0.2	0.1	0.1	0.15	0.15	0.1	1

Annex IX: MCA Matrix – Transport Sector

Scoring Matrix									
	Costs		**Economic**	**Social**		**Environmental**	**Climate related**	**Other** **Institutional / Implementation**	
	Capital Costs	**O+M Costs**	**Improve economic performance (including job creation)**	**Build technical capacity**	**Improve health**	**Protect Environmental Resources**	**Reduce GHG emissions**	**Ease of implementation / Replicability / Appropriateness**	
Development and rehabilitation of sidewalks, cycle ways and lanes and safe cycle parking	40	70	60	30	90	80	80	30	
Intelligent transport systems	40	60	50	75	50	60	50	50	
Hybrids and Battery electric vehicles	30	55	70	75	75	75	60	50	
Fuel-cell hydrogen vehicles	20	40	50	75	75	75	70	10	
Scoring scale	0=very high cost --> 100=very low cost	0=very high cost --> 100=very low cost	0= Very low --> 100= Very high	0= Very low --> 100= Very high	0= Very low --> 100= Very high	0= Very low --> 100= Very high	0= Very low --> 100= Very high	0=Very Difficult --> 100=Very Easy	
Criterion weight	0.1	0.1	0.2	0.1	0.1	0.15	0.15	0.1	1

Decision Matrix: Weighted Scores

	Costs		Economic	Social		Environment	Climate	Other: Institutional / Implementation	
	Capital Costs	O+M Costs	Improve economic performance (including job creation)	Build technical capacity	Improve health	Protect Environmental Resources	Reduce GHG emissions	Ease of implementation / Replicability / Appropriateness	Total Weighted Score
Development and rehabilitation of sidewalks, cycle ways and lanes and safe cycle parking	4	7	12	3	9	12	12	3	62
Intelligent transport systems	4	6	10	7.5	5	9	7.5	5	54
Hybrids and Battery electric vehicles	3	5.5	14	7.5	7.5	11.25	9	5	62.75
Fuel-cell hydrogen vehicles	2	4	10	7.5	7.5	11.25	10.5	1	53.75
Criterion weight	0.1	0.1	0.2	0.1	0.1	0.15	0.15	0.1	1