GRENADA

TECHNOLOGY NEEDS ASSESSMENT

ADAPTATION REPORT

February 2017

Foreword

Grenada, a small island developing nation, is among the countries most vulnerable to the projected impacts of climate change. Having experienced several extreme events in the recent past, including drought and flooding, and growing coastal erosion all resulting in significant impacts on the economy, adaptation is increasingly becoming more prominent on the national agenda.

The Technology Needs Assessment (TNA) project which was initiated by the Ministry of Agriculture, Lands, Forestry, Fisheries and the Environment in collaboration with the Climate Technology Centre & Network (CTCN), United Nations Environment Program and Technical University of Denmark (UNEP-DTU) partnership, is most timely as we have been able to build on recent studies as well as ensure alignment with ongoing planning processes such at the National Adaptation plan (NAP) process and the 15 years National Development Plan process.

I am confident that the TNA project is among the initiatives that would contribute significantly to building Grenada's resilience to climate change. The sectors selected for the adaptation project came out of rigorous stakeholder consultations and are in line with those prioritized in other processes and policies for Grenada.

I would like to thank the National TNA Coordinator and National TNA Committee, the environment division and the adaptation working group of the National Climate Change Committee for their consistent participation when called upon throughout this TNA process.

In addition, I would like to thank the adaptation consultant Mrs. Joyce Thomas Peters for her flexibility and the UNEP-DTU partnership for their support and all the technical support they have provided thus far for the implementation of the TNA project

Kevin Andall
Permanent Secretary w.r.f Human Resource Development and the Environment.

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EXECUTIVE SUMMARY

Grenada is one of twenty-six countries participating in the second phase of the Technology Needs Assessment (TNA) Project. The project is being implemented by UNEP and DTU partnership. It assists developing countries to determine their technology priorities for greenhouse gas mitigation and climate change adaptation. This report presents the results of the technology needs assessment, which was conducted to determine the priorities for adaptation for Grenada.

An initial national stakeholder consultation determined that water would be the priority sector for adaptation to climate change with domestic water supply, agriculture and tourism as the priority subsectors.

Several national documents also identified water as a priority area for adapting to the projected changes in rainfall patterns; including the National Strategic Development Plan 2012-2017.

A review of the literature confirmed that Grenada is vulnerable to climate change and that it is already experiencing changes in its rainfall pattern, resulting in reduced rainfall and more prolonged dry periods.

Ten adaptation technology options were evaluated using the Multi-Criteria Analysis (MCA) methodology. A stakeholder group which was established for that purpose evaluated the technologies. The group was made up of stakeholders with expertise in areas such as water resources management, economics, agronomy, irrigation and environment.

The stakeholders established and weighted the criteria. The importance of each criteria and technology options were discussed separately and voted on individually and as a group; during the first workshop. This process was repeated twice before an agreement was reach on the ranking of the technologies. The micro-sprinkler, drip irrigation, micro-dam and rainwater harvesting consistently received the highest score.

In the absence of data on costs and benefits, expert judgment was used to conduct the analysis. Technology options, which were considered to be expensive, were scored low and therefore received a low priority.

Five of these technologies were selected for further analysis and inclusion in the Technology Action Plan. The following technologies were selected for the next step in the TNA process:

- Micro Sprinkler
- Drip Irrigation
- Desalination
- Micro dam
- Water Reclamation and Reuse

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List of ACRONYMS

CCCCC	Caribbean Community Climate Change Centre
DTU	Technical University of Denmark
GEF	Global Environment Facility
GIZ	Deutsche Gesellschaft fur Internationale Zusammenarbeit
GCM	Global Circulation Model
ICCAS	Integrated Climate Change Adaptation Strategies Programme
iNDC	Intended Nationally Determined Contributions
MCA	Multi-Criteria Analysis
NAWASA	National Water and Sewerage Authority
NDC	Nationally Determined Contribution
RCM	Regional Circulation Model
TNA	Technology Needs Assessment
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNESCO	United Nations Education Scientific and Cultural Organisation
UNFCCC	United Nations Framework Convention on Climate Change

1 Introduction

This report documents the first step in the technology needs assessment process to determine the technology priorities for adaptation to climate change and evaluate alternative technology options for adaptation for Grenada. After the priorities were established the Multi-Criteria Analysis (MCA) methodology was used to evaluate and prioritize the alternative technology options.

The Ministry of Agriculture, Lands, Forestry and Fisheries and the Environment received financial support from the Global Environment Facility /Technical University of Denmark partnership to conduct the Technology Needs Assessment for Grenada.

This section looks at the existing policies and plans relevant to the process, a look at the vulnerability of Grenada with emphasis on the water sector and the sector selection process.

1.1 About the TNA project

The Technology Needs Assessment (TNA) Project is a global project that is being implemented by UNEP and UDT partnership. The project is into its second phase. Grenada is one of 26 countries participating in the second phase of the project which started in 2014.

The TNA project assists developing countries, which are Parties to the United Nations Framework Convention on Climate Change (UNFCCC), to determine their technology priorities for greenhouse gas emission reduction and adaptation.

1.2 Existing national policies related to technology innovation, adaptation to climate change and development priorities

A review of the existing national policy documents relevant to adaptation to climate change and national development plans found that over the past few years Grenada elaborated a National Strategic Development Plan 2012-2017 and several other policies and plans which speak to the water sector. The strategic development plan recognizes the need for long -term water resource planning in light of the prediction of global water scarcity and the emerging patterns of extreme weather events (Charles 2011). One of the objectives of the plan is to ensure a sustainable supply and quality of water to meet domestic and business requirements and the strategy is water sector planning.

The review of the relevant policies and documents found that water was among the sectors identified as a priority for adaptation to climate change. These documents included the Initial Communication to the UNFCCC, the Climate Change Policy and Action Plan 2007-2011 and Grenada's NDCs.

A water policy was drafted in 2007 but it was never finalized. A climate change policy and action plan was developed in 2007. Grenada is currently in the process of updating the National Climate Change policy and developing a National Adaptation Plan and therefore the National Climate Change Policy and Action Plan 2007-2011, although dated, is still being used as the main guiding document for climate change adaptation for Grenada.

In 2015 Grenada submitted its Intended Nationally Determined Contributions (iNDCs) to the UNFCCC and ratified the Paris Agreement on April 22, 2016. The commitments in the now NDC are focused on reduction of greenhouse gases but a report on adaptation activities was also included.

A National adaptation plan and vulnerability assessments for the water sector as well as a national agricultural plan were completed in 2015. Both documents considered the vulnerability of Grenada to climate change and included potential adaptation measures to address the vulnerabilities identified.

Grenada is currently preparing its Second National Communication to the UNFCCC. It is also preparing a National Sustainable Development Plan 2030, which will set out the framework for development for Grenada for the next 15 years.

The NDC document reported that water is crucial to the long-term development of Grenada as a nation. It stated that Grenada's goal is to promote and maintain equitable and sustainable use of the water sources and their watersheds and to improve capture, storage, distribution and conservation of water because it increases the adaptive capacity of individuals and communities (Government of Grenada 2016). . The NDC report cites increased incidents of drought, longer dry seasons, and shorter rainy seasons as evidence of the changes.

The draft National Water Policy 2007 identifies lack of planning for the impacts of climate change as a constraint, and technical sustainability as one of the key challenges to the management of water resources. However, it does not directly address the impact of climate change on water resources.

A National Agricultural Plan for Grenada was completed in 2015. One of the areas of focus of the plan is the strengthening of the agricultural sector's resilience to climate change. It identified the availability of water for irrigation as a potential impact of climate change on the agriculture sector. Storage using rainwater harvesting systems and use of water efficient technologies such as drip irrigation were recommended as adaptation strategies (James 2015). The Grenada National Agricultural Plan 2015 -2030 is predicting that the main economic sectors of agriculture and tourism would be severely impacted by climate change and this could result in a serious blow to the economy, which is in a critical condition (James 2015).

In 2015 a National Adaptation Strategy and Action Plan was completed for the water sector. The strategy documented the vulnerability of the water sector to climate change and addressed the socio-economic impact on agriculture, tourism and the domestic water supply.

In the case of agriculture, the National Adaptation Strategy for water noted that few farmers harvested rainwater. It identified adequate catchment and storage as the main challenge for farmers in the area. Lack of financing for adequate catchment and storage was also identified as a problem. The strategy further stated that the lack of adequate storage resulted in irrigation being practiced mostly in areas close to a river or tributary. According to the strategy, drip irrigation technology is widely used among farmers practicing irrigation (Environmental Solutions Limited 2015).

The strategy recommends changes in institutional arrangements and policy but does not suggest technologies for assisting the water sector in adapting to changes in climate. However, it indicated that farmers perceived irrigation technology as expensive.

It is also useful to note that Grenada is one of the beneficiary countries under the Japan-Caribbean Climate Change Partnership, which was launched in January 2016. Water is also a priority under that project. Outcome 2: Output 2.1 aims to support "Affordable climate-resilient community- based water harvesting storage and distribution systems design, built and rehabilitated in selected target areas (e.g. community reservoirs, rooftops catchment, rainwater storage tanks and conveyance)" and Output 2.3 aims to support "Community- based water capacity and irrigation systems improved to test their ability to raise agricultural production" (United Nations Development Programme Regional: Caribbean Project Document, Japan-Caribbean Climate Change Partnership n.d.).

The National Water and Sewerage Authority (NAWASA) has begun to invest in rainwater harvesting infrastructure. Using funds provided under the adaptation investments subsection of the World Bank funded "Regional Disaster Vulnerability Reduction Project", NAWASA recently installed several water storage tanks. Additionally, NAWASA is currently constructing the first community-based rainwater harvesting system for a community which does not have access to pipe borne water due to its remoteness and altitude. This is being implemented jointly with GIZ and funded as part of the Integrated Climate Change Adaptation Strategies (ICCAS) programme. In addition NAWASA and the Department for Economic and Technical Cooperation with support from GIZ as part of the ICCAS programme are preparing a multi-million USD dollar project proposal for the Green Climate Fund with a focus on water security.

The Caribbean Community Climate Change Centre (CCCCC) has completed the installation of two reverse osmosis desalination plants on the sister isles of Carriacou and Petit Martinique. The plants are already producing water for sale. The plant on Carriacou is a 13m3 /h Salt Water Reverse Osmosis (SWRO) plant while the plant on Petite Martinique is 5m3/h SWRO plant. The plant utilizes photovoltaic panels to produce potable water. The cost of both plants is approximately US $2.5 million.

The Regional Disaster Vulnerability Reduction Project includes a component on Forestry and Water Resources. This component will include the modernization of the hydro-meteorological network of rain and stream flow gauges.

The list of technology options for adaptation in the water sector were selected based on the review of the relevant climate change related documents; while government policies and development priorities were used to guide the prioritization of the technology options.

1.3 Climate Change Vulnerability Assessment Grenada

The vulnerability of the water sector to climate variability and change has been established in several documents. The exposure to prolonged dry periods, which Grenada is already experiencing, is the main threat. These prolonged dry periods have been negatively affecting water supply for agriculture, tourism and potable water use. Studies on vulnerability of the water sector indicate that rainfall patterns have become more uncertain resulting in unreliable rainfall patterns.

In 2012 CARIBSAVE prepared a Climate Change Risk Profile for Grenada; it concluded that Grenada was already experiencing the effects of climate variability and change and that the climate model projections were predicting reduced annual rainfall. The risk profile also concludes that the climate change effects are evident in the decline in the socio-economic sectors such as agriculture and water resources.

The CARIBSAVE report acknowledges the projections of the General Circulation Model (GCM) that overall there would be both increases and decreases in rainfall. However, the report points out that most projections tend toward decreases. It highlights the projections of the Regional Climate Model (RCM), driven by HadCM3 boundary conditions, which indicates decreases in annual rainfall and the simulations based on ECHAM4, which also project significant decreases in rainfall as supporting evidence (CARIBSAVE 2012).

According to the CARIBSAVE risk profile Grenada's agricultural sector is highly vulnerable to the existing climate and susceptible to extended periods of drought. Given the projected seasonal decreases in precipitation, it recommended the management of scarce water resources. Additionally, since higher temperatures and longer dry periods would have implications for productivity, use of efficient irrigation technology in agriculture is also recommended.

According to the risk profile Grenada gets its water supply from permanent rivers, ground water, rainwater harvesting and desalination. It cites a prediction that the surface water can decrease by as much as 30% - 40% during the dry season as evidence that the water sector would be impacted by changes in rainfall (CARIBSAVE 2012).

A vulnerability and capacity assessment for the water sector was conducted in 2015 and the findings support the predictions of the CARIBSAVE risk profile. The vulnerability and capacity assessment showed that between 1986 -2010 there has been a change in the amount of rainfall observed throughout the year; particularly during the wet season. It also reports that the GCMs and the RCMs have projected decreases in rainfall. A sensitivity analysis was conducted as part of the vulnerability assessment and it is also projecting increasingly drier conditions, reduction in surface flows and reduced ground water recharge (Environmental Solutions Limited 2015).

Findings from the vulnerability assessment suggest that there is an increasing awareness of the importance of rain water harvesting. Most small farmers now have some form of irrigation system and limited catchment storage.

The vulnerability assessment recommends increased and improved rainwater harvesting and storage on farms; and investigation into the use of grey water, on-farm water storage; harvested rainwater; surface water (such as streams); sub-surface or ground water; and recycled water (Environmental Solutions Limited 2015).

Water shortages are common during the dry season even when there is no prolonged dry period. During those times the water authority is forced to institute valve regulation and issue restrictions on the use of water. The storage capacity of the water authority is limited to the extent that whenever there is reduced rainfall during the rainy season, it has implications for the availability of water during the following dry season for the tourism industry and domestic water supply.

Reduced rainfall also has implications for local agriculture. In Grenada, agriculture is mostly rain fed and only a limited number of farmers have access to surface water for use of irrigation technology. The eastern side of the island generally receives less rainfall than the western side therefore irrigation technology is more widely used on the eastern side of the island.

A prolonged dry period in 2009/2010 affected the availability of water for agriculture, tourism and domestic use. This was an indication of the sensitivity of the sector and subsectors to climate variability and change. During that period Grenada experienced shortages in domestic water supply and the tourism industry. There was a shortage of agricultural produce, particularly vegetables that were water intensive. Officials from the Agronomy Division of the Ministry of Agriculture reported that tree crops were affected as well.

In order to cope with the projected increase in frequency of prolonged dry periods, the water authority has recently been encouraging property owners to invest in storage tanks in order to increase the storage capacity in the country and increase the adaptive capacity.

Farmers also indicated the need to create storage for water for use in irrigation. This is necessary because of the drastic reduction in the flow level of the river during the dry season. Low flow levels often lead to farmers purchasing larger water pumps and reducing the river to below minimum ecological flows. In addition, low reduced river flow is resulting in competing uses and user conflict over water usage. The limited water storage capacity available to farmers means their adaptive capacity is very low.

Based on the current situation the water sector, and the subsectors of agriculture, tourism and domestic water supply are exposed to prolonged and dry periods. This is because they are negatively affected and the adaptive capacity is low due to limited storage capacity and the reliance on mostly surface water. The potable water supply is also vulnerable. According to the 2011 Population and Housing Census, 97% of households in Grenada rely on potable water from NAWASA. NAWASA relies mostly on surface water, which will be impacted by climate change.

1.4 Sector selection

The sector selection process began with a national stakeholder consultation, which identified water as the priority sector for adaptation for Grenada.

Reduction in rainfall is one of the expected changes in the climate system and it has the potential to negatively impact both sectors as well as domestic water supply; that could have a significant negative impact on the Grenada economy. The number of farmers requiring irrigation technology for use in farming has been increasing. In the case of tourism, most of the hotels are located in the Southwest, which is also the driest part of the island. This means that water must be diverted from water rich areas to the south of the island. The reduction in the availability of water would be a constraint to the development of the hotel sector in the south of the island.

At follow-up meetings of the national TNA team the sector and sub-sectors were discussed further taking into consideration the priority areas in the National Climate Change Policy and NDCs. Domestic water supply, agriculture and tourism were identified as the sub-sectors in the National Climate Change Policy while water was also identified as a priority in the NDCs.

Water was agreed as the priority sector for the TNA and a proposal was developed subject to finalization and Cabinet approval as follows:

Sector/System (resource) Water

Subsectors	**Mitigation**	**Adaptation**
Supply	Water transport and supply (energy for)	Water quality
Demand		Agriculture use
		Tourism use
Waste	Waste Water	

Further discussions on the priority sectors and subsectors were held at the TNA workshop in Peru in July, 2015. Following the workshop in Peru, additional discussions on sector prioritization were held with stakeholders and water was confirmed as the priority sector with agriculture, domestic water supply and tourism as sub-sectors.

The existing climate change policy documents and other relevant national documents also guided the sector and sub-sectors selection. The National Climate Change Policy and Action Plan 2007-2011 and the Initial Communication to the UNFCCC list water, agriculture and tourism as the main sectors vulnerable to climate change.

The TNA team considered that water is a cross cutting sector and therefore one technology option could have the potential to provide adaptation benefits to more than one sub-sector. Both the agriculture and tourism sectors are water intensive sectors; therefore they are vulnerable to the predicted impacts of climate change.

Another factor considered was the importance of water to the sub-sectors and to the national economy. Agriculture and tourism are important to Grenada's economy because they are the main economic sectors of the economy both in terms of GDP and employment. The Central Statistical Office has estimated that in 2014 economic activity in agriculture including fisheries contributed 13.5 % and tourism contributed 9.25 % to the Gross Domestic Product. According to the National Agricultural Plan 2015, the agricultural sector is the second largest source of employment.

2 Institutional arrangement for TNA and stakeholder involvement

2.1 National TNA committee

For the purpose of the TNA project Grenada has set up a TNA committee under the Environment division containing officers from the various ministries and organizations most relevant to the sector selected. The head of the TNA committee and National Coordinator of the TNA project is the Permanent Secretary with responsibility for the Environment. The Climate Change focal point assists the Permanent Secretary in executing the role of the TNA coordinator and responsible for the day to day activities of the project.

The National TNA committee is composed of representatives from the following Ministries and organizations:

- Ministry of Education, Human Resource Development and the Environment
- Ministry of Agriculture, Lands, Forestry and Fisheries
- Ministry of Tourism
- National Water and Sewage Authority

All climate change projects in Grenada fall under the overall guidance of the National Climate Change Committee (NCCC). The NCCC contains several working groups including adaptation, mitigation, finance and sustainable development and international negotiations and relations. The adaptation working group is the Technical Working Group responsible for the adaptation component of the TNA project.

2.2 Stakeholder engagement process followed in the TNA - Overall assessment

A stakeholder mapping exercise was conducted to determine who to engage in the process. The primary stakeholders were staff from:

- The departments of agronomy, irrigation, and climate change in the Ministry of Agriculture, Lands, Forestry, Fisheries and the Environment
- The Economic Affairs Department of the Ministry of Finance;
- The Ministry of Tourism and;
- The National Water and Sewerage Authority.

The secondary stakeholders included representatives from the National Meteorological Office, climate related projects, financial institutions, farmers organizations and farmers.

All stakeholders with the ability to influence the success of the project or those who will be expected to promote or implement the project were identified. The list of stakeholders can be found in the Annex.

A total of two stakeholder workshops were held. The first workshop was held on 27, September 2015 and the second on January 14, 2016. During the workshops, stakeholders were introduced to the TNA process and the Multi-Criteria Analysis Methodology. Ten fact sheets on the alternative technology options were presented and discussed with stakeholders at the workshop. Experts on the technology options led the discussion and provided information on the status of the technology option in Grenada.

The criteria categories were also presented at the workshop and stakeholders were asked to provide feedback. Participants requested that the weights for the criteria category be discussed as a group. The categories of cost and feasibility generated the most discussions.

The fact sheets also generated much discussion. Stakeholders were generally unfamiliar with the reclamation and reuse technology option. Some were uncomfortable discussing water reclamation and reuse and made it clear it would not be socially acceptable. At the workshop's end, stakeholders identified the weights they wanted assigned to each category criteria; however there was no consensus on weights for costs and environment.

Stakeholders were also reluctant to consider desalination as a technology option because they perceived it to be expensive and the water quality unacceptable for potable purposes. They also perceived desalination to be too expensive for use in agriculture.

Following the first workshop, emails were sent to all workshop participants asking them to assign weights to the criteria category and criteria to be used to judge the technology options against the criteria. Some participants completed the process on their own while others requested the guidance of the consultant.

The second workshop focused on reviewing the results of the weighting and scoring exercise done individually. The weights for criteria category and criteria were reviewed and agreed to and the technology options were judged against each criteria and the given a score value. The score value for each technology option was aggregated.

3 Technology prioritization sector

3.1 Key climate change vulnerabilities

Grenada like the rest of the Caribbean is reported to have a bimodal seasonal rainfall pattern with an early (April – July) and a late (August – November) rainfall season; separated by a mid-summer drought (MSD) (Taylor 2002). In Grenada the midsummer drought is known as Petit Carême. The late rainfall season is important because it is during that rainfall season that there is recharge of ground water and storage for the next dry season.

Most of the water used in Grenada comes from surface water and springs while rainwater harvesting and ground water, to a lesser extent, are the sources of water for Carriacou and Petit Martinique.

Changes in the rainfall pattern resulting from climate change are expected to impact water resources. The projections are that Grenada and other Caribbean countries would experience longer dry spells. Some studies suggest that the region is already experiencing a drying trend (CARIBSAVE 2012), which is already negatively impacting the quality and quantity of Grenada's water supply.

In addition to the increase in the frequency of prolonged dry spells rainfall projections have also indicated that the country is expected to receive reduced annual rainfall. Studies have reported that the country is already recording reduced rainfall during the rainy season when recharge of ground water supplies takes place. Reduced rainfall would mean reduced quantity of surface water and reduced potential for ground water extraction. It would also mean an increase in the demand for irrigation water. It is also interesting to note that the dry season normally coincide with the high tourist season which means that potable water demand is greatest during the dry season.

Most of Grenada's potable water supplies come from surface water and apart from Carriacou, rain water harvesting is not widely practiced. Farmers in Grenada also depend on rainfall and surface water for agriculture with limited water storage practiced.

It has been reported that Grenada is experiencing sea level rise and this would result in salinization of ground water supplies and a reduction in the potential for extraction which is an added pressure on the ground water resources (Environmental Solutions Limited 2015).

The people of Carriacou and Petit Martinique have developed adaptive capacity to cope with prolonged dry periods and have invested heavily in rainwater harvesting and storage at the household level. Their adaptive capacity was increased with the recent installation of two Saltwater Reverse Osmosis plants one each on Carriacou and Petit Martinique. However, water for irrigation remains vulnerable to the impact of prolonged dry periods because of inadequate storage.

3.2 Decision context

The TNA team decided on the priority sector for the TNA and the sub-sectors after much discussion. The team agreed that water should be the priority sector with agriculture, tourism and domestic water supply as sub-sectors.

The objective being prioritization of the technology options which could be used to increase water availability for agriculture, tourism and domestic water supply during prolonged dry periods.

In selecting the technologies priority was given to those which are already being used in Grenada, those which were in keeping with written or expressed government policies, and those that have the potential for funding either from grants or local financing institutions.

After agreement was reached on the sector and sub-sectors the technology options were identified. Information for the fact sheets was gathered from the techwiki and other online databases. The research on the adaptation technologies revealed that information on the use of the technologies locally was limited. Likewise, information on cost and benefits were also unavailable locally for the technologies. In the absence of information on costs and benefits of the technologies, the team decided to use expert judgement. Stakeholders with the requisite expertise and experience in the different technology options were invited to participate in the workshops.

The participants were individuals with training and experience in areas such as agronomy, agricultural economics, water resources management, engineering, irrigation, meteorology, climate change, agriculture and economics. None of the participants were experts in wastewater management and desalination and stakeholders were not familiar with these technology options.

The fact sheets for ten adaptation technologies were prepared and presented at the first workshop, which was held on September 27, 2015. The technology fact sheets were discussed at the stakeholder workshop and the participants decided that it was important to keep all the options on the table and to prioritize them based on their perceived ability to deliver benefits in the short term, medium term and long term within the context of the challenges faced as a result of reduced rainfall.

Participants also provided information on the status of each technology in Grenada and historical information about technologies, which have been used in Grenada. Participants were experienced with all the technologies except wastewater treatment and desalination. The consultant provided guidance on both technologies based on experience and research.

The participants expressed their desire to have the weights assigned to the criteria category as a group. That was done and weights were assigned and technologies were ranked. However, there was no consensus on the weights to be assigned to costs versus environment.

Following the workshop the results were discussed and it was decided to allow participants to assign weights and assign score values individually. A form was prepared and circulated to stakeholders by email. Ten of the key stakeholders from the workshop assigned weights and assigned score values the technology options; some with the assistance of the consultant.

A second workshop was held in January 14, 2016 and members of the TNA team and the key participants were invited to participate. The results of the individual weighting and scoring exercise were discussed after which the final criteria and ranking were agreed to. The technologies were scored and the results were distributed to participants.

3.3 Overview of existing technologies

The first step in the technology prioritization process was research on adaptation technology options currently in use, and selection of technologies for adaptation in the water sector in Grenada. The research found that all of the technologies selected were in use in Grenada.

Drip irrigation and micro sprinklers have been in use in Grenada since the 1980's but it is not widely used (United Nations Department of Economic and Social Affairs 2012). Irrigation technology was introduced by the Ministry of Agriculture using project funds. Micro-dams were constructed for crop production but on a limited scale. Two micro-dams were constructed in the early 1980's as part of a soil and water conservation project. Those dams are still in use. Farmers on the eastern side of the island have constructed dams for irrigation purposes with varying levels of success and some are still in use today. However, the idea of mini-dams is gaining popularity as farmers turn to irrigation to cope with the increase in frequency of prolonged dry periods. In the case of Carriacou mini-dams are known as ponds and are more widespread and they are used for both crop and livestock management. Carriacou does not have any surface water and the ponds play an important role in coping with prolonged dry periods.

NAWASA currently has equipment to detect leaks in its distribution network. The percentage of non-revenue water is high and loss of water through leakage affects availability. In 2015 NAWASA received two (2) sets of leak detection equipment from the German Government which can detect leaks in both metal and plastic (PVC) pipes.

Household water treatment technologies are sold in stores in Grenada. It is not widely used because only a small percentage of households do not have access to the potable water supply. It is becoming more popular as the country experiences water shortages during prolonged dry periods.

According to a UNESCO 2006 report on the use of Desalination Plants in the Caribbean, in 2005 NAWASA was managing three reverse osmosis desalination plants one each in Grenada, Carriacou and Petit Martinique. The plants had a capacity of 3,000 gpd, 100,000 gpd and 40,000 gpd respectively. The UNESCO report stated the plants were not operational after five years. The plants in Carriacou and Petit Martinique were commissioned but the one in Grenada was never commissioned (UNESCO 2006).

Currently the technology exists in Grenada but it is owned by the private sector. As part of a CCCCC project two new saltwater reverse osmosis plants recently began operating on Carriacou and Petit Martinique. The pipe distribution network is incomplete but water is being sold from the plants.

Rainwater harvesting is the most widely used technology option. In Carriacou it was the main option especially for portable water supply prior to the installation of the saltwater reverse osmosis plant. During prolonged dry periods water is sent from Grenada to Carriacou and Petit Martinique by boat. In the case of Grenada rainwater harvesting became less prevalent as access to piped-onto premises drinking water increased. Some small hotels have rainwater harvesting capacity.

Water efficient fixtures are available in Grenada but the benefits of the technology option are not promoted. Some hotels have started installing water efficient fixtures and fittings. Stakeholders at the workshop perceived the technology option as expensive.

There is no central waste water system in Grenada but waste water technology is being used in four small hotels and one large chain hotel to reclaim water and reuse it for irrigation of lawns.

3.4 Adaptation Technology Options for the Water Sector and their Main Adaptation benefits

The selection of the technologies was also guided by the main recommendations from the relevant documents. Increased water storage for potable supply and irrigation were among the most frequent recommendations in these documents. The projection for reduced rainfall was also considered and technologies to increase the sources and reduce reliance on surface water were also among the recommendations. Water efficient technologies for potable water supply and agriculture were also recommended.

Ten technology options for adaptation in the water sector to climate change were identified and agreed with the members of the TNA team. Factsheets for the approved technologies were prepared and presented to stakeholders for review and revision.

The fact sheets provided a description of the technology, its potential to contribute to adaptation to climate change and the status of the technology in Grenada. An estimated cost of the technology options was provided where available. Attempts were made to get data on the benefits of the technology but no data was available because the relevant data is not recorded.

The fact sheets can be found in the Annex.

Table 1: Shows sub-sectors and potential technology options

Sub-sector	Technology options
Agriculture	Micro-sprinkler, micro-dam, drip irrigation, rainwater harvesting, water reclamation and reuse
Tourism	Desalination, rainwater harvesting, water reclamation and reuse, water efficient fixtures
Potable water supply	Rainwater harvesting, desalination, household drinking, treatment & storage, leak detection and management, borehole

Below is a brief summary of each of the ten technologies and how they can contribute to adaptation:

Desalination - This technology will not be impacted by changes in rainfall pattern. Hotels along the coast have used this technology in the past to meet the shortfall in domestic water supply resulting from prolonged dry periods. It is the only option to increase potable water supply apart from surface and ground water. Two SWRO plants began operating in Carriacou and Petit Martinique in early 2016. They have an advantage over the household cisterns because they will eliminate the cost of pumping from the underground rainwater cisterns.

Borehole - Ground water is currently being used to meet the shortfall in domestic water supply in two areas in Grenada. Boreholes are widely used in Carriacou and experts have recommended it for agriculture use in Grenada. It could become more important as surface water supply is reduced.

Micro Sprinkler – This technology is already in use in Grenada but it is not widespread. The UNDESA 2012 report on the water sector stated that irrigation flourished between the 1950-60s with the widespread use of overhead boom sprinklers. In the 1980's micro sprinklers were introduced but there was low uptake of the technology (United Nations Department of Economic and Social Affairs 2012). This technology could result in more efficient use of agriculture water and contribute to climate change adaptation.

Drip Irrigation - This technology is already in use in Grenada but it is not widespread. The UNDESA 2012 water sector report stated that drip irrigation was introduced in Grenada in the 1980's as part of a project but there was low uptake of the technology after the project was ended. It can be used to save irrigation water and contribute to adaptation to the changing rainfall pattern.

Mini-dam – This technology is already in use in Grenada but is limited. It can be used to provide storage for farmers during prolonged dry periods and serve as retention ponds during intense rainfall periods. The UNDESA 2012 study suggested that surface water could either be stored in stream or river diversion. It can be used to store irrigation water and contribute to adaption to the changing rainfall pattern.

Water Reclamation and Reuse – Wastewater treatment technology is currently in limited use in Grenada. There is central wastewater treatment system. Currently technology for tertiary treatment of wastewater is not in use in Grenada. This technology can be used to treat wastewater to secondary level and the water could be used for irrigation purposes especially during prolonged dry periods. The Caribbean Environmental Health Institute have recommended Small Foot Print (SFP) type systems Membrane Bioreactors and Biologically Engineered Single sludge Systems for small islands like Grenada (BESST). These systems are appropriate for tourism accommodations, health sector and educational institutions (Caribbean Environmental Health Institute 2009). There is a well-established practice in Grenada where grey water is reused for irrigation purposes at the household level.

Rooftop Rainwater harvesting – RWH is being promoted as the key adaptation option to cope with prolonged dry periods because it can increase storage at the institutional level and household level and reduce the pressure on municipal storage. Rainwater harvesting is widely practiced in Carriacou and Petit Martinique but not as much in Grenada. Hotels and households can use rainwater harvesting to increase storage and cope with shortage in water supply. Some of the smaller hotels have rain water harvesting capacity.

Household Drinking Water Treatment and Safe Storage – Households could use this technology to treat non-potable water during water shortages caused either by drought conditions or floods. Households harvesting rainwater could use the technology to make the water potable.

Leak Detection and Management – The main adaptation benefit of this technology is the reduction of water loss from broken underground water mains, which is currently very high. Water saved can reduce water shortages especially during dry periods. The water authority has received leak detection and management equipment.

Water Efficient Fixtures and Appliances – Retrofitting of homes, institutions and commercial buildings with water efficient fixtures and appliances will save water and reduce water shortage generally making more water available during prolonged dry periods. Some of the smaller hotels have started to replace the water intensive fixtures and fittings with water efficient technologies.

3.5 Criteria and process of technology prioritization

The Multi-Criteria Analysis was used to prioritize the various technology options to short-list some technology options for subsequent detailed appraisal.

A list of categories for the criteria was developed and discussed with the Assistant TNA Coordinator. The list was based on the objectives set by the TNA Coordinator. The following objectives were considered in the selection of the criteria:

- To contribute to sustainable economic development
- To contribute to poverty reduction through increased employment or income
- To contribute to climate change adaptation and protection of the environment

The categories selected were economic, social, environmental, political, climatic, financial and technical. The criteria categories selected considered whether the technology was affordable, appropriate and acceptable to both expected users in keeping with government policy. The criteria were used to compare how the technology options would contribute to the objectives.

It was also agreed that the weights would range from 0-100 with a high value score assigned to a criterion which was most preferred, and a lower value score assigned to a criterion with a lower preference. It was decided that the weights would be derived from the views of key stakeholders at a face- to -face meeting.

A workshop to guide stakeholders through the process of determining weights was convened. Participants were guided through the process of estimating the relative importance of weights to be assigned to each category criteria in judging the contribution of each technology option to each performance criterion.

Participants were presented with fact sheets containing information about the technology options. The cost and benefits of the technology options were discussed although data on costs were only available for some of the technology options and data was not available on benefits. The fact sheets were discussed and stakeholders provided inputs. They were also given a preliminary list of criteria categories and they were asked to use a relative weighting system for the criteria so that the weight of each criterion category would reflect both the range of difference of the options and how much that difference matters.

The weighting of the criteria categories generated much debate. Much of the debate centered on whether the cost of the technology option should be assigned a higher level of importance than the contribution of the technology option to the protection of the environment.

Stakeholders representing different interests had different views on the relative importance of the weights of each criteria category. Those representing the interests of the environment were of the view that the protection of the environment should be valued higher than costs while the representative from the Ministry of Finance was of the view that cost should take precedence because of the challenging economic situation the country was experiencing. At the end of the first workshop there was no agreement on the weights to be assigned to these criteria category.

The stakeholders at the workshop were also of the opinion that some of the criteria categories should be disaggregated and sub-divided.

Table 2: Shows issues considered for each criteria category

Criteria category	Criteria description
Cost	Cost was separated into capital cost and operating cost. Priority given to technology with low operating cost.
Economic	The technology should have the potential to create employment and or increase farmers' income.
Social	Poverty reduction and food security were initially considered but social acceptability replaced food security.
Environmental	Protection of the environment was the main consideration.
Climatic	The contribution of the technology to climate change adaptation was considered.
Political	Whether the technology was in keeping with government's written or expressed policy was important to avoid recommending a technology which government may not accept.
Technological	Consideration was given to whether the technology was mature and appropriate and whether it was tried and tested in Grenada or in the region. Technical capability to install and maintain the technology was also a consideration.

Stakeholders wanted to see cost subdivided into operational cost and capital cost. The criteria category on feasibility of the technology option was also discussed and there was general agreement that feasibility should be sub-divided into maintenance and installation. Stakeholders shared experiences where equipment was provided without consideration for maintenance; this resulted in loss of use of the equipment. The social category criteria also generated much debate on whether it should be subdivided into social acceptance and poverty reduction or social acceptance and food security.

Since there was no agreement on the weights for the criteria category, it was decided that the criteria category would be reassessed individually and the weights would be averaged. Participants also decided to sub-divide some of the other criteria based on the discussions at the first workshop. The criteria categories that were sub-divided were cost, economic, social, and feasibility. They were sub-divided into criteria based on the workshop discussions.

Forms were prepared and emailed to workshop participants. They were asked to assign weights to the criteria category and the criteria; and to assign a score value to the performance of the ten options relative to each criterion.

It was decided that the individual score values for the criteria category and criteria will be calculated and the average taken. Individual stakeholders were also asked assign a score value to the performance of the ten technology options.

Some participants felt it was best to complete one form per department where there was more than one participant from a department at the stakeholder workshop. For example the Forestry and Land Use departments completed one form for each department. Some participants requested the guidance from the consultant in completing the form while others completed it on their own.

Weights were assigned to all of the criteria categories and criteria and each of the technology options was assigned a score value between 1-5. The scores for the criteria category were averaged and they added up to 100 but the values for the criteria proved to be too challenging to average because of the wide range of score values. Two criteria categories--cost and environment--were assigned the highest level of importance and therefore the highest weight. However, range of score values assigned to criteria were too wide to reach an average.

It was decided that a second facilitated workshop would be held to repeat the steps of the Multi-Criteria Analysis process. All of the steps beginning with a review of the fact sheets were followed. At that workshop it was agreed that the values for both criteria category and the criteria should add up to 100 as seen in Table 2.

It was agreed that the two most important criteria categories—cost and environment—would be given the same score value.

The criteria category weights added up to one hundred but participants were allowed assign weights to the criteria that would add up to the weight of the category criteria. This meant that the weights for the criteria added up to 100. This was done to avoid the wide range of score values.

The maintenance criterion was given the highest score value because stakeholders were influenced by past experience where maintenance was not considered in the decision to purchase equipment.

Table 3: Shows the weights for Criteria Category and Criteria

Criteria category	Weight	Criteria	Weight
Cost	20	Capital cost	08
		Operating cost	12
Economic	15	Increase farmer income	9
		Increase employment	6
Social	10	Social acceptability	6
		Contribution to reducing poverty	4
Environmental	20	Contribution of the technology to protect and sustain ecosystem services	20
Climate related	15	Contribution to reducing vulnerability to the impacts climate variability and change	15
Political	05	Alignment with national development goals	05
Technical feasibility	15	Ease of implementation	5
		Maintenance	10
	100		100

Stakeholders were asked to assign a score value between 1-5 to each technology option. An expert on the technology option led the discussion on the ranking of the performance of the technology option against the criterion. The expert would propose a preferred score with an explanation for the score. It would then be debated until an agreement is reached.

Stakeholders were asked to rate the performance of each technology independently. However, in the absence of cost and benefit data, the group felt it would be better to compare against a standard. The desalination technology was used as the standard and therefore it was assigned a score first.

3.6 Results of technology prioritization

One of the challenges faced in the prioritization of the options was the lack of data to estimate cost and benefit. In the absence of the data the experts debated the known benefits of the technology options and their relevance to reducing vulnerability to prolonged dry periods.

In some cases where the technology was new and the capital cost was known, the benefits could not be calculated. Such was the case with the desalination plant at Carriacou and Petit Martinique. Even in the case of drip irrigation and micro-sprinkler which are not new to Grenada, the estimated cost was available but the benefits were challenging to estimate in the absence of data.

Taking those challenges into consideration it was decided to assign a weight to the criteria category and criteria and assign a score value to the technology options. One of the challenges with assigning weights to the criteria was that some participants were of the view that operating cost should be given a higher value based on experience where the capital cost was funded under a project and the operating cost was so high the operations was unsustainable after the project funds expired. There was also the argument that based on the current economic situation in Grenada the capital cost should be given a higher value because if the cost is too high it will not be affordable except it could be implemented with grant funding.

Only technologies with the potential to contribute to adaptation to prolonged dry periods were included among the technology options. In prioritizing the technology options, emphasis was placed on whether implementing the technology option could save water or increase the amount of water available for domestic water supply, irrigation and tourism.

Desalination, borehole and water reclamation and reuse technologies were seen as the only options currently available to Grenada to increase water availability during the prolonged dry period.

Participants agreed that drip irrigation technology, micro sprinkler technology and water efficient fixtures were water saving technologies which have the potential to contribute to adaptation in the agriculture and tourism sectors to prolonged dry periods.

The potential of micro dams and rainwater storage technologies to increase water availability during prolonged dry periods was noted. Household water treatment technology was considered useful for treating stored rainwater to make it potable; while leak detection and management technology would reduce water loss and increase the availability of surface water during prolonged dry periods.

The technology options were intended to be implemented mainly by the National Water and Sewerage Authority, hotels, and groups of farmers.

The weight assigned to each criterion was multiplied by the score value (1-5) that each technology was assigned. The scores for each technology option were aggregated and the technology option receiving the highest score was assigned the highest priority. The results of the prioritization are presented in the following performance matrix.

Table 4: Shows performance matrix with results of overall scoring of technology options

Criteria	Rate Wt	Ranking										Score									
		D	B	L	M	R	DI	WEF	WRR	MS	HDS	D	B	L	M	R	DI	WEF	WRR	MS	HDS
Capital cost	8	2	2	4	5	5	4	5	3	5	5	16	16	32	40	40	32	40	24	40	40
Operating cost	12	3	3	4	5	5	4	5	3	5	5	36	36	48	60	60	48	60	36	60	60
Increase farmer income	9	2	3	1	5	5	5	1	4	5	1	18	27	9	45	45	45	9	36	40	9
Increase employment	6	2	2	1	4	4	4	1	2	4	1	12	12	6	24	24	24	6	12	24	6
Social acceptability	6	3	4	5	5	5	5	3	1	5	5	18	24	30	30	30	30	18	6	30	30
Contribution to reducing poverty	4	3	3	1	3	4	4	2	3	4	3	12	12	4	12	16	16	8	12	16	12
Contribution of the technology to protect and sustain ecosystem services	20	1	1	1	4	5	5	4	5	5	3	20	20	20	80	100	100	80	100	100	60
Contribution to reducing vulnerability to the impacts climate variability and change	15	5	5	4	5	5	5	5	5	5	4	75	75	60	75	75	75	75	75	75	60
Alignment with national development goals	5	5	4	5	5	5	5	1	1	5	1	25	20	25	25	25	25	5	5	25	5
Ease of implementation	5	3	3	4	5	5	5	5	2	5	5	15	15	20	25	25	25	25	10	25	25
Maintenance	10	1	3	5	5	5	5	5	4	5	5	10	30	50	50	50	50	50	40	50	50
Total	100											257	287	304	471	490	479	376	356	485	357

Legend

D- Desalination
B- Borehole
R- Rain water harvesting
M- Micro dam
HDS – Household drinking treatment & storage
MS- Micro- Sprinkler
DI- Drip Irrigation
Water efficient fixtures and appliances

The score results showed that the technology options were prioritized in the following order:

1 Rainwater harvesting (490)
2 Micro sprinkler (485)
3 Drip irrigation (479)
4 Micro dam (471)
5 Water efficient fixtures and appliances (376)
6 Household drinking & storage (357)
7 Water reclamation and reuse (356)
8 Leak detection and management (304)
9 Borehole (287)
10 Desalination (257)

Each row in the performance matrix describes the performance of the technology options against the criterion and each column describes the technology options.

Each technology option was assigned a score from 1-5 on a strength of preference scale for each option for each criterion. The more preferred technology options scored higher and less preferred technology options scored lower. The lower the score the lower was the preference and the higher the score the higher was the preference.

The judged strength of the preference for a technology option on one criterion was independent of its judged strength of another criterion; so that a low score on one criterion could have been compensated for by a high score on another criterion.

All technology options were appraised to determine how well they performed on each criterion. The scores for each technology option's performance across all criteria were aggregated to form an overall assessment of each option on the basis of which the technology options were compared.

The technology options with lower capital and operating costs were the most preferred and therefore had the highest aggregated score values. Desalination was perceived to be the technology with the highest capital and operating cost and was therefore it consistently received the lowest score. The micro sprinkler technology dominated all the other technology options on all criteria.

4 Summary and Conclusion

An initial workshop was held at the start of the Technology Needs Assessment process where the project and process were introduced to stakeholders. The establishment of TNA team and the selection of the water sector as the priority sector to be assessed followed this. The TNA team selected agriculture, tourism and domestic water supply as the sub-sectors.

The selection and prioritization of the adaptation technology options using the Multi-Criteria Analysis was the first phase of the Technology Needs Assessment process. A review of the relevant literature confirmed that the water sector is one of the main sectors, which is vulnerable to the impact of climate change. The literature also revealed the water sector is cross sectoral and its vulnerability had implications for agriculture, tourism and domestic water supply.

Regional scenarios for climate change for the Caribbean region including Grenada are projecting longer dry periods and more frequent intense rainfall events. Based on these scenarios of more frequent prolonged dry periods and, therefore, reduced rainfall fact sheets were prepared for ten technology options, which Grenada could use to adapt to climate change in the areas of agriculture, tourism and domestic water supply. The fact sheets provide information on the adaptation potential of the technologies and their status in Grenada. Information for the fact sheets was gathered from research of Internet sites, online databases and interviews with local and regional experts and stakeholders at the two national workshops. The fact sheets were presented and discussed at both workshops.

The technologies were prioritized using the Multi-Criteria Analysis method. There was insufficient data available on cost and benefits of the technologies and therefore the expertise of the stakeholders was used to make judgments about the technologies.

Criteria for comparing the performance of the technologies were selected and presented to the key stakeholders at the first facilitated workshop. Among the criteria selected were poverty reduction and employment creation which are influenced by the prevailing economic conditions. Technologies which scored low on those two criteria were ranked low even if they had very good adaptation potential. Technologies which had high capital cost were also ranked low.

There were no expertise available for the reverse osmosis and wastewater technology but these technologies were classified as culturally unacceptable by stakeholders.

The results of the individual weighting and scoring process were presented at the second facilitated workshop where the final weights and scores were agreed to. The criteria score values and the score values assigned to the performance of the technology option against the criteria were entered into a performance matrix. Score values entered in the matrix assessed how well the technology option performed with respect to each criterion.

Although there were no cost and benefit data available as a basis for decision-making, the micro-sprinkler received the highest aggregated score value followed by rainwater harvesting. Drip irrigation and the micro-dam were also among the others with the highest aggregated score values.

The results of the multi-criteria analysis, which was conducted to prioritize the technology options, were generally consistent each time the analysis was done. The micro-sprinkler technology and rainwater harvesting received the highest aggregated score on the two occasions.

Stakeholders' level of knowledge and perception of the technology influenced the results because it was based on consensus among the stakeholders. There was bias against water reclamation and reuse technology because it was perceived as unacceptable to the population. Technologies that were perceived to be expensive had a low preference.

The challenging economic situation existing in the country had the greatest influence on the decision-making. Stakeholders were pre-occupied with whether the technology was affordable and whether it had the ability to increase income and not as much consideration was given to the other benefits. The wastewater and reclamation technology option was a case in point. Although there are more environmental benefits to be derived from the wastewater technology option than any other technology option and this technology option is one that is promoted as one of the main adaptation options it had a low aggregated score.

The results of the Multi-Criteria Analysis were in keeping with the report on the vulnerability assessment of the water sector and the Adaptation Plan for the water sector which recommended that investment in rainwater harvesting.

However all of the technologies ranked high for climate adaptation potential. As a result the stakeholders were of the view that all of the technologies should be taken forward to the barrier analysis phase.

The TNA team discussed the results of the multi-criteria analysis and made the decision to take only five of the technologies to the next stage, which is the barrier analysis.

The five technologies selected were not those receiving the five highest scores because in making the decision the TNA team did not only consider the ranking but also whether the technology was included under projects that were being implemented. Those that were already included in projects were eliminated from the barrier phase. For example rooftop rainwater harvesting although it was ranked very high was not included among the technologies to be taken to the barrier analysis phase because it is already implemented under both the GIZ and UNDP components of the ICCAS project.

Equipment for leak detection and training was provided to the national water authority therefore there was no need to take it further to the next stage.

Household water storage and water efficient fixtures were not considered for further analysis because these technologies are now generally widely available in the country and the team was of the view that the water inefficient technologies are being phases out gradually. The team was also of the view that the tourism sector for example could be encouraged to gradually replace water efficient fixtures with efficient ones.

Although borehole technology has adaptation potential it was not taken forward because of the unavailability of data on the location of aquifers.

Two technologies which were not ranked highly were recommended to be taken forward because they were considered to have the adaptation potential. Reverse osmosis was successfully introduced in two of the smaller islands belonging to the state of Grenada and consumers have since overcome the cultural barriers to the use of the water.

Waste water reuse technology was also recommended to be taken forward because this technology has huge adaptation potential for the tourism sector which is a water intensive industry. It is currently in use at four small hotels and one large hotel in Grenada. A pilot project was successfully implemented at a hotel facility in another Caribbean country St Lucia. Besides new products are now available on the market for stand alone wastewater systems which can utilize solar energy.

The team therefore decided to take forward micro sprinkler/drip irrigation and micro dam, which were among those ranked the highest, and to also take forward reverse osmosis and waste water which were ranked among the lowest.

Next Steps

The next step will be the break up of the large stakeholder into three subsector groups. There will be an agriculture group, tourism group and a domestic water supply group. These groups will include the stakeholders from the original stakeholder group but will now include stakeholders who have been using the technology and can share experience on the barriers to the diffusion of the technology.

It was decided that agriculture subsector will analyze the barriers to drip irrigation, micro sprinkler and micro dam technologies, the tourism subsector will analyze barriers to diffusion of waste water technologies while the domestic water supply subsector will analyze the barriers to desalination.

The Technology Needs Assessment Report would be used to inform the development of the National Adaptation Plan, and the selection of projects for funding under adaptation.

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Annexes

Fact Sheet Desalination

Definition

Desalination is the removal of sodium chloride and other dissolved constituents from seawater, brackish waters, wastewater, or contaminated freshwater. Approximately 75 million people worldwide rely on desalination and that number is expected to grow as freshwater resources are stressed by population growth and millions more move to coastal cities with inadequate freshwater resources.

Desalination plants provide water for many countries in the Caribbean. Historically, the hoteliers of Grenada have voiced concern with the reliability of the public water supply and have resorted to obtaining small desalination plants for the provision of adequate volumes of freshwater to their facilities. In recent times, with the introduction of the metering programme, upgrade and extension to the water storage, treatment and distribution systems by NAWASA, public water supplies have been more reliable. A desalination plant recently becomes operational in Carriacou.

Brackish waters made up the majority of source waters for desalination, with most of the remainder consisting of river waters and wastewaters. Two streams of water result from desalination: (1) a pure product water and (2) a high-concentration waste stream or brine.

If the brackish water is used as the feed water then the brine would have low salinity and could be reintroduced using deep boreholes near the coast without increasing the salinity of the receiving body as is done in Barbados.

How does the technology/practice contribute to climate change adaptation?
Desalination can greatly aid climate change adaptation, primarily through diversification of water supply and resilience to water quality degradation. Diversification of water supply can provide alternative or supplementary sources of water when current water resources are inadequate in quantity or quality. Desalination technologies also provide resilience to water quality degradation because they can usually produce very pure product water, even from highly contaminated source waters. Increasing resilience to reduced per capita freshwater availability is one of the key challenges of climate change adaptation. Both short-term drought and longer-term climatic trends of decreased precipitation can lead to decreased water availability per capita. These climatic trends are occurring in parallel with population growth, land use change, and groundwater depletion; therefore, rapid decreases.

What are the costs and financial requirements?

The cost of production for the plant in Carriacou in 2005 was EC$ 18-20/1000 gallons. The maintenance includes the cost of consumables and replacement parts including chemicals membranes filters.

Status of the technology in Grenada
Until recently only hotels in Grenada had functioning desalination plants. Those plants were installed to cope with water shortages experienced during the dry season.

The government of Grenada with the support of grant funds completed the installation of a solar desalination plant on the island of Carriacou and one on the island of Petit Martinique. The National Water ad Sewerage reported that it was reluctant to invest in the technology in Grenada due to the high capital cost.

Fact Sheet Borehole

Definition

Boreholes are defined as tubewells penetrating bedrock, with casing not extending below the interface between unconsolidated soil and bedrock. Boreholes require a drilling method with an external power source.

Three major strategies are employed for increasing borehole water supply during drought:

• Drilling new boreholes/deepening existing boreholes: These strategies form the basis of conventional approaches to improving groundwater access in rural areas during drought. They are frequently appropriate for mitigating extreme symptoms of drought. However, they are often not the most efficient use of limited resources. Additionally, groundwater surveys and proper siting of boreholes are necessary for achieving maximum impact.

• Repairing damaged boreholes: In many droughts, regional groundwater depletion is not the main factor affecting domestic access to water. When individual boreholes fail during drought, the cause is often local drawdown or mechanical failure. During a recent drought in southern Africa, a survey of water points by Oxfam revealed that most non-functional boreholes had failed because of problems with hardware (e.g. pump failure) or demand management (e.g. localized drawdown). The failure of a water point (including traditional sources) increases pressure on boreholes, increasing demand, local drawdown and hardware failure. Repairing damaged boreholes is a quick and inexpensive way to prevent this cascade of water point failure.

• Relief boreholes with use restricted to drought periods: Many authors have proposed developing deep "relief boreholes" that remain capped when water supplies are adequate and are uncapped for use during drought.

How does the technology/practice contribute to climate change adaptation?

A warmer climate is highly likely to result in more frequent drought. Deep tubewells, usually defined by engineers as those that penetrate at least one impermeable layer, generally have much greater resilience to drought than traditional water supplies including springs, and surface water sources.

Costs and financial requirements?

The costs of drilling new boreholes vary widely depending many factors, so quoting 'typical' costs can be misleading. However, the average cost in much of Africa is $10,000-15,000; in contrast, the average cost in India is less than one-tenth as much. 70, 74 A detailed methodology for costing borehole drilling operations in Ethiopia is available, incorporating (i) mobilisation/demobilisation, (ii) drilling, (iii) casing and completion, and (iv) development and test pumping. Repairing damaged wells can cost far less (sometimes by three or more orders of magnitude) than drilling new boreholes.

Status of the technology in Grenada

The national water authority currently operates seven boreholes (wells) six in Grenada and one in Carriacou.

Fact Sheet Leakage Management and Detection System

Definition

Leakage in distribution systems is a major problem for water utilities throughout the world, in both wealthy and developing countries. Many water distribution pipes in Grenada were installed decades ago and are approaching the end of their useful life. Leakage rate in Grenada is reported to be approximately 48 percent.

Management, detection and repair of small leaks in a distribution system are critical functions of system operation and maintenance, yet they are often neglected. 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.

How does the technology/practice contribute to climate change adaptation?
Growing population will push many countries into water stress and water scarcity in the coming decades. Detection and repair of leaks in water systems is an important part of comprehensive strategies to reduce pressure on existing water resources.

What are the costs and financial requirements?
The costs of leak management, detection and repair include staff training, management, labor, and equipment. However, leak management, detection and repair programs generally pay for themselves by enabling early repair of leaks and reducing water waste. Leaks often damage pipes through erosion; therefore, additional benefits of early detection include reduced maintenance costs and lower probability of catastrophic failures.

Status of the technology in Grenada
NAWASA currently has equipment to detect water leaks in the distribution network.

Fact sheet micro sprinkler

Definition

Micro-sprinkler is a micro irrigation system. Micro-spray is a cross between surface spray irrigation and drip irrigation. Like drip irrigation, micro-spray is considered a type of low pressure irrigation typically operating with pressures between 15 and 30 psi. It is generally considered low volume with application rates of 5 to 70 gallons per hour (gph). Micro-spray typically creates a larger wetted area than drip irrigation making it well suited for irrigating ground covers.

Description

The micro-sprinkler can be configured in two ways; either drop down sprinklers from suspended irrigation lines or risers mounted on stakes from surface irrigation lines.
It is a low pressure, low- medium volume irrigation system suitable for tree crops. It is deal for irrigating slopes.

The system consist of:
System head – pump, filter, pressure gauge, pressure regulator
Distribution network – main pipes and secondary pipes, laterals, pipe fittings, sprinklers and valves,

Adaptation to climate change

The micro-sprinkler irrigation technology can support farmers to adapt to climate change by making more efficient use of their water supply. This is particularly appropriate where there is (or is expected to be) limited or irregular water supply for agricultural use. The sprinkler technology uses less water than irrigation by gravity, and provides a more even application of water to the cultivated plot.

Advantages of the technology

- The micro-sprinkler applies water directly to the soil surface area allowing water to dissipate under low pressure and infiltrate the soil.
- The irrigation system is less susceptible to clogging than drip irrigation due to larger orifice sizes than drip irrigation systems, which reduces the need for finer filtration system.
- Water is distributed more evenly across crops helping to avoid wastage.
- The risk of soil erosion could be reduced because the sprinkler system limits soil disturbance.

Disadvantages of the technology

- It puts out a higher volume of water than drip irrigation.
- It is subject to evaporative losses and spray pattern disruptive in windy conditions.
- Larger wetted areas may result in more weeds.

- The nozzles can be blown off due to high pressure, tampering with flow adjustments can result in flows that are too high or too low.

Cost and financial requirements

The estimated cost of a family farm micro-sprinkler is US$ 250 to US$1000 per acre depending on the type of material used.

Status of the technology in Grenada

Farmers are using micro-sprinklers and have been receiving support from the Irrigation Department Ministry of Agriculture to install them. There is no distributor operating in Grenada and the technology has imported into Grenada by the Ministry of Agriculture under various projects. Farmers have difficulty obtaining spare parts for the system. The Marketing and Importing Board recently started selling some equipment but they are not compatible with the existing systems.

Fact Sheet Rainwater Collection from Ground Surfaces – micro dams

Definition

The rainwater collection from ground surfaces is referring to collection, storage and use of rainfall that lands on the ground.

Description
There are two main categories:

1. 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

2. Collecting flows from a river, stream or other natural watercourse (sometimes called floodwater harvesting). This technique often includes an earthen or other structure to dam the watercourse and form "small reservoirs".

Micro-catchments are often used to "store" water as soil moisture for agriculture. Small reservoirs are typically used in areas with seasonal rainfall to ensure that adequate water is available during the dry season.

As soil moisture for agriculture, many runoff control methods for irrigation incorporate inundation or extended contact time with soils to increase topsoil moisture. Traditional methods were often developed in response to local conditions and have been practiced for centuries.

Rainwater collected from the ground surface can be used for non-potable purposes, including irrigation and livestock.

How does the technology/practice contribute to climate change adaptation?
Collection and storage of rainwater can provide a convenient and reliable water supply during seasonal dry periods and droughts. Additionally, widespread rainwater storage capacity can greatly reduce land erosion and flood inflow to major rivers. Storage of rainwater can provide short-term security against periods of low rainfall.

Cost and financial requirements
It is difficult to determine the cost for the construction of a micro-dam. The cost will depend on factors such as the size and the location.

Status of the technology in Grenada
Micro-dams exist in Grenada and Carriacou. In Carriacou they are known as ponds and are used for watering animals. There is a large micro-dam, which is serving several farmers in Grenada.

Fact Sheet Rainwater Harvesting from Rooftops

Definition

Collection of rainwater from rooftop catchment and storing it in a tank or barrel is well established practice in Grenada and more so in Carriacou and Petite Martinique.

Rainwater harvesting is used to collect water for potable and other household uses in Grenada, Carriacou and Petit Martnique. In Carriacou RWH for irrigated agriculture was recently promoted under a food security programme by the Ministry of Agriculture. Several 3600 to 4500 litres Polyvinyl Chloride (PVC) plastic tanks along with materials for the construction of the support platforms and catchments were distributed to some 20 farmers.

RWH has been traditionally used in animal husbandry by strategically ponding run-off for provision of drinking water to herds, and in maintenance of sanitation. In Petite Martinique however, RWH for agriculture is practiced to a limited extent since agriculture is not a key activity and most of the food is imported. However, there is potential for expanding RWH for agricultural applications if the requisite investments are made.

How does the technology/practice contribute to climate change adaptation?

RWH contributes to climate change adaptation at the household level primarily through two mechanisms:

(1) Diversification of household water supply; and
(2) Increased resilience to water quality degradation. It can also reduce the pressure on surface water by decreasing household demand. Another possible benefit of rooftop RWH is mitigation of flooding by capturing rooftop runoff during rainstorms.

What are the costs and financial requirements?

RWH can often provide household water at lower expense than other available options. If a household already has a suitable hard roof for use as a catchment surface, storage containers are the major expense. The cost of storage containers typically depends on construction quality, tank size, and other factors. A large, high quality storage container can be a major investment for poor households. In the context of climate change, increased precipitation extremes could necessitate greater storage volume, thus enabling the capture of maximum volume during intense periods and providing for household water needs during extended dry periods.

Status of the technology in Grenada

RWH is becoming a priority as the country experience longer dry periods and the national water authority is now encouraging the public to harvest rainwater. The water authority recently constructed a RHW system to serve a community, which is not served by its distribution network.

Another project is currently providing support for RWH systems for Grenada and Carriacou including a school agricultural project.

Fact sheet drip irrigation

Definition

Drip irrigation is a micro irrigation system. Drip irrigation is based on the constant application of a specific and calculated quantity of water to the soil crops.

The system uses pipes, valves and small drippers or emitters transporting water from the sources (tanks, reservoirs) to the root area and applies it under particular quantity and pressure specifications. The system can maintain adequate levels of soil moisture in the rooting areas. Drip irrigation can maintain the exact (or almost) moisture requirement for each plant and can significantly reduce water wastage and promotes efficient use.

Description

A drip irrigation system typically consists of:

- Pumps or pressurized water system
- Filtration system
- Backwash controller
- Systems control -pressure control valve (pressure control regulator), pressure gauges
- Distribution system -pipes (including main pipe line and drip tubes with emitters)
- Control valves and safety valves
- Poly fittings and accessories (to make connections)

How the technology contributes to climate change adaptation

Drip irrigation technology can support farmers to adapt to climate change by making more efficient use of their water supply. Compared to surface irrigation, which can provide 75 per cent, efficiency drip irrigation can provide as much as 90 percent water use efficiency.

Drip irrigation reduces demand for water and reduces water evaporation losses (as evaporation increases in high temperatures). Scheduled water application will provide the necessary water resources direct to the plant when required. Drip irrigation is not affected by wind rain.

Advantages

Drip irrigation can help use water efficiently. A well-designed drip irrigation system reduce water run-off through deep percolation or evaporation is almost zero. It is adaptable to terrains where other systems cannot work well due to climatic or soil conditions. Drip irrigation technology can be adapted to lands with different topographies and crops growing in a wide range of soil characteristics. It is particularly efficient in sand areas with crops such as vegetables. Drip irrigation systems are the best type of irrigation for windy conditions.

Disadvantages

The initial cost of drip irrigation systems can be higher than other systems. Final cost will depend on the terrain characteristics, soil structure, crop and water source. Higher costs are generally associated with costs of pipes, tubes, pumps, emitters and installation. Unexpected rainfall can affect drip system either by flooding emitters and moving pipes. Rodents or animals can damage drip irrigation equipment. It can be difficult to combine drip irrigation with mechanized production such as tractors which can damage pipes tubes and emitters. Drip irrigation requires maintenance and high quality water.

Knowledge and Monitoring Requirements

Investment will also be required to build capacities to accurately manage maintenance and water flow. For example the drip tape or tubing must be maintained in order to avoid leaking or plugging and emitters must be regularly cleaned to avoid blockage from chemical deposits.

Costs and financial requirements

The technology is widely variable, however the cost of a drip irrigation system ranges from US$ 500 – US$ 1200 per acre based on the specific type of technology.

Status of the technology in Grenada

The Irrigation Management Unit (IMU) provides support to farmers to install and operate irrigation systems. This Unit is based and operated by personnel from the Land Use Division. The unit has implemented several projects including the On-Farm Irrigation programme. Through this programme irrigation equipment was provided to farmers on a contractual basis. Additionally, under the Agricultural Enhancement and Development Programme (AEDP) implemented by GoG through the MoA Extension Division, loans of XCD 40,000.00 were provided to farmers to install drip irrigation systems.

There is no distributor selling this equipment in Grenada. The Marketing and Importing Board recently started selling equipment. The equipment is not compatible with the existing systems so farmers are unable to purchase spare parts from them.

Fact Sheet Water Efficient Fixtures and Appliances

Definition

The most common water efficient appliances include dishwashers and clothes washing machines; popular fixtures include toilets, showerheads and faucets. They can simply use less water while yielding comparable performance (e.g. low-flow showerheads).

Strategies used to increase the use of water efficient technologies include:

• Mandates – mandating water efficiency standards for new construction and replacement of old fixtures and appliances; mandating use of water efficient products in government facilities.

• Labeling – certification systems for water efficient products; adding the estimated cost of use, also called the "second price tag," to labels.

• Tax incentives – for purchasing and installing efficient products; for retro-fitting and replacing older fixtures.

How does the technology/practice contribute to climate change adaptation?

Residential conservation efforts can make a strong positive contribution to reducing pressure on water resources.

Reducing water use in municipal systems also contributes to climate change mitigation by decreasing energy consumption and greenhouse gas emissions. Water conservation can lead to large savings in the energy used to transport, treat and distribute piped water.

What are the costs and financial requirements?

Establishing a functioning certification process may be costly depending on existing capacity. However, the costs for individual households are generally small and may be fully recovered by water savings over the lifetime of the product.

Status of the technology in Grenada

Water efficient washing machines are sold in Grenada but they are more expensive and are therefore not widely used. The low flow faucets and shower heads are sold but they tend to be more expensive and therefore not widely used. Many of the toilets imported today are 1.5 gallons.

Some hotels have started to replace the existing fixtures ad faucets with water efficient ones.

Fact Sheet Water Reclamation and Reuse

Definition

Water reclamation is the treatment or processing of wastewater to make it reusable with definable treatment reliability and meeting appropriate water quality criteria; water reuse is the use of treated wastewater or reclaimed water for a beneficial purpose. The term reclaimed water is used interchangeably with the often more culturally-acceptable term recycled water.

Typical wastewater treatment schemes incorporate multiple levels of physical, biological, and chemical treatment in order to ensure that water discharged to the environment does not pose a significant risk of adverse environmental or health impacts.

Water reclamation approaches uses the same technologies as conventional waste water treatment. There are three levels of treatment. They are primary, secondary and tertiary treatment. Direct potable reuse is very rarely recommended; regardless of the level of treatment reclaimed water has received. Reclaimed water is mostly used in Grenada for irrigation.

Description

There are several secondary treatment technologies they include:

Stabilization and aerated ponds lowest capital cost lowest operation cost, lowest skill level but requires large land space but produces small amount of sludge. It uses macrophytic plants and microorganisms in an artificial pond to treat organic residues and clarify wastewater. The treated water could be used for irrigation.

Trickling filter or Rotating biological contractor is a biological treatment process used in the treatment of wastewater after the removal of grit and solids in a primary screen process followed by settling. The treated water can be emptied into a body of water.

Activated sludge is also a biological treatment and it has the highest capital and operations cost, it requires a high operational skill and is energy intensive but uses lowest land space. Produces large amount of sludge. This process remove nitrogen and phosphorus from the treated water.

How does the technology/practice contribute to climate change adaptation?

Water reclamation and reuse approaches can and have been shown
to be effective for adapting water resource management in the face of such stressors. Most importantly, water reclamation and reuse contributes to climate change adaptation by allowing water resources to be diversified and conserved.

What are the costs and financial requirements?

In general, the most economically viable applications for water reuse are those that replace potable water with reclaimed water for use in irrigation, environmental restoration, cleaning, toilet flushing, and industrial uses.

The financial requirements for implementing water reclamation and reuse programs will vary significantly based on the type of application that is planned for the reclaimed water. An economic analysis should be conducted in order to weigh the cost of maintaining traditional approaches and of possibly needing to develop additional water sources versus the cost of retrofitting existing and constructing new infrastructure for reuse applications.

In 1992 a study wastewater treatment put the cost of the technologies for Grenada as follows:

Technology	**Capital cost** (US$)	**Operating cost** (US$ per year)
Stabilization pond	600, 000 – 1 500,000	60,000.00
Aerated pond/oxidation ditches	1,000,000 – 1 500,000	140,000
Rotating biological contractor/trickling filter	1,000,000- 1500 000	220, 000
Activated sludge	2,000,000 – 2,500,000	270,000

The Caribbean Environmental Health Institute (CEHI) in 2009 estimated that the capital costs for a centralized waste stabilization pond treatment plant for Grenada to be US$ 885, 614, 216 and the operating cost to be US$ 227, 368, 986.

A stabilization pond secondary treatment system was installed at a 254-room hotel in the region at a cost of $EC 773, 847

Status of technology in Grenada
Wastewater treatment technology is currently only practiced by two entities in Grenada. Both facilities use treatment lagoons and the water is used for landscaping. There is no mechanical treatment system at the national level with the capacity to do tertiary treatment.

Site-specific conditions, social and economic considerations, local preference or whether the system will be on-site or off site has to be taken into account for in selecting “appropriate” or “correct” technology for different part of Grenada.

Four small hotel properties and one major hotel currently have waste water treatment systems and the water is reused for irrigation of lawns.

Fact Sheet Household Drinking Water Treatment and Safe Storage

Definition

Household or point of use (POU), drinking water treatment and safe storage provides a means to improve the quality of their water by treating it in the home. Popular treatment technologies include chemical disinfectants, coagulants, ceramic filters, biological sand filters, solar disinfection (SODIS) or ultraviolet disinfection processes, and combined products with both coagulant and disinfectant. This technology is not widely used in Grenada but pitcher water filters are available for home use.

How does the technology/practice contribute to climate change adaptation?

Degradation of water quality is expected to be one of the key impacts of climate change on water resources and water supply. Projected increases in flooding, drought, decreasing water availability, algal blooms, coastal inundation and sea level rise have both direct and indirect effects on drinking water quality.

HWTS increases resilience to water quality degradation by enabling users to improve water quality at the point of use.

It is estimated that there were 18.8 million users of HWTS devices worldwide in 2007, with rapid growth of roughly 25% per year.

The HWTS is useful for Grenada as the changes in rainfall pattern is affecting water quality and quantity in normal times but the technology is perceived to be expense and therefore not widely used.

What are the costs and financial requirements?

Both capital and ongoing costs must be taken into account when considering the appropriateness of an HWTS implementation program for a given community. Some technologies (e.g chemical disinfectants) have few if any capital costs but must be purchased periodically; others (e.g. biosand filters) have relatively large up-front costs with little or no on-going costs.

The costs associated with training and educating users will exceed all costs associated with the HWTS "hardware." One example is solar disinfection (SODIS). In many settings, SODIS can be practiced with negligible costs, either capital or on-going. However, uptake and sustained use cannot be achieved without significant investment in training and education. Regardless of the technology, attempting to implement HWTS programs without a substantial education component is likely to decrease the long-term sustainability and impact. Many HWTS implementation programs are donor-driven, offering partial or complete subsidization of product costs.

Status of the technology in Grenada

This technology is not widely used in Grenada but pitcher water filters are available for home use.