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TNA TECHNOLOGY NEEDS ASSESSMENT

TRINIDAD AND TOBAGO

Identification and Prioritization of Technologies for Adaptation

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Technology Needs Assessment (TNA) Report - Trinidad and Tobago
Identification and Prioritization of Technologies for Adaptation
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Contents

List of Acronyms

BAU	Business as usual
CEC	Certificate of Environmental Clearance
EMA	Environment Management Authority
GCM	General Circulation Models
GDP	Gross Domestic Product
GEF	Global Environment Facility
GHG	Greenhouse gas
GORTT	Government of the Republic of Trinidad and Tobago
ICZM	Integrated coastal zone management
ITCZ	Intertropical convergence zone
LECB	Low emission capacity building
PAHO	Pan American Health Organisation
NDC	Nationally determined contributions
NGO	Non-Governmental Organisations
RCM	Regional climate models
SIDS	Small island developing states
SLR	Sea level rise
TAC	Technology needs assessment advisory committee
TAP	Technology action plan
TWG	Technology Working Group
TNA	Technology needs assessment
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
VCA	Vulnerability and capacity assessment
WHO	World Health Organisation

List of Tables

Executive Summary

The Ministry of Planning and Development joined a multi-country project entitled "Technology Needs Assessment (TNA) - Phase III" in collaboration with the United Nations Environment Programme and Danish Technical University (UNEP/DTU) Partnership with funding from the Global Environment Facility (GEF). This third phase of the Global Technology Needs Assessment project intends to provide participating countries with targeted financial and technical support to assist participating developing countries to carry out Technology Needs Assessments (TNAs), and develop national Technology Action Plans (TAPs) for prioritized technologies.

The project aims to assist with implementing technologies to reduce greenhouse gas emissions, support adaptation to climate change, and enhance national sustainable development objectives. Given that climate change is mainly a development issue, the TNA process is not a standalone process that is separated from the national development process that addresses climate change separately and specifically. The TNA process is as an opportunity to identify, assess, adapt, adopt, synergise, and implement relevant technologies and technological applications, within the national development process, to address climate change through low carbon development pathways and building climate resilience.

The National Climate Change Policy is the framework for the decision context in this report as it charts the way forward for both climate mitigation and building resilience for Trinidad and Tobago. The TNA report outlines actions needed to build resilience in key sectors and builds upon extensive work done in climate adaptation and mitigation including the Vulnerability and Capacity Assessment (VCA) conducted in 2018 and the Nationally Determined Contributions (NDC) Implementation Plan completed in 2020 in Trinidad and Tobago.

The chosen sectors for technology prioritisation were agriculture, health, and water because of their importance in the planning and management disaster risk reduction for a small island developing states. The mounting impact to humans and the natural environment due to climate change is outlined for each sector and technologies were chosen that would build resilience in these key sectors. The technologies were scored based on a number of criteria and key among them was the synergies and the ability to maximize co-benefits from the chosen technologies.

The results of the multicriteria analysis are listed below:

1. The prioritised technology technologies for the agriculture sector were pressurized irrigation technologies and protective structure cooling systems – caterpillar tunnels.
2. The prioritised technology for the health sector were solar powered backup power generation systems for health institutions and second is disease surveillance and early warning data on climate-sensitive environmental risks and epidemiological trends.
3. The prioritised technology for the water sector is rainwater harvesting and second is water metering.

These six technologies will form the bases for the next step in the TNA process; the Barrier Analysis and Enabling Framework (BAEF) Report

1. Introduction

1.1 About the TNA Project

The Ministry of Planning and Development joined a multi-country project entitled "Technology Needs Assessment (TNA) - Phase III" in collaboration with the United Nations Environment Programme and Danish Technical University (UNEP/DTU) Partnership with funding from the Global Environment Facility (GEF). This third phase of the Global Technology Needs Assessment project intends to provide participating countries with targeted financial and technical support to assist participating developing countries to carry out Technology Needs Assessments (TNAs), and develop national Technology Action Plans (TAPs) for prioritized technologies.

The project aims to assist in implementing technologies to reduce greenhouse gas emissions, support adaptation to climate change, and enhance national sustainable development objectives. It will support Trinidad and Tobago in further defining the national technology barriers to the diffusion of these adaptation technologies in the prioritised sectors. The development of technology action plans (TAP) can then be used by countries to access funding for implementation of these strategies. This report is primarily focused on the Technology Needs Assessment (TNA) for adaptation.

This TNA was developed and informed by the approach adopted by Trinidad and Tobago for adaptation which is building climate resilience into national development through a pathways approach (Werners et al, 2021) based on identified climate risks, with a view to long-term adaptation based on climate scenarios. This allows for an iterative process of intervention, monitoring and evaluation, and adjustment. The TNA was based on the extensive work already completed on climate risk assessments for various sectors. This TNA process is an opportunity to identify, assess, adapt, adopt, synergize, and implement relevant technologies and technological applications, within the national development process, to address climate change through low carbon development pathways and building climate resilience in these chosen sectors. The chosen sectors were agriculture, health, and water because of their close interrelatedness and the potential to optimize synergy by maximizing co-benefits of intervention measures in any one of the sectors on other sectors.

1.2 Existing national policies related to adaptation and development priorities

The first step in the TNA process was a comprehensive desktop review of all relevant legislation governing relevant adaptation and development priorities. The policies and related documents are outlined in the table below and represent the first stage of identifying and selecting relevant sectors for adaptation.

Table 1: List of policies and legislation with relevance to adaptation technologies

Legislation	**Relevance to technological innovation, adaptation to climate change and development priorities**
National Climate Change Policy	The Climate Change Policy addresses mitigation and adaptation and sets the policy framework for climate action in Trinidad and Tobago.
National Determined Contribution of T&T	The Nationally Determined Contribution (NDC) of Trinidad and Tobago was developed by the Ministry of Planning and Development in 2015 and outlines the public commitment of the Government of the Republic of Trinidad and Tobago (GORTT) to low carbon development under the Paris Agreement, of conditional 15% reduction of GHG emissions by 2030 from a Business as Usual (BAU) scenario and unconditional 3% reduction of GHG emissions in the transport sector by 2030 from BAU. While the NDC does not contain an explicit adaptation component, it addresses sectors that may have an adaptation co-benefit.
Nationally determined contributions (NDC) Implementation Plan	The NDC Implementation Plan outlines the way forward for low carbon development in Trinidad and Tobago up to 2030.
Environmental Management (EM) Act	The EM Act provides the legislative framework for addressing issues related to environmental protection and conservation.
Certificate of Environmental Clearance (CEC) Rules	The Certificate of Environmental Clearance (CEC) Rules were established in 2001 under the EMA Act as subsidiary legislation and provides for assessing environmental impacts, including climate change impact assessments.
National Environmental Policy 2018	The National Environment Policy 2018 provides the overall policy framework for environmental protection and conservation and specifically provides for climate change action, including adaptation.
Miscellaneous Taxes Act (Green Fund Levy)	The Miscellaneous Taxes Act 2000, Chapter 77:01 Part XIV established a national environmental fund (Green Fund Levy) capitalised by a 0.3% tax on gross sales of receipts of companies doing business in Trinidad and Tobago and is payable quarterly, and provides

Legislation	Relevance to technological innovation, adaptation to climate change and development priorities
	for funding of environmental projects aimed at protection and conservation.
Draft National Spatial Development Strategy	The Draft National Spatial Development Strategy outlines the national development and spatial planning up to 2033 for Trinidad and Tobago.
Draft Integrated Coastal Zone Management (ICZM) Policy	The Draft ICZM Policy aims to plan and manage development in the coastal zone so as to avoid increasing the incidence and severity of natural hazards and to avoid exposure of people, property and economic activities to significant risk from dynamic coastal process and impacts from climate change. Specific strategies include; encouraging the protection and maintenance of dynamic coastal features that act as a buffer against natural coastal processes and hazards; conducting coastal vulnerability and risk assessments and incorporating appropriate preventative and adaptive measures into all planning and management policies and decision making processes to account for projected changes in climate, particularly increases in sea level; and; developing a holistic programme for coastal zone protection.
Draft National Integrated Water Resources Management Policy	A major objective for the National Integrated Water Resources Management Policy is to establish an integrated framework for water resources and wastewater management, particularly as it relates to planning, environmental management, pollution control and adaptation to the impacts of climate change and variability. It identifies that the GORTT will ensure the enhancement of the public water supply system to satisfy the quality and reliability requirements of public water demand, through the implementation of a universal metering programme among other thing and development of new freshwater sources, including new and enhanced reservoirs and groundwater aquifers, promote the use of other supplies such as advanced technology systems e.g., desalinisation, water reuse and rain water harvesting where it is economically, technically, and environmentally feasible.
National Forest Policy 2010	The National Forest Policy outlines guidance for the conservation, rehabilitation, restoration and protection of forests and mangrove coastlines for coastal protection as well as the protection from the loss of soil biodiversity. It outlines the maintenance and enhancement of the natural productivity of forest ecosystems and ecological processes to provide important ecosystem services including watershed functions.
National Wildlife Policy	The scope of the National Wildlife Policy is to provide guidance on the sustainable management of undomesticated animals and plants found in Trinidad and Tobago including identify, protect and manage wildlife habitats providing key ecological services, including areas that are critically important watersheds; protecting land vulnerable to natural

Legislation	Relevance to technological innovation, adaptation to climate change and development priorities
	disasters; providing coastal protection (e.g. coastal mangroves and wind-belts); providing protection for sensitive ecosystems (e.g. coastal wetlands, protecting reefs, sea-grass beds and fish spawning grounds); important in climate regulation in agricultural production.
National Protected Areas Policy	The National Protected Areas Policy prescribes the restoration and protection of ecosystems that provide important ecological services including restoring, protecting and enhancing mangroves, wetlands, coral reefs, beaches, forests and other important ecosystems to reduce the risk of disasters; restoring, protecting and enhancing watersheds to support the supply and quality of water and restoring, protecting and enhancing mangroves, coral reefs, wetlands and other ecosystems for the provision of fish nurseries; restoring, protecting and enhancing forests and wetlands and other ecosystems important in carbon sequestration.

1.3 Vulnerability assessments in the country

A comprehensive Vulnerability and Capacity Assessment (VCA) was conducted for Trinidad and Tobago in 2018-2019. The Vulnerability and Capacity Assessment report provides a comprehensive picture of the impacts of climate change, climate variability and projected climate change impacts to facilitate decision-making on climate change risk management by key agencies. The report also presented extensive data on climate modelling for temperature, rainfall and wind and identified vulnerable communities and sectors in Trinidad and Tobago to the main projected effects of climate change. The VCA report identified six major areas of focus for adaptation. These included:

1. Natural coastal and marine resources
2. Agriculture and food security
3. Water resources
4. Human health
5. Terrestrial biodiversity
6. Infrastructure and human settlements

The results of this VCA report formed the basis for the selection of sectors and technologies for adaptation since this report contextualised the climate vulnerabilities by sector and detailed the required adaptations to actively and appropriately respond to the future projected climate risks for Trinidad and Tobago.

1.4 An overview of expected climate impacts in sectors vulnerable to climate change

Observed sea level rise in Trinidad and Tobago has been estimated at a rate of 6.7 mm/year from 2009 to 2016 (VCA 2018). Through General Circulation Models (GCM) and Regional Climate Models (RCM) outputs from climate modelling work conducted for Trinidad and Tobago, projects that sea level could rise to between 75 cm and 126 cm by 2100. These projected increases in sea level could directly influence storm surge heights and be enhanced by the projected increases in intensity of tropical weather systems like tropical storms and hurricanes.

The anticipated effects also include increased incidences and intensity of rainfall events resulting in flooding, including areas where flooding has not been a major problem in the past. There is also evidence that there may be increased incidences of diseases exacerbated by flooding and its effects. Sea level rise is expected to directly impact natural coastal barriers to storm surge and flooding. The devastation of coastal resources including effects such as salt-water intrusion, and denudation of coral reefs and mangroves forests can affect coastal agriculture as well as coastal ecosystems which are an integral part of the revenue stream for lower income groups in both Trinidad and Tobago.

Key climate-related impacts for agriculture and food security already being observed include: increased aridity of soils and decreased crop yields due to increase in air temperature, salinization of soils and ground water due to coastal inundation and reduced availability of fresh water due to lower precipitation. The projected climate change impacts are expected to negatively affect the agricultural sector nationwide and the vulnerability of agricultural systems globally coupled with the continued reliance of Trinidad and Tobago on imports of staples such as wheat and maize is an important consideration for climate change planning (VCA 2018).

Reduced freshwater supply has also been reported due to decreased rainfall and subsequent reduction in stream flow. Projections suggest an increase in intense rainfall events over shorter periods that will result in lower surface water quality, reduction in the recharge of ground water as run off would be at a maximum; while increase in longer dry spells and drought events coupled with warmer temperatures would increase agricultural irrigation demands, affect crop scheduling, increased health impacts, coral bleaching and saline intrusion (VCA 2018). Given the climate risk factors on water resources, the increasingly warmer climate, frequency of intensifying cyclones, droughts and floods are of major concern and present varying degrees of challenges to development of adaptation strategies.

The impact of climate change on human health especially for SIDS like Trinidad & Tobago could be devastating even though the island has a well-developed health system. The varying threats and the unpredictability with regards to timing and types of disease and their relation to climate is hard to predict. Trinidad and Tobago will face health impacts from heatwaves, floods, droughts and storms. Human health and healthcare are provided through both public and private health facilities across Trinidad and Tobago and the current global Covid-19 Pandemic is having a major negative impact on both public and private health services. Like many other countries there is a reduced capacity of hospitals and health care institutions due to Covid-19 related illness and hospitalisations as well as the illness and loss of lives of health care workers.

Trinidad has a very high biodiversity index which is attributable to its geological history and proximity to the South American continent. This biodiversity supports a number of natural diverse ecosystem like wetlands and mangroves that serve as protection for coastal areas (VCA 2018). The potential effects due to climate changes include damage and destruction of coastal infrastructure, fisheries infrastructure, coastal and terrestrial ecosystems including biodiversity, agriculture and forests from extreme weather events.

Settlements and infrastructure are also estimated to be heavily impacted due to the effects of climate changes and it was determined that risks from sea level rise and storm surge include: damage to access roads and major roads and transportation links like marinas, ports, jetties and sea defences and offshore industrial, residential infrastructure, utilities, industrial facilities and plants including sewage. The risks from extreme weather events (intense precipitation) include flash flood damage to bridges, roads, residential and commercial properties, utilities, access, services, critical infrastructure, cultural historical buildings and recreational structures and impacts on sewage and garbage management infrastructure.

1.5 Sector selection for adaptation technologies

The Vulnerability and Capacity Assessment (VCA) conducted in 2018 formed the basis for the selection of sectors as well as the selection of technologies in each sector. Based on the information presented the national TNA team performed a mapping and clustering exercise in order to assist in identifying the most value-added sectors by identifying the number and degrees of synergies between the sectors reviewed for the vulnerability risk assessments. The mapping and clustering exercise (ANNEX IV) identified the largest crosscutting areas for the greatest impact from climate adaptation measures to effect positive long-term solutions. The sectors chosen by the Technology Working Group (TWG) for the TNA process were the areas where action in one sector would have positive impact on other sectors and were identified by the relative risk and vulnerability to the impact of climate change with a key focus on areas that are prioritised for development in Trinidad and Tobago.

1.5.1 Agriculture

The first area chosen for the TNA for adaptation was agriculture, with a focus on water availability and food security. The agricultural sector could be severely impacted by sea level rise and resultant salt water intrusion into coastal agricultural settlements which exist in both Trinidad and Tobago. Extreme weather events and resultant flooding of farm lands is particularly important as many of these lands are located in low lying areas that have historically been impacted by flooding. It is expected that there will be an increase in these occurrences for many agricultural communities. These effects will create a reduction in the capacity of farm lands in the future and the output of food will be decreased. Trinidad and Tobago also currently have a high food import bill. The availability of food for import could decrease in the future and the cost of imported food could increase making adaptation and resilience building for local agriculture a top priority for the future.

1.5.2 Health

The second area chosen for TNA was the health sector. The health sector will primarily face complex problems during climate related disasters and emergencies from flooding and extreme weather. Additionally, the means to provide potable water to the health services during extreme weather events or disasters will be imperative. The impact on human heath from climate related intensification of pest and disease is also an important consideration and in light of the Covid-19 pandemic up-to-date technologies was deemed vital for adaptation in the heath sector.

1.5.3 Water

The third area of focus for the TNA the water sector due to the direct risks posed to both the health sector and the agriculture sector as a result of impacts on water quality and availability from extreme weather events causing flooding and flash flooding as well as its effects and sea level rise and temperature increases. These water sector technologies focus on water availability for agriculture and heath care in particular because of the synergies approach.

2. Institutional arrangement for the TNA and the stakeholder involvement

2.1 The TNA Advisory Committee

The National TNA team consisted of the National Consultants and representatives of the Ministry of Planning and Development (National TNA Coordinator), Climate Change Unit, and the UNEP DTU representatives. This team was responsible for the coordination of the National TNA Advisory Committee (TAC). The TAC included representation from a number of agencies and ministries which hold responsibility for the sectors identified in the TNA process. The members of the TAC were all included in the Technology Working Groups (TWG) for each chosen sector in order to have the widest participation and diverse feedback. The TNA Advisory Committee included stakeholders that were also involved in the working groups that developed the VCA as follows:

1. Council of Presidents for the Environment (Cope)
2. The University of the West Indies (UWI)
3. The University of Trinidad and Tobago (UTT)
4. The Environmental Management Authority (EMA)
5. The Institute of Marine Affairs
6. The Energy Chamber of Trinidad and Tobago
7. Water Resources Agency
8. The Water and Sewerage Authority of Trinidad and Tobago (WASA)
9. The Office of Disaster Preparedness and Management (ODPM)
10. Trinidad and Tobago Meteorological Services (TTMS)
11. The Office of the Prime Minister
12. Ministry of Agriculture Land and Fisheries
13. Ministry of Energy and Energy Industries
14. Ministry of Finance
15. Ministry of Planning and Development
16. Ministry of Public Utilities
17. Ministry of Rural Development
18. Ministry of Tourism
19. Ministry of Works and Transport

2.2 Stakeholder Engagement Process

These stakeholders were selected for the TNA process building upon the initial stakeholders selected to conduct the Vulnerability and Capacity assessment in Trinidad and Tobago in 2018. These stakeholders were engaged in the VCA process and though the development of the VCA they would have shared their expertise in the various sectors studied through the VCA. These stakeholders were also involved in the development of the NDC implementation program and their knowledge and expertise developing both reports were utilised for the TNA development for adaptation.

Letters were sent to these organisations inviting nominations to become part of the TNA Advisory Committee (TAC). Through letters of appointment from the various organisations the final TAC list consisted of the same departments within the various organisations represented in the VCA and in most cases was the same individual. The team therefore had a good background on the VCA outcomes and were well informed of the potential technology needs within the various sectors.

The TAC members along with any additional members of their organisation that wished to attend were invited to all of the stakeholder engagement sessions. The nominated TAC members also formed the Technology Working Groups (TWG) for the TNA project. Further sector specialists were recommended and consulted on select technologies by the members of the TWG within their organisations and their own stakeholder networks where necessary. The structured engagement sessions took place virtually due to the Covid-19 Pandemic restrictions and a round robin approach was employed for technology discussions and feedback for each sector and for the multicriteria analysis scoring. The national stakeholders were consulted on a continuous basis during the development of the TNA report by the TNA team. The identified national stakeholders making up the TWG are listed in Annex I.

The TAC was used as the working group and was engaged firstly in a round robin approach to assist in the identification of a long list of technologies for the relevant sectors with the help of the national TNA team. The consultant provided and initial list which was then sent around to the TWG to add additional technologies not yet considered. Through another round of email consultations, the TWG made assessments on the suitability, need, potential and current impact of the technologies. The technologies that were deemed inappropriate, as well as technologies that were already well developed in the country were removed resulting in a shorter list of technologies which were then scored by the TAC members and a multicriteria analysis (MCA) was done to rank the identified short list of technologies for further study and development.

2.3 Criteria and process of technology prioritisation

The criteria chosen for scoring under the multicriteria analysis for the four sectors were derived from stakeholders through a consultative approach. The list of criteria was chosen as a baseline of the needs required for the implementation of any new technology as well as the potential and risks and benefits derived from the economic and social implications of implementation the technology. Table 2 below outlines the list of criteria and the weightings for each.

Table 2: List of criteria for MCA for the three priority sectors

Criteria	Description and weighting	%
1. Ease of Implementation	Measures the difficulties of deploying a particular technology in the sector. The ease of implementation score rating was 5% because while it is a consideration there are other more important consideration on the list.	**5**
2. Sustainability of technology	Sustainability of the technology measures the level of technical input and institutional capacity required for maintenance and the relative long-term sustainability of the technology. It was given 10% weighting because it has relatively high importance since this would be a good indicator of the long-term viability of such technology.	**10**
3. Relative Cost	The cost scores are based on cost figures obtained in a desktop review/research. The cost scores are not consistent across sectors because the range of costs can differ substantially with respect to local factors however it was given a 10% weighting because cost is an important consideration for both market and non-market goods.	**10**
4. Market Readiness	This criterion considers factors such as the availability of technology through private markets or an academic institution, or its use by other international organizations. It characterizes funding channels as public or private, and as established or emerging. It also considers how easy the technology can penetrate the local markets of the islands. Market readiness is scored lower at 5% because it is assumed that the technologies chosen inherently are fully developed technologies and the chief concern would be the availability in country. For public goods	**5**
5. Ecosystem Benefit & Protection	This criterion measures the perceived contribution of the technology to protect and sustain ecosystem services. This has been weighted at 15% since the importance of protection and ecosystem benefit for adaptation is of paramount importance.	**15**
6. Risk of Maladaptation	This criterion measures the subsequent negative impact on the environment that could occur if technology is maladapted. It is a negatively rated weighting (i.e., higher scores from the TAC means higher chance of maladaptation and ranks lower) and was normalized before calculation. This has been weighted at 15% since the risk of maladaptation was viewed as important as ecosystem benefit and protection.	**15**
7. Climate benefit	This criterion measures the impact on enhancing resilience against climate change impacts. It deals with how effective a technology is at reducing climate risks. The higher the synergistic benefits	**20**

Criteria	Description and weighting	%
	amongst other sectors, the greater the risk reduction and the higher the awarded score.	
8. Social Benefit	Measures the increase in the welfare of a society that is derived from a particular course of action including gender mainstreaming benefits. The ccontribution to social and sustainable development (benefit to society) considerations were given to job creation, benefits to women and lower income households, entry point for entrepreneurship educational impact and	**10**
9. Synergy Benefits	This criterion looks at the related positive benefits to other adaptation sectors from coastal resources, human settlements, infrastructure, agriculture, water, and health.	**10**
Total		**100**

2.4 Gender considerations in the TNA process

An Action Plan for Mainstreaming Gender in the Climate Change Sector and NDC Implementation in Trinidad and Tobago was created under the NDC Support Programme. The key actions identified from this policy include identifying areas that potentially affect men and women in different ways and incorporate actions to address these differentiated outcomes and impacts so that inequality is not perpetuated (GAP 2019).

In the TNA process the inclusion of women in decision making as well as identification and scoring of the related technologies was made a priority with eight of the seventeen agencies being represented by women on the stakeholder committee. The members of the TNA working group (TWG) for adaptation were required to deliberate on the selected technologies including the gender related impacts and these were included in the scoring of each technology under the social benefit criterion. The social benefit criterion weighting was included in the multicriteria analysis and consequently technologies were given higher weighting if positive gender impacts among other social impacts was an identifiable outcome if implementing the technology.

3. Technology prioritisation for Agriculture

3.1 Key climate change vulnerabilities in the Agriculture sector

Despite the decline in export oriented agricultural activities in Trinidad and Tobago (FAO 2015), domestic agriculture for subsistence and local food security remains vital. The GORTT has articulated the intention to transition towards a more diversified economy (UNECLAC 2019) including agriculture and agro-processing as areas for new business. Climate change however poses a threat to localised agricultural production and small-scale agriculture which relies heavily on the natural environment is greatly exposed to the various changes in local climatic variables.

The industry's vulnerability is further amplified by the low inputs of capital and limited access to other resources, particularly by poor rural households who farm to meet their household needs. Changes in rainfall and temperature have thus far forced farmers to change the timing of their activities and in the case of droughts to install irrigation systems, at significant financial expense. There are concerns which can negatively impact the ability of the sector to adapt to and build the resilience needed to ensure food security in the future. Impediments identified in Trinidad and Tobago to producing local crop commodities include the inability of crops to adapt to local climatic conditions, as well as the unavailability of germplasm suited to local conditions (JSC, T&T 2018).

In addition to the constraints on agriculture through the availability and selection of crops is the issue of soil health. Poor farming practices, including pesticide applications at a higher frequency than the standard (Patloo et al, 2018) has been linked to immense damage to agricultural soils leading to more leaching of nutrients, increased surface runoff, and loss of the productive top layer of soil. There is ongoing work to equip farmers with the necessary soil conservation techniques by the Ministry of Agriculture and soil conservation is increasingly more important as climatic changes will negatively affect soil fertility, including moisture and organic content.

There is also a need to boost the application of good agriculture practices in farming coupled with altering the time crops are planted to take advantage of the cyclic water variations, through planting crops which require more water in the wet season and those which require less water, in the dry season since approximately 33.6% of agricultural land is subject to flooding (IDB 2018) in Trinidad and Tobago.

Trinidad and Tobago has limited arable land space for agriculture and the areas used for farming have not historically been the most fertile. There is a tendency to utilise areas that are primarily composed of heavy clays as agricultural land. These types of soils respond negatively to dry conditions and the importance of proper irrigation as well as proper soil conservation practices is increasing for the agricultural sector in the face of further dry arid conditions together with more intense rainfall events predicted for the future.

Agriculture still mostly relies on rain-fed water (only 11% of agricultural land was irrigated and agriculture consumes 4% of the public water supply) supply of water for irrigation remains an issue due to lack of irrigation infrastructure and lack of resources for its operation and maintenance (IDB 2018).

Currently in the agriculture sector there is a focus on building the local food production levels and increasing export of agricultural produce and products through entrepreneurship programmes and assistance with export preparation and packaging of produce. The Ministry of Agriculture is also involved in the provision of root material and seeds that are adapted to current local climatic conditions. The varieties of crop species are however limited and external suppliers who may offer more variety do not have crops specifically bred for local climatic conditions or even future climatic extremes. Building soil conservation practices into the routine of agricultural practices is also required to ensure the soil's fertility and productivity for the future. This will ensure that future crop varieties and planting material can thrive in the expected increase in extreme soil and weather conditions, drought, and increased soil aridity.

3.2 Decision context for prioritisation for the Agriculture sector

In Trinidad and Tobago, the agriculture sector mainly provides goods for local consumption with limited exports of produce. The vulnerabilities to the agriculture sector include the projected increases in ambient surface temperatures resulting in increased aridity of soils and decreased crop yields due to intolerance of crop varieties as well as increased incidence of invasive species, pests and diseases Projected increase in sea level is likely to result in inundation of coastal areas and salinisation of productive soils and can also cause reduction in the available areas for agricultural production due to reduction in coastal land space. Decreases in precipitation can also increase the aridity of soils and decreased crop yields due to less irrigation water availability.

The development of appropriate and integrated plans for the agriculture sector to prepare for adaptation to the impacts of climate change is stated in the national climate change policy (NCCP2011) objectives. The enhancement of agricultural production and establishment of a food secure economy is at the core of this policy.

As such, measures and technologies that increase agriculture productivity, develop drought adaptations, increase irrigation and water availability and protect agricultural land were selected by the TWG to be evaluated.

3.3 Overview of existing technologies in the Agriculture sector

A desktop study was done firstly to identify suitable technologies in line with the climate vulnerabilities and the decision context. This long list of technologies went through deliberation by the TWG members and stakeholders as to the suitability of the technology to address the adaptation issues in agriculture and the need for the technology.

From the long list below five technologies were chosen and adjusted and adapted for use in Trinidad. The multicriteria analysis was then undertaken taking the main adaptation benefits into consideration. The technologies removed were either not appropriate for agriculture in Trinidad and Tobago or were already being utilised.

Table 3. Long list of technologies for Agriculture sector

Technology	Description and decision context
Fungal symbionts	One area of frontier research that shows potential for improving crop resilience is fungal symbionts. Fungal symbionts refer to fungi that live in a mutually beneficial symbiotic relationship with plants. In the context of climate adaptation technologies, the term specifically refers to several classes of fungal organisms with the potential to alter the host plants' response to stresses brought on by climate. This technology is still very much in its infancy **(ADB 2014)** and it was deemed inappropriate for current implementation as further research and development is required. (Not market ready).
Laser land levelling	The use of laser technology mounted on a tripod or tower and used in combination with a tractor to flatten or level agriculture fields in an effort to conserve irrigated water **(ADB 2014).** This precisely flat land aids in runoff control as much water loss in agriculture is a result of unnecessary runoff from fields. This technology was not considered appropriate since many agriculture fields are prone to was logging due to flooding and increased runoff ability was seen as equally important as irrigation.
Floating Agriculture	Floating agriculture involves the production of food in waterlogged and flood prone areas for extended periods of time and can also be implemented in waterways and water collections where there is increased food demand. This can benefit flood prone communities and can be a more productive farming system once the capacity is built. **(ADB 2014).** Although floating gardens provide a useful adaptation to some types of climate change impact such as increased flooding, they remain vulnerable to other types of impact, particularly salinity intrusion and precipitation variability. Floating agriculture is seen as not appropriate for T&T given the small land space and tendency toward very wet and then very dry conditions between the two weather seasons.
Pressurized irrigation technologies	Pressurized irrigation system using sprinkler or drip irrigation. These irrigation systems deliver water directly to the plants' roots, and can aid in providing an ideal moisture level for plants. Unlike flooding techniques, drip systems enable farmers to deliver water directly to the plants' roots drop by drop. The TWG agreed that this technology should be included for prioritisation.
Protective Structure Cooling Systems – Caterpillar tunnel	Caterpillar or bell tunnels provide sun protection and reduce evapotranspiration reducing water and heat stress on plants. Caterpillars are easy to build and move. They are inexpensive compared to permanent greenhouses and most of the materials can be found locally. They provide protection but, at the same time,

Technology	Description and decision context
	excellent air flow. These tunnels can be adapted to small or large farms and are lower in cost than traditional built greenhouse structures. The TWG agreed that this technology should be included for prioritisation.
Crop breeding of heat and drought resistant varieties of crops.	Crop breeding programs can use both traditional techniques and modern biotechnology to identify strains with traits relevant to climate change. This technology would involve the development/testing and introduction of alternative crop species and varieties for salt tolerance, heat and drought resilience, pest and diseases that are adapted to the climatic conditions specific to Trinidad and Tobago. These breeding programs can involve amplifying the potential of existing traits or transferring traits to other plants. This can be done to increase varietal tolerance of factors such as increased average minimum and maximum temperatures, extreme heat events, droughts, flooding, and increased salinity, to help a plant cope with climate change. This technology was deemed important for the long-term sustainability of the agriculture sector in T&T by the TWG.
E-livestock management for temperature, health and disease.	Use of automated data monitoring systems for health and disease control and management of livestock. Adoption of more integrated and intensive livestock farming, better design of livestock and poultry pens and facilities to allow for greater airflow and temperature management and disease and manure management. Benefits include reduced livestock loses due to illness, heat stress and disease, better disease control and health monitoring, increase by-product yields and reduced waste, (health and food security). The TWG agreed that this is and important technology for T&T.
Virtual Soils Doctor	Soil health monitoring system where data are used to support farmers soil management practices. Including e-platform and laboratory testing for soils conservation and management. Increased soil fertility, sustainable soil use, enhancement of soil productivity, biological activity and output of soil. (food security). Better soil management practices to conserve and protect land from soil degradation and loss of fertility, crop rotation, better clearing practices, land contouring through a virtual platform. The TWG agreed that this is and important technology for T&T in particular in light of the Covid-19 pandemic and increase in virtual collaborations for ministries and agencies.
Improved extreme weather event prediction and early warning systems	Mobile technologies linked to metrological monitoring systems to alert farmers on impending flood, drought, extreme temperatures, and pest alerts. Climate smart agriculture and climate early warning systems coupled with disaster risk reduction and disaster response planning. This technology can reduce impact to agriculture and livestock from natural disasters including extreme weather, flooding, pest, and diseases. (health and food security) by assisting in the preparedness and response of farmers to weather events. Deemed important for T&T by the TWG.

3.4 Adaptation technology options for Agriculture and their main adaptation benefits

The TNA focused on food security and building resilience for agricultural land and crops to flooding or prolonged periods of drought, both of which are potential impacts to the agricultural sector. Based on the approach taken, the table below identifies the technologies for the agriculture sector that was identified and short-listed technologies by the TWG. The short-listed technologies account for the major applicable technologies that take into account the current needs, and expected future circumstances due to the impact of climate change. The adaptation benefits to other relevant sectors including the interrelatedness among the health sector and water resources outlined from the synergies mapping exercise was also a major consideration in rating the technologies.

Table 4: Short list of technologies selected for the Agriculture sector

Technology	Description and adaptation benefits
Pressurized irrigation technologies	Pressurized irrigation system using sprinkler or drip irrigation can deliver water directly to the plants' roots, and can aid in providing an ideal moisture level for plants. Unlike flooding techniques, drip systems enable farmers to deliver water directly to the plants' roots drop by drop, nearly eliminating reducing or even eliminating water waste, it is suitable for clay soils and can be set up to operate with gravity flow. This technology can be coupled with fertiliser application in the form of fertigation which can also reduce fertiliser cost through minimising wastage. There is also the potential for this type of irrigation to be set up with rain water harvesting mechanisms to have independent water supply and irrigation for small holder farmers. (Rain Water harvesting dealt with in the water resources section.) the Use of solar power can truly make these systems independent and the technology can be adapted to the size of the farm and the climatic conditions from season to season and can also be operated independent of the national potable water supply. This can reduce the demand for water treatment and allow treated potable water to be utilised in other sectors such as manufacturing and health care.
Protective Structure Cooling Systems – Caterpillar tunnel	Caterpillar or bell tunnels provide sun protection and reduce evapotranspiration reducing water and heat stress on plants. These tunnels can be adapted to small or large farms and are lower in cost than traditional built greenhouse structures. It can also reduce the frequency needed to apply pesticide. These tunnels can be easily constructed, lightweight and can be easily opened and closed to allow the movement of pollinators. In Trinidad and Tobago protecting farms from extreme temperatures is particularly important as surface temperatures are expected to rise and drought conditions are expected to increase in frequency. The benefits from these protective structures include allowing farms to be more resilient to the cyclic temperature variations and increase food security. These protective structures can reduce the amount of water that is lost from plants and reduce water and heat stress. These structures can also reduce the impact of the sun and temperature extremes on plants by reducing the amount of sunlight the pants are exposed to. The tunnels can also minimise the transfer of pests and diseases from one area to the next and allow for more resilience in the plants to fight diseases and pest by forming a barrier between tunnels limiting the movement of pests and disease vectors. They can also help to maintain health of soils and increase crop yields due to less irrigation water needed and less pesticide usage.

Technology	Description and adaptation benefits
Crop breeding of heat and drought resistant varieties of crops.	This technology would involve the development/testing and introduction of alternative crop species and varieties for salt tolerance, heat and drought resilience, pest and diseases that are adapted to the climatic conditions specific to Trinidad and Tobago. These breeding programs can involve amplifying the potential of existing traits or transferring traits to other plants. This can be done to increase varietal tolerance of factors such as increased average minimum and maximum temperatures, extreme heat events, droughts, flooding, and increased salinity, to help a plant cope with climate change. This technology was deemed important for the long-term sustainability of the agriculture sector. Some varieties of root crops are already being bred locally and there is need for further research and development for enhanced crop varieties. (ADB 2014). Climate resilient crops which can tolerate extreme conditions; heat/ drought, humid/arid conditions, oversaturation and flooding, tolerance to increased salinity. Higher disease and pest resistance will also have a direct impact on the food security for Trinidad and Tobago.
E-livestock management for temperature, health and disease.	The benefits of automated data monitoring systems for health and disease control in livestock management include reduced livestock loses due to illness, heat stress and disease, better disease control and health monitoring, increase by-product yields and reduced waste and cost. There is a direct link to reduced health cost though pest and diseases and capital losses. The technology can assist in making T&T more food secure and allow farms to be able to respond to extreme weather events in real time reducing health stress on animals and capital losses while keeping prices even. Trinidad and Tobago has a high food import bill and ensuring the resilience of livestock farming can be of great benefit by allowing T&T to continue to provide safe farming goods locally.
Virtual Soils Doctor	Soil health monitoring system soils conservation and management can give farmers the technical backstopping to maintain and increase the soil fertility, sustainable soil use, enhancement of soil productivity, biological activity and output of soil. Through a virtual platform can run independently and help farmers to conserve and protect land from soil degradation and loss of fertility. The benefits include reduction in biodiversity loss in the soil and land degradation, increasing food security. In light of the Covid-19 pandemic and increase in virtual collaborations for ministries and agencies this virtual platform can bridge the gap between farmers and ministries and agencies responsible for agriculture and land resources.
Improved extreme weather event prediction and early warning systems	Mobile technologies linked to metrological monitoring systems to alert farmers on impending flood, drought, extreme temperatures, and pest alerts. Climate smart agriculture and climate early warning systems coupled with disaster risk reduction and disaster response planning. This technology can reduce impact to agriculture and livestock from natural disasters including extreme weather, flooding, pest, and diseases. (health and food security) by assisting in the preparedness and response of farmers to weather events. It can boost the soil conservation practices by giving farmers real time data and predictions on extreme weather events and response measures.

3.5 Criteria and process of technology prioritisation for Agriculture

The criteria chosen were derived from the list of potential effects on the agriculture sector and considering the synergies identified in the mapping exercise. The criteria used to score each of the technologies in agriculture by the TAC stakeholder are outlined in Section 2.3. The criteria used are, ease of implementation, sustainability of technology, relative cost, market readiness, protection & ecosystem benefit, risk of maladaptation, climate benefit and social benefit.

3.6 Results of technology prioritisation for Agriculture

Table 5 shows a summary of the results of the multicriteria analysis of the prioritised technologies for the Agriculture sector.

Table 5: Multicriteria analysis results for technologies selected for the Agriculture sector in Trinidad and Tobago

TECHNOLOGY PRIORITISATION SCORES FOR THE AGRICULTURE SECTOR											
	List of criteria/ normalised scores										
Weighting %	5%	10%	10%	5%	15%	15%	20%	10%	10%	100%	---
Normalised criteria	*Ease of implementation*	*Sustainability*	*Cost*	*Market readiness*	*Ecosystem benefit*	*Risk of maladaptation*	*Climate benefit*	*Social benefit*	*Synergy benefit*	*Combined Score & weight*	*Ranking*
Crop breeding	50.0	16.7	0.0	80.0	100.0	20.0	50.0	40.0	75.0	47.67	4th
Pressurized irrigation technologies	75.0	66.7	50.0	100.0	75.0	80.0	75.0	100.0	50.0	73.67	1st
Protective Structure Cooling Systems – Caterpillar tunnel	25.0	100.0	100.0	80.0	75.0	40.0	25.0	80.0	12.5	56.75	2nd
E-livestock management	0.0	0.0	37.5	20.0	0.0	0.0	100.0	40.0	0.0	28.75	5th
Virtual Soils Doctor	25.0	33.3	62.5	0.0	50.0	20.0	0.0	0.0	25.0	23.83	6th
Establishment of early warning systems	100.0	50.0	87.5	40.0	0.0	100.0	25.0	20.0	100.0	52.75	3rd

4. Technology prioritisation for the Health sector

4.1 Key climate change vulnerabilities the Health sector

Human health is a critical consideration in adaptation to the negative effects of climate change and building resilience in the health sector to respond and adapt to the increases in illness rates as a result of climate changes as well as disasters associated with extreme weather events are both priorities for Trinidad and Tobago.

There will be a number of long term and short-term impacts to human health as a result of climate change which can be direct through health and disease or indirect through hey systematic impacts of climate change such as exacerbation of pest and disease. Changes in climatic conditions can alter behavior, range and disease carrying capacity of many vectors. The potential direct effects from heat waves, flooding, landslides, hurricanes or other extreme weather events include need for emergency medical care and the potential for large sections of the population to require emergency care at the same time. This means it is important that disaster risk management systems allocate resources within the health services to deal with, and respond to, increase incidences of climate related emergencies.

Indirectly there could be an increase in hunger and malnutrition from crop failure and increased food prices. Impacts from lack of potable water and sanitation can also cause increase in water-borne diseases, diarrheal diseases and vector-borne diseases such as dengue, leptospirosis yellow fever and malaria. Health impacts are also directly linked to impacts in other sectors such as decreasing food security, increasing price instability further discouraging production and therefore increasing poverty and hunger. Trinidad and Tobago is currently dealing with the Covid-19 pandemic along with the globe and this pandemic has already put a heavy strain on the economy not to mention the health care systems including its human resources.

Current systems in place within the health sector to deal with the seasonal impacts of adverse weather and flooding include environmental sanitation, vector control programmes, impact assessment and response planning, health education promotion and community empowerment around the issues related to vector borne diseases particularly.

While non communicable lifestyle diseases are the main focus of many health intervention programmes, there continues to be outreach and focus on vector borne illnesses. Access to potable drinking water and sanitary facilities in the health sector is a huge concern during potential adverse weather evens and flooding as well as emergency field health care and treatment. Surveillance for diseases in particular vector borne illnesses is also a key facility needed for building resilience to the effects of climate change.

4.2 Decision context for prioritisation for the Health sector

The National Climate Change Policy (NCCP 2011) identifies projected increases in ambient air temperature are likely to result in the increased spread of vector borne diseases due to increased humidity, while also giving rise to favourable conditions for increased vector populations. Projected decreased precipitation is likely to result in reduced availability of potable water. Additionally, reduced rainfall will indirectly affect food availability due to inability to water crops. Projected increased sea level and precipitation intensity is likely to result in an increase in the incidences of water borne diseases in permanently or often flooded areas (NCCP 2011).

The policy speaks to protection of the natural environment and human health. It outlines the commitment to assessing sectoral vulnerability to climate change by conducting vulnerability analyses and formulating adaptation options, including technological application, in biophysical and socio-economic systems, revising sectoral policies to include consideration of climate change impacts derived from vulnerability analyses, revising national development plans to incorporate climate change vulnerability, impacts and adaptation options with a view to climate proofing new developments and retrofitting existing infrastructure.

The Disaster Risk Reduction Country Document prepared by the Office of Disaster Preparedness and Management (ODPM 2014) outcome 3; outlines that disaster risk management to be mainstreamed at national levels and incorporated into key sectors of national economies including health and agriculture and medium-term priorities for the National Development Strategy include health and hospitals.

A country profile on Trinidad and Tobago conducted in 2020 to provide a summary of available evidence on climate hazards, health vulnerabilities, health impacts and progress to date in health sector efforts to realize a climate-resilient health system identified the measures than can be taken to prevent the potentially devastating impacts of climate change on health service provision. These measures include strengthening structural safety; and contingency planning for essential health systems including electricity, heating, cooling, ventilation, water supply, sanitation services, waste management and communications (WHO/PAHO 2020).

Additionally, a technical briefing paper done for the World Health Organisation (Watts et al /WHO 2017) that new technologies are already transforming the way healthcare is managed in many countries around the world, from innovative eHealth data management systems, tele-health practices, personalised data monitoring, and medical technologies with lower energy requirements and some of these technologies have the added benefit of improving the climate resilience of the health system, decreasing its environmental impact.

The report makes specific mention to the need for health facilities to have access to sustainable energy and water supplies where appropriate including solar energy for vaccine cold chains, lighting for surgery and water pumping. This would be specifically important for disaster risk reduction and preparedness in country. It also highlights the need for new technologies or processes improvements in the way health interventions are delivered to increase climate resilience such as eHealth or satellite imagery used to improve health system performance and the adaptation of current technologies and procedures to respond to the risks posed by climate change.

In summary the needs of the health services in line with disaster response and adaptation to the ill effects of climate change are numerous however technologies to bolster the health care system to deal with health issues, disasters and emergencies from extreme weather to disease outbreaks would require better health surveillance and communication as well rapid response to health emergencies.

4.3 Overview of existing technologies in the Health sector

For the Health sector a long list of technologies was not derived as this sector required very specific interventions based on need and direction as outlined in the decision context. The technologies reviewed for the health sector included; rapid diagnostic tests (RDTs), disease surveillance systems, e-Health, flood-proof drinking water wells (ADB 2014). The TAC carefully reviewed the list and reworked the technologies and adjusted the context to meet the local needs and circumstances and this new list was created below in Table 6.

Table 6 List of technologies for the Health sector

Technology	Description and decision context
Solar powered backup power generation systems.	Alternative energy sources for medical equipment, lighting and water storage and pumping for health care institutions. Potable water and refrigeration which is not impacted by power outages and is renewable. This was seen as an important adaptation technology to bolster the ability of health care institutions, hospitals and health centres to operate during disasters and respond to emergencies including flooding and extreme weather events.
e-Health – for diagnosis and disease prevention	E-health involves the use of advanced computing by health-care providers like electronic medical records, digital prescriptions, inventory monitoring systems, laboratory information management, pharmacy information systems, patient registration or scheduling systems, monitoring and evaluation and patient tracking systems, clinical decision support, research and data collection. It can also involve the use of distance-spanning communication technologies like telemedicine, virtual office visits or specialist consultations, remote diagnostics, automated telephone monitoring and self-care support calls. It would require provider support and patient communication with the help of mobile phones, tablet computers, and other mobile devices. This technology requires virtual ICT platform and user training. It can also involve the use of health and disease surveillance systems, outbreak mapping, telemedicine in disasters when roads or hospitals or other important infrastructure are destroyed or inaccessible. It was chosen by the TAC as an important measure to bridge

Technology	Description and decision context
	the gap between climate adaptation requirements and modern medical treatment measures.
Disease Surveillance and emergency early warning.	This is another technology requiring virtual ICT platform and user training. Disease surveillance systems refer to various types of advanced information and communication devices and applications that can assist health professionals in collecting, processing, interpreting, and disseminating data more efficiently to support infectious disease monitoring and response. The need to strengthen such systems has been recognized for decades, in view of the gaps in global coverage left by limited and fragmented surveillance capacity. A disease surveillance system must be user-friendly and speed disease detection and provide early warning and efficient mobilization, preferably without any need for expensive licensing and burdensome training. Must have real-time or near-real-time monitoring; be timely, accurate reporting and flexible response planning and networked health-care professionals. Coupled with current disease monitoring programmes it can be integrated and operationalised to rapidly respond to health emergencies from disease through a virtual platform in real time and foster a resilient health care system.
Rapid diagnostic tests (RDT)	Rapid diagnostic tests Description. RDTs (sometimes known as "dipsticks") are simple, point-of-care testing kits that allow, through various methods, quick diagnosis of illnesses such as malaria, tuberculosis, HIV, H1N1 and Covid-19. They are single use and function by detecting antigens or antibodies in the blood samples of chronically infected or recently infected patients. Compared with traditional laboratory microscopy for diagnosis, RDTs require less time with results available in under 30 minutes and require less training, no equipment but can be costly. RDTs were chosen as a means to rapidly respond in emergency situations where there could be a large number of patients seeking medical care at one time.

4.4 Adaptation technology options for the health sector and their main adaptation benefits

Table 7 below outlines the key benefits of the adaptation technologies outlined in the previous section.

Table 7: Short list of technologies selected for the Health sector

Technology	Adaptation benefits
Solar powered backup power generation systems for health care institutions including water pumps.	This technology was identified since there was a need for reliable water supply, refrigeration of vaccines and medicine and lifesaving devices like respirators and oxygen supply. As such solar powered independent water supply would be a needed technology. Alternative energy sources ensures that it is independent of power outages, this technology would add value to disaster preparedness and response of health services and falls in line

Technology	Adaptation benefits
	with climate proofing through retrofitting of existing structures from the National Climate Change Policy.
e-Health – for diagnosis and disease prevention	E health can offer reliable mobile communication in the health sector for patients and in the face of disasters. It can be relevant for situations when important infrastructure, such as roads and hospital buildings, are destroyed and access to health institutions is hindered. E-health can also provide real time data on patients to diagnosticians and allow pest and infectious diseases to be quickly communicated to prevent outbreaks and assist in patient care while in some circumstances removing the physical risks to medical staff of patient interaction. E-Health can also make medical care more accessible to public.
e-Disease Surveillance and Early Warning	The health care system currently does systematic disease surveillance for malaria, yellow fever and leptospirosis however emerging diseases like covid-19 and H1N1 the protocols for surveillance have to be instituted on an as needed basis. An e- platform for the disease surveillance and early warning systems can bolster the rapidity of disaster response to infection diseases and allow health services to reallocate limited human resources in a timely manner. It provides an opportunity to treat with and minimise the spread of infectious diseases through better coordination of different agencies and real time data acquisition. Disease surveillance can help to build a more climate resilient health care system.
Rapid diagnostic test for infectious diseases	RDTs for infectious diseases can help the health care providers to acquire real time data for faster health diagnosis and treatment. This direct testing is best for field hospitals in disaster planning and response and can ensure better management of disease outbreak and prevention of infectious diseases. Introduction of these tests while expensive can save lives during extreme weather events causing flooding and limited access to hospitals.

4.5 Criteria and process of technology prioritisation for the health sector

The Health Services together with disaster response services like fire and police services will be the frontline of disease outbreaks and natural disasters due to climate related extreme weather. Building resilience in the health systems will ensure human health standards and kept high through disasters and assist with the disaster response and management through natural disasters. The technologies chosen for prioritisation were scored based on a number of criteria including; ease of implementation, sustainability of technology, relative cost, market readiness, protection & ecosystem benefit, risk of maladaptation, climate benefit and social benefit. These criteria used to score each of the technologies in health by the TAC stakeholder are outlined in Section 2.3. The criteria chosen were derived from the list of potential effects on the health sector and considering the synergies identified in the mapping exercise.

4.6 Results of technology prioritisation for the health sector

Table 8: Multicriteria analysis results for technologies selected for the Health sector in Trinidad and Tobago

Health Sector	List of criteria/ normalised scores after MCA									
Weighting %	5%	10%	10%	5%	15%	15%	20%	10%	10%	100%	---
List of criteria	Ease of implementation	Sustainability	Cost	Market readiness	Ecosystem benefit	Risk of maladaptation	Climate benefit	Social benefit	Synergy benefit	Combined	Ranking
Solar powered backup power generation systems	75.0	50.0	100.0	100.0	85.7	100.0	66.7	28.6	60.0	73.8	1st
e-Health	0.0	0.0	0.0	0.0	42.9	0.0	100.0	100.0	80.0	44.4	3rd
e-Disease Surveillance and Early Warning	25.0	25.0	42.9	25.0	100.0	20.0	66.7	85.7	100.0	59.2	2nd
Rapid diagnostic test	100.0	100.0	57.1	87.5	0.0	60.0	0.0	0.0	0.0	34.1	4th

5. Technology prioritisation for the Water sector

5.1 Key climate change vulnerabilities the Water sector

The current water storage capacity for the 4 dams and reservoirs in Trinidad and Tobago is 72 million m^3 while the total Internal Renewable Water Resources (IRWR) are estimated at 3840 million m^3/year and the current consumption is estimated at 383.2 million m^3/year (2011) (FAO 2015) which is just 8.8 % of the available water resources. This means there is a greater threat to the accessibility and provision of clean potable water to the health and agriculture sectors in particular rather than the availability of water as a resource.

In 2011 of the total water withdrawn, surface water accounts for 60% while 28% comes from groundwater and 12% from desalinated water (FAO 2015). Municipal use accounted for 62%, industrial use accounted for 34% and agriculture around 4% of the total water used. It is important to note that currently there is approximately 30000 Ha of land that is both suitable and available for farming while only 5000 Ha are currently irrigated (FAO 2015). The provision therefore of water for irrigation for farming is an important measure for the development of a resilient food secure economy in T&T. This could also have positive social benefits including gender since women play a critical role in the provision and management of water (Schneiderman Reddock,2004) in the agriculture sector.

In T&T there is an absence of thick overlying clay layers that make them vulnerable to contamination. In the past intermittent high levels of nitrates were detected in ground water as well as trihalomethanes and lead. The levels indicate that there could be a growing risk to health if these contaminants are not monitored, halted and reversed (FAO 2015). Another serious concern is saltwater intrusion due to over-abstraction in coastal aquifers (FAO 2015). The conservation of surface water and enhancing its distribution to ensure that there is adequate supply of clean surface water is important for reducing abstraction from coastal aquifers.

Currently there are a number of reforestation and rehabilitation projects being conducted in line with protecting denuded lands and ecosystems to protect biodiversity. These projects also contribute to aquifer recharge and the availability of fresh water. These projects are expected to reduce the impact of surface pollution on the quality of surface runoff. Active reforestation is being conducted by some civil society organisations as well as at the State level through the National Reforestation and Watershed Rehabilitation Programme (NRWRP), which aims to re-plant 13,367 hectares of forests including 4,452 hectares of watersheds that have been denuded or destroyed. (MPD, T&T 2019).

The adopt a river programme that was initiated in 2012 by the Water and Sewerage authority is another venture that is geared toward the protection of surface water from pollution and the wise use of surface water as a resource in small rural communities. The results of this programme include improving raw water quality and decreased costs for treating raw water to bring to potable standards, reduction of solid waste disposed in rivers, reduced incidences of flooding caused by blockages in the watercourse and improved water quality for irrigation purposes among the communities involved.

Apart from the availability of water there is a need for the thoughtful distribution of water to the sectors that need it in the climate adaptation context. The health and agriculture sectors are two important sectors for consideration. The adaptability of the agriculture sector for both flood and drought is an important consideration and technologies that assist with either scenario is desirable.

5.2 Decision context for prioritisation for the Water sector

In Trinidad and Tobago like many small islands, the vulnerabilities of water resources to the impacts of the changing climate are numerous. Increases in adverse weather events and higher rainfall events while more drought conditions prevail otherwise i.e., less rainfall is expected but higher intensity as well as increases in average surface temperatures can have affect many sectors. These effects include:

- Intensified storm surges which can push the salt water farther inland, and increase salinization and impact coastal agriculture due to sea level rise and more intense rainfall events (VCA2018).
- Salt water intrusion due to sea level rise for coastal aquifers that may be over extracted.
- Reduced agricultural productivity due to higher evapotranspiration rates and heat stress on plants.
- Increase in flash flooding of land including agricultural land causing damage to crops and reduced yield and increase in pest and diseases.
- Extreme weather events causing health emergencies and power outages can impact health services.
- Exacerbation of unsustainable land use directly impacting runoff rates, and reducing recharge of groundwater as well as increasing the quantity of surface runoff intensifying flash flood events.

The main objective for the national climate change policy (NCCP 2011) is to prepare for adaptation to the impacts of climate change; develop and elaborate appropriate and integrated plans for coastal zone management, water resources and agriculture, and for the protection and rehabilitation of areas affected by drought and desertification, as well as floods. The policy outlines specifically the protection of the natural environment and human health and conserving and guaranteeing a sustainable supply of potable water.

If water can be conserved then there is more of the resource to be allotted to distribution for irrigation of agriculture. In extreme weather events and natural disasters, the provisions on health services are paramount and ensuring the water availability to health institutions in the event of utility failure or shutdown is another priority area.

The use of water metering has always been discussed in Trinidad and Tobago but has thus far not been instituted. The need for water metering is also directly linked to the considerate used of this precious natural resource and can diminish wastage. A report done by the regulated industries commission in 2018 exploring universal water metering as a demand side management measure for water distribution estimated that there could be a 50% reduction in overconsumption of water in addition water losses from leakage and theft could be reduced from 51% to 25% (RIC 2018).

A rain gauge network can also provide real time data to predict flood events and assist in planning and response mechanisms. Accurate and reliable spatiotemporal estimates of precipitation are crucial to the successful prediction of catchment response, and are particularly important in the case of (flash) flooding. Volkmann et. al. 2010.

5.3 Overview of existing technologies in the Water sector

The long list of technologies was identified through a desktop study firstly and then the stakeholders were consulted through a round robin approach for input on the applicability to Trinidad and Tobago, the suitability of the technology to address the adaptation issues and the need for the technology in country. The long list of technologies is listed below in Table 9 and from these five technologies were chosen and adjusted and adapted for use in Trinidad. The multicriteria analysis was then undertaken taking the main adaptation benefits into consideration. The technologies removed were either already instituted in the country such as dams, desalination, and LiDAR or were deemed unsuitable for Trinidad and Tobago based on key vulnerabilities and the decision context.

Table 9 Long list of technologies for Water sector

Technology	Description and decision context
Multipurpose dams	Multipurpose dams may combine storing and supplying water for irrigation, industry and human consumption with other uses such as flood control, power generation, navigation, run-off storage and water discharge regulation. Dams and reservoirs for water storage are already implemented and multipurpose use was not deemed critical for T&T in the context of adaptation.
Sea water desalination	Already implemented in Point Lisas industrial estate and provides approximately 12% of the water supply.
Disaster risk assessment using LIDAR	being utilised by the IMA to study watershed hydrology and estuarine hydrodynamic modelling of water and pollution flows, and mangrove forest carbon estimation using LiDAR - (IMA 2019)
Basin level modelling and seasonal forecasting	Deemed unsuitable as water metering for the reduction in domestic consumption and wastage seen as more of a priority, as well as irrigation.
Boreholes and tube wells	An important adaptation technology measure for providing a domestic water supply during times of water shortages and drought. They extract freshwater from subsurface or deeper groundwater aquifers. The approach can include both creating new boreholes and tube wells (for example as a drought response

Technology	Description and decision context
	measure), or deepening or rehabilitating existing ones. This measure was not deemed suitable as surface water conservation was seen as more of a priority
Bioswales	This vegetation measure to reduce flooding in urban settings require a long and straight area to increase retention and filtration time. It was deemed unsuitable for T&T as the urban centres where flooding take place are either on reclaimed land or does not have the land space to accommodate bioswales.
Bioremediation of ground water	Given that ground water is not currently considered polluted it was identified that measures to protect groundwater from further pollution was more important.
Solar water distillation	Currently the cost for water treatment is subsidised through oil and gas subsidies and there is one major water treatment plant which
Structural barriers to flooding - dams, dikes, locks, and levees	Structural barriers currently exist in the form of levees for the major water courses in Trinidad and Tobago that contribute to flood and are working solutions to seasonal (wet season) flooding.
Water metering	Considered important for both adaptation and mitigation as there is currently high amounts of wastage and overuse of treated water.
Agro-Hydro-Meteorological Monitoring	The metrological office of Trinidad and Tobago currently does hydro met monitoring and has real time data on rainfall and flood events. It needs to be integrated into agro-met monitoring for soil moisture, temperature and speed of change measurements in flood prone areas in order to tie into early warning system.
Catchment-based tipping bucket rain gauge network	This can give a real time data on amount of rainfall as well as intensity of the rain and tie into the early warning system.
Flood-proofed drinking water	This measure was deemed vital for water supply for disaster preparedness
Rainwater harvesting	This measure was deemed vital for water supply for irrigation for farmland and livestock especially in rural communities and small holder farms
Managed aquifer recharge (MAR)	A managed recharge implies that the recharge process is controlled and ensures health and environmental risks are minimized. MAR is a vital adaptation opportunity for developing countries coping with water variability and shortages. Aquifer recharge may only be an issue in times of drought since once the extraction of groundwater increases beyond the natural recharge rates of existing aquifer, they will become depleted. This measure was deemed relevant to adaptation for disaster risk management for droughts.

5.4 Adaptation Technology Options for the Water Sector and Their Main Adaptation benefits

The options for adaptation technologies for the water sector in Trinidad and Tobago include; water metering, Agro-Hydro-Meteorological Monitoring, Early warning alerts for flooding using catchment-based tipping bucket rain gauge network in flood prone communities and cities, Standalone flood-proofed drinking water systems for health services including hospitals and health centers and rain water harvesting and irrigation for farming communities.

Table 10: Short list of technologies selected for the Water sector

Technology	Description and adaptation benefits
Water metering	Metering all pipe borne water in Trinidad and Tobago and is considered important for both adaptation and mitigation as there is currently high amounts of wastage and overuse of treated water. This is a long term water management strategy that should encourage water conservation, reduce wastage, reduce energy required for water treatment and distribution and increase capital gains. The capital cost is however very high. The adaptation benefits include job creation for the implementation of a metering programme and can be integrated to provide positive social gender benefits.
Agro-Hydro-Meteorological Monitoring	Weather stations to monitor a range of agro-hydro-metrological data to provide real-time data to support early warning systems. The metrological office of Trinidad and Tobago currently does hydro met monitoring and has real time data on rainfall and flood events. It needs to be integrated into agro-met monitoring for soil moisture, temperature and speed of change measurements in flood prone areas in order to tie into early warning system. This technology will support national Early Warning Systems in other sectors to help with food security and health surveillance. It will support planning, engineering and disaster early warning activities to reduce vulnerability to potential disaster events, as well as improved hazard mitigation. In flood prone communities these can also have a high social benefit through the creation of jobs.
Early warning alerts for flooding using catchment-based tipping bucket rain gauge network in flood prone communities and cities.	The deployment and installation of a catchment-based tipping bucket rain gauge network on a national scale to support early flood warning. Such rain gauge stations should be equipped with temperature, wind and humidity gauges to monitor evaporation. Reduced impact to agriculture and livestock from natural disasters including extreme weather, flooding, pest, and diseases. (health and food security) Rain gauge network can provide real time data to predict flood events and assist in planning and response mechanisms Accurate and reliable spatiotemporal estimates of precipitation are crucial to the successful prediction of catchment response, and are particularly important in the case of (flash) flooding. Volkmann et. al. 2010.
Standalone flood-proofed drinking water systems for health services including hospitals and health centres.	Safe access to drinking water in flood events, infrastructure developments for water treatment facilities and increased storage capacities in flood prone areas at hospitals and health centres. Better disaster response and planning, public health access to potable water during disasters, better health care and communicable disease prevention. These standalone technologies would include emergency sanitization and solar powered distribution in order to be operable in times of power outages.

Technology	Description and adaptation benefits
Surface rain water harvesting for farming communities	Alternative water collections, especially important for rural communities and areas that do not have a steady supply of pipe borne water. More resilient water resources, Important for dry arid drought conditions that area expected to occur in the future and considerable agriculture sector benefits. This measure was deemed vital for water supply for irrigation for farmland and livestock especially in rural communities and small holder farms as drought becomes a major effect of climate change.
Managed aquifer recharge (MAR)	Aquifer recharge was deemed relevant to adaptation for disaster risk management for droughts. The benefits include the availability of potable water that does not need to be processed heavily for human use and can be used directly for irrigation and livestock.

5.5 Criteria and process of technology prioritisation for the Water sector

The prioritisation for the water sector included the consideration of many factors. The criteria chosen were derived from the list of potential effects on the adaptation sectors and considering the synergies identified in the mapping exercise. The criteria used are outlined and detailed in Section 2.3 and are employed to score each of the technologies in the water sector by the TAC stakeholders. The criteria used are, Ease of Implementation, Sustainability of technology, Relative Cost, Market Readiness, Protection & Ecosystem Benefit, Risk of Maladaptation, Climate benefit and Social Benefit.

5.6 Results of technology prioritisation for the Water Sector

Table 11 Below outlines the results of the multicriteria analysis for the Water sector technologies.

Table 11: Multicriteria analysis results for technologies selected for the Water sector in Trinidad and Tobago

Water Sector	List of criteria/ normalised scores after MCA										
Weighting %	5%	10%	10%	5%	15%	15%	20%	10%	10%	100%	---
List of criteria	Ease of implementation	Sustainability	Cost	Market readiness	Ecosystem benefit	Risk of maladaptation	Climate benefit	Social benefit	Synergy benefit	Combined	Ranking
Water metering	25.0	80.0	0.0	57.1	0.0	83.3	100.0	50.0	100.0	59.6	2ND
Agro-Hydro-Meteorological Monitoring	50.0	0.0	25.0	14.3	50.0	100.0	0.0	0.0	0.0	28.2	5TH
Catchment-based tipping bucket rain gauge network.	75.0	40.0	100.0	0.0	50.0	100.0	0.0	25.0	20.0	44.8	4TH
Flood-proofed drinking water	75.0	80.0	25.0	71.4	16.7	83.3	20.0	75.0	60.0	50.3	3RD
Rain water harvesting	100.0	100.0	75.0	100.0	100.0	50.0	60.0	100.0	80.0	80.0	1ST
Managed aquifer recharge (MAR)	0.0	0.0	0.0	14.3	16.7	0.0	40.0	75.0	60.0	24.7	6TH

6. Summary and Conclusions

The analysis done for the three sectors, agriculture, health and water for the various technologies included a dynamic list of criteria that including social, environmental and climate benefits to name a few. The selected technologies were the two technologies which scored the highest in each sector and are listed below:

1. The prioritised technology technologies for the agriculture sector are pressurized irrigation technologies and protective structure cooling systems – caterpillar tunnels.
2. The prioritised technology for the health sector is solar powered backup power generation systems for health institutions and second is disease surveillance and early warning data on climate-sensitive environmental risks and epidemiological trends.
3. The prioritised technology for the water sector is rainwater harvesting and second is water metering.

These six technologies will form the bases for the next step in the TNA process; the barrier analysis and enabling framework (BAEF).

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Annex I - Technology factsheets for selected technologies

AGRICULTURE - Technology Fact Sheet

Technology: Crop breeding		
Sector: Agriculture		
Technology Characteristics		
Description		Crop breeding programs includes the use both traditional techniques and modern biotechnology to identify strains with traits relevant to climate change (extreme heat, flood resistant, etc.) Strains with the traits such as greater heat tolerance, lower water requirements, higher moisture tolerance, improve pest and diseases resilience can contribute to building food security and reduce climate vulnerabilities.
Criterion 1	*Ease of Implementation.*	In Trinidad and Tobago, there are certain barriers such as the stigmas against GMO food products. Biotechnological breeding of crops is not cheaper or faster than conventional breeding even though its benefits are relevant for demanding growth conditions. Introduction of new species to an unknown environment can inadvertently bring unforeseen diseases or other difficulties.
Criterion 2	Sustainability of technology.	Large scale production of crop breeding requires substantial financial and biochemical input to be successful both in yield and profit. Large scale production requires high amounts of resources such as real estate, water and chemical research. Pest control may be a major problem dependent on the type of crop or season. Strains of crops may be selected to weather climate and environmental challenges therefore reducing the demand of upkeep for crops.
Criterion 3	Relative cost.	GMO seeds are more expensive compared to non-engineered seeds. According to the Asian Development Bank (2014) crop breeding with respect to relative cost per hectare was deemed to be intermediate between ($100-$500USD/ per hectare. After a brief period of adaptation around 60 to 80 per cent of the financial benefit of the seed tends to go the farmer and about 10 per cent to the technology developer.
Criterion 4	Market readiness.	Local, private agricultural suppliers have implemented the distribution and use of GMO products such as papaya, cucumbers, peppers and much more crops. The market is familiar with GMO products. Local research institutes and universities may be able to aid in research and problem solving. There maybe be a stigma against GMO's and its health, agricultural, economic, environmental, and social benefits. Seed companies will be ready to exploit the demand in the market of crop breeding.
Criterion 5	Protection & Ecosystem benefit.	Increased production of crops can contribute to the reduction of greenhouse gases. Increased crop resistance extreme heat, flood resistant, etc. Introduction of crop varieties to aid in ecological diversity.
Criterion 6	Risk of maladaptation.	There have been numerous studies indicating the fear of the unknown and consequences it may have on greater ecosystems (insects, loss of indigenous crops etc.) and human health. There may be negative responses to GMO products due to misinformed opinions.
Criterion 7	Climate benefit.	Increased crop production has the benefit of the reduction of greenhouse gases by natural photosynthesis contributing to mitigation. The biochemical engineering of new/modified strains of plants contribute to increased food production in current climates contributing to adaptation.
Criterion 8	Social Benefit	Increased food and health security for population. Increased standard of living by produced better more nutrient rich crops. Increased jobs in the agricultural and food sector. Can also contribute to economic diversification. Can contribute to gender mainstreaming and unemployment crisis by offering training to housewives, young entrepreneurs, college graduates/students providing technical training.
Criterion 9	Synergy benefits.	Increased crop breeding and production contributes to the agricultural, food and health sector by increasing food production and nutritional quality as well as expansion of the agricultural sector.

Technology: Floating Agriculture		
Sector: Agriculture		
Technology Characteristics		
Description		Floating agriculture involves the production of food in waterlogged and flood prone areas for extended periods of time and can also be implemented in waterways and water collections where there is increased food demand. It is primarily based on floating rafts made of composted organic materials and is related to hydroponic systems, a known technology in T&T.
Criterion 1	*Ease of Implementation.*	Rafts are usually made of cheap, organic media such as straw, stubble and bamboo as well as quick rotting waterworks used as compost. T&T has vast amounts of materials and space available for production. Local institutes can provide agricultural consultation and support for projects. Floating agriculture is a low complexity system that requires little maintenance.
Criterion 2	Sustainability of technology.	Large scale production of projects requires low financial and biochemical input to be successful both in yield and profit. Large scale production requires no real estate and is based in waterways and any water collection system. Low maintenance and low initial investments relative to yield and profit. Media such as straw, stubble and bamboo as well as quick rotting waterworks used as compost can all be produced locally. Requires no additional chemical fertilisers or manure.
Criterion 3	Relative cost.	This technology cost is minimal, allowing for high profitability with very low investment cost. It was ranked relatively cheap compared to the other technologies. Requires no additional chemical fertilisers or manure.
Criterion 4	Market readiness.	Local, private agricultural suppliers have implemented the distribution and use of organic materials used for raft construction. Local research institutes and universities may be able to aid in research and problem solving. In T&T, there are current problems with flooding and vast waterways that can be exploited for production. Local farmers in flood prone, low lying areas can implement this cheap alternative and minimize crop loss during natural disasters.
Criterion 5	Protection & Ecosystem benefit.	Increased production of crops can contribute to the reduction of greenhouse gases. Implementation can increase crop resistance to extreme heat, flood resistance and water deficiency. Floating agriculture uses water hyacinth, an invasive weed that can be harvested for use has the beneficial side effect of reducing breeding grounds for mosquitoes and improving conditions for open water fishing and wildlife sustainability. Floating agricultural rafts encourage wildlife growth by proving more underwater habitats. Floating rafts are completely organic and compostable, reducing the amount of environmentally damaging waste products. Floating agriculture poses the risk of encourage insect and rodent infestation.
Criterion 6	Risk of maladaptation.	No identifiable maladaptation could have been noted.
Criterion 7	Climate benefit.	Increased crop production has the benefit of the reduction of greenhouse gases by natural photosynthesis contributing to mitigation.
Criterion 8	Social Benefit	Increased food and health security for population. Increased standard of living by producing more dietary options. Increased jobs and more opportunities for gender mainstreaming in the agricultural and food sector. Serves as an alternative growing medium for flood victims. More productive compared to traditional farmed land (Haq et l. 2004) Increased jobs in the agricultural and food sector. Can also contribute to economic diversification. Can contribute to gender mainstreaming and unemployment crisis by offering training to housewives, young entrepreneurs, college graduates/students providing technical training.
Criterion 9	Synergy benefits.	Increased crop production contributes to the agricultural, food and health sector by increasing food production and nutritional quality as well as expansion of the agricultural sector.

Technology: Crop Diversification		
Sector: Agriculture		
Technology Characteristics		
Description		Crop diversification is the addition of crops and agricultural systems within a region, country, or household to increase production, diversification or reduction vulnerability to climate.
Criterion 1	*Ease of Implementation.*	Crop breeding is limited by climate and seasons, Trinidad's climate is limited to tropical crops, GMO seeds may be needed. Increased risk of diseases and crop/livestock loss and invasive species due to unknown nature of crops. Importation of exotic and region-specific foods may be reduced. Increased demand and availability of irrigation, rainfall, and soil fertility. Farmers may need to be trained to produce exotic or region-specific crops. Crops can be selected based on tolerance of heat, humidity, saturation, pest resistance, flooding, and salinity. The use of local institutions may be required for biochemical and agricultural consulting.
Criterion 2	Sustainability of technology.	Due to less experience with certain crops may require extensive care at first to flourish. Crop specific pesticides, herbicides and fertilizers may need to be outsourced and imported for use depending on nature of crop Crops may be required to be grown under special conditions and the use of special equipment. Crops may be more vulnerable to unforeseen climate events or natural disasters such as flooding. A limitation of crop diversification is that it may be difficult for farmers to achieve a high yield in terms of tons per hectare.
Criterion 3	Relative cost.	Implementation of new crops may require the employment of specialized personnel such as botanists, chemists, biologists, etc. Importation of new species may be costly relative to locally available species. New crops may need more man hours depending on technical input. Region specific crops may require specialized infrastructure such as storage, growing media, processing, etc. In a project in Mexico, estimated total costs of a five-year project involving around 1,000 farmers and man hours came to around $300,000 USD (Smale et al, 2003) which is substantially more expensive compared to local production.
Criterion 4	Market readiness.	Local research institutes and universities may be able to aid in research and problem solving dependent on the extent of current local research being conducted. Local, private agricultural suppliers may not be antiquated to the demand of specialized equipment, pesticides, herbicides, fertilizers, etc. Local farmers may not be open to experimentation with new and exotic crops.
Criterion 5	Protection & Ecosystem benefit.	Increased production of crops can contribute to the reduction of greenhouse gases.
Criterion 6	Risk of maladaptation.	Implementation my result in higher vulnerability to diseases, susceptibility to pest invasions, crop/livestock loss and invasive species due to poor selection and improper breeding.
Criterion 7	Climate benefit.	Increased crop production has the benefit of the reduction of greenhouse gases by natural photosynthesis contributing to mitigation.
Criterion 8	Social Benefit	Increased food and health security for population. Reduced cost of food, due to less importation of goods. Increased standard of living by producing more dietary options. Increased jobs and more opportunities for gender mainstreaming in the agricultural and food sector. Increased jobs and more opportunities for gender mainstreaming in the agricultural and food sector. Can also contribute to economic diversification. Can contribute to gender mainstreaming and unemployment crisis by offering training to housewives, young entrepreneurs, college graduates/students providing technical training.
Criterion 9	Synergy benefits.	Increased crop production contributes to the agricultural, food and health sector by increasing food production and nutritional quality as well as expansion of the agricultural sector.

Technology: Establishment of Early Warning Systems.		
Sector: Agriculture		
Technology Characteristics		
Description		The use of mobile technologies for information to safeguard against climate smart agriculture, disaster risk reduction and disaster response planning and creating early warning alerts on various emerging threats and monitoring crop seasons by use of drought, flood, and climate change monitoring. These may include meteorological and seismic research along with market research such as monitoring food prices and fluctuations.
Criterion 1	*Ease of Implementation.*	Remote sensing, local climate and meteorological data are key for producing the relevant indices. Risk knowledge: Establish a system/agreement to collect and share data, figures, maps, etc. on flood risks and vulnerability in the area. A local database must receive all data and produce a warning message when variations in normal water are predicted. Training should be part of the planning process. The local population should also be educated on drought risks and warning responses, and dissemination programs/networks should be established.
Criterion 2	Sustainability of technology.	The effects of climate change result in increasingly unpredictable weather patterns, making forecasts less precise. Models may produce a wide range of probabilities, with a healthy level of uncertainty. Some systems, such as model simulations, require a high level of technical expertise to install and operate.
Criterion 3	Relative cost.	The main disadvantage of a national climate monitoring system and early warning system is the cost, the capital required to purchase, install and/or operate all the necessary equipment, the ongoing costs of maintaining the equipment and ensuring accurate collecting of data, building and maintaining databases, making sure that that data is processed and distributed via mobile or static means timely fashion is very expensive.
Criterion 4	Market readiness.	There is often an issue with management and cooperation for data sharing amongst institutions. Preparedness for forecasted disasters my not be possible in growing countries. The warning has a degree of uncertainty, which can lead to false alarms.
Criterion 5	Protection & Ecosystem benefit.	Provides timely measures to minimize impacts such as land degradation, flooding, and desertification of ecosystems. I.T Systems can be converted to run on alternative and renewable energy sources.
Criterion 6	Risk of maladaptation.	Limited telecommunication networks could reduce flood warning efficiency and distribution, particularly in remote regions of developing countries The warning carries a degree of uncertainty, which could lead to false alarms Availability of good quality real time data may be limited.
Criterion 7	Climate benefit.	Provides important climate change adaptation benefits in regions suffering from water scarcity, drought risk, and other natural disasters.
Criterion 8	Social Benefit	Improves network connectivity within and between local communities. Mitigates human fatalities, health risks and poor water and food security. This minimizes safety and infrastructure threats. As part of the warning, the system provides a prediction of the scale, timing, location, and likely damages of the impending flood. Can also contribute to economic diversification. Can contribute to gender mainstreaming and unemployment crisis by offering training to young entrepreneurs, college graduates/students providing technical training.
Criterion 9	Synergy benefits.	Reduces costs related to post-flood rehabilitation and rebuilding.

HEALTH- Technology Fact Sheet

Technology: E-Health.		
Sector: Health		
Technology Characteristics		
Description		E-health is a broad term used to describe the use of information, communication, and technology in healthcare to address care, monitoring, concerns and management.
Criterion 1	*Ease of Implementation.*	One of the factors blocking the use of e-Health tools from widespread acceptance is the concern about privacy issues regarding patient records, most specifically the electronic patient records. To standardize the exchange of information, various coding schemes may be used in combination with international medical standards. An information exchange platform for doctors and patients will need to be established. A simple example of information exchange is a patient sending a photo taken by mobile phone of a healing wound and sending it by email to the family doctor for control. Such a system may avoid the cost of an expensive visit to the hospital. Doctors who then may request access to the patient's health records, such as medicine prescriptions, x-ray photographs, or blood test results. Such an action may reveal allergies or other prior conditions that are relevant to the visit. E-mental health has a few advantages such as being low cost, easily accessible and providing anonymity to users. However, there are also several disadvantages such as concerns regarding treatment credibility, user privacy and confidentiality. Implementation of appropriate safeguards to protect user privacy and confidentiality. This includes appropriate collection and handling of user data, the protection of data from unauthorized access and modification and the safe storage of data.
Criterion 2	Sustainability of technology.	Some systems require a high level of technical expertise to install and operate. Electronic databases are vulnerable to several cyber-attacks such as denial of service attacks, phishing attack, malware attacks etc.
Criterion 3	Relative cost.	Equipment will need to be outsources/imported. Maintenance and operational personnel will need to be trained. Establishment of databases, networks, user interfaces are very expensive.
Criterion 4	Market readiness.	Internet connectivity, and the benefits of eHealth, can be brought to these regions using satellite broadband technology, and satellite is often the only solution where terrestrial access may be limited, or poor quality. In many regions there is not only a significant lack of facilities and trained health professionals, but also no access to eHealth because there is also no internet access in remote villages, or even a reliable electricity supply. Health in general, and telemedicine, is a vital resource to remote regions of emerging and developing countries but is often difficult to establish because of the lack of communications infrastructure.
Criterion 5	Protection & Ecosystem benefit.	I.T Systems can be converted to run on alternative and renewable energy sources.
Criterion 6	Risk of maladaptation.	Each medical practise has its own jargon and diagnostic tools and would be difficult to standardise. The lack of physical connection between patient and doctor may result in misdiagnosis and maltreatment. Poorly managed and maintained systems may result in a backlog of health care and result in more suffrage.
Criterion 7	Climate benefit.	No notable effects to climate change.
Criterion 8	Social Benefit	Knowledge of the socio-economic performance of eHealth is limited. Implemented systems can reduce the spread of infectious diseases through remote access to patients. Patients in rural areas may be able to save money from commuting to doctor's offices/hospitals/clinics. *Improved efficiencies and lower health care costs.*

		Situations when important infrastructure, such as roads and hospital buildings, are destroyed, health care and management can be supported through mobile technology and satellite communications. Creates more jobs in the tech industry. Can also contribute to economic diversification. Can contribute to gender mainstreaming and unemployment crisis by offering training to young entrepreneurs, college graduates/students providing technical training.
Criterion 9	Synergy benefits.	No notable synergy benefits.

Technology: Disease Surveillance and Early Warning Systems for Environmental Risks and Epidemiology trends.		
Sector: Health		
Technology Characteristics		
Description		Disease surveillance is an information-based analysis, collection, and interpretation of large volumes of data originating from a variety of sources related to epidemiology. These evaluations lend to the implementation or early warning systems. This methodology is conducted worldwide as a form of environmental security and in conjunction with communication services and warning systems on a national/international level.
Criterion 1	*Ease of Implementation.*	Requires large communications systems and skilled workforce to relate data between healthcare and disaster management facilities. To be effective, the collection of surveillance data must be standardized on a national basis and be made available at local, regional, and national level. Requires supplemental systems related to e-health and its system dynamics. Dissemination and communication (e.g. media, governance institutions, NGOs). A means to improve the area telecommunication network may be necessary. Logistical issues such as establishing a system of conveyance and processing of data locally with international allies.
Criterion 2	Sustainability of technology.	Some systems require a high level of technical expertise to install and operate. Electronic databases are vulnerable to several cyber-attacks such as denial of service attacks, phishing attack, malware attacks etc.
Criterion 3	Relative cost.	Equipment will need to be outsources/imported. Maintenance and operational personnel will need to be trained. Establishment of databases, networks, user interfaces are very expensive.
Criterion 4	Market readiness.	Infrastructure currently does not exist locally and would need to be developed with international assistance from countries with developed monitoring systems.
Criterion 5	Protection & Ecosystem benefit.	No notable ecological benefits.
Criterion 6	Risk of maladaptation.	Provides an opportunity to treat and minimise spread of disease.
Criterion 7	Climate benefit.	No notable synergy benefits.
Criterion 8	Social Benefit	Public health surveillance and response will reduce the spread of diseases and reduce public panic. Can also contribute to economic diversification. Can contribute to gender mainstreaming and unemployment crisis by offering training to young entrepreneurs, college graduates/students providing technical training.
Criterion 9	Synergy benefits.	No notable synergy benefits.

Technology: Integrated E-platforms for Rapid Response Services.		
Sector: Health		
Technology Characteristics		
Description		Rapid response systems work in conjunction with e-health, by using in its infrastructure, interfaces, monitoring system and databases to respond to and improve the quality health care.
Criterion 1	*Ease of Implementation.*	To standardize the exchange of information, various coding schemes may be used in combination with international medical standards. An information exchange platform for first responders, patients and health care facilities will need to be established. A simple example of information exchange is a mobile application as well as emergency communication systems in public spaces. Implementation of appropriate safeguards to protect user privacy and confidentiality. This includes appropriate collection and handling of user data, the protection of data from unauthorized access and modification and the safe storage of data. Rapid response services will need to develop a new processing and response system for new infrastructure.
Criterion 2	Sustainability of technology.	Some systems require a high level of technical expertise to install and operate. Electronic databases are vulnerable to several cyber-attacks such as denial of service attacks, malware attacks etc.
Criterion 3	Relative cost.	Equipment will need to be outsources/imported. Maintenance and operational personnel will need to be trained to deal with the system and interfaces. Establishment of databases, networks, user interfaces are very expensive.
Criterion 4	Market readiness.	Internet connectivity, and the benefits of eHealth, can be brought to these regions using satellite broadband technology, and satellite is often the only solution where terrestrial access may be limited, or poor quality. In many regions there is not only a significant lack of facilities and trained health professionals, but also no access to eHealth because there is also no internet access in remote villages, or even a reliable electricity supply. Health in general, and telemedicine, is a vital resource to remote regions of emerging and developing countries but is often difficult to establish because of the lack of communications infrastructure.
Criterion 5	Protection & Ecosystem benefit.	No notable benefits.
Criterion 6	Risk of maladaptation.	I.T. Networks are vulnerable to many cyber-attacks creating a weak point in healthcare. Can also contribute to economic diversification. Can contribute to gender mainstreaming and unemployment crisis by offering training to young entrepreneurs, college graduates/students providing technical training.
Criterion 7	Climate benefit.	No notable benefit.
Criterion 8	Social Benefit	Better disaster response through coordination of different agencies and real time data acquisition and sharing. Can be utilised for disaster and communicable disease response, requires mobile communications system and skilled workforce Creates more jobs in the tech industry.
Criterion 9	Synergy benefits.	No notable synergy benefits.

Technology: Rapid Diagnostics.		
Sector: Health		
Technology Characteristics		
Description		Rapid diagnostic tests (RDT'S), described as a point-of-care test, are easy to perform and used for preliminary and emergency screening in medical facilities with limited resources and in-field testing with same-day results. Rapid diagnostic tests (RDT'S) usually include testing kits for HIV, influenza, strep, urease, Ebola, plasma and antigen tests and many more, all of which are one use and disposable.
Criterion 1	*Ease of Implementation.*	RDT's are available for a wide rand of viral and infection diseases, however, does not cover all diseases. Basic training of medical personnel is required for implementation RDT's. Tests become unusable after expiration.
Criterion 2	Sustainability of technology.	Test kits are completely disposable but requires incineration to reduce health risks as are most other disposable medical equipment.
Criterion 3	Relative cost.	Test kits are very cheap to import, In the case of malaria RDT's, a single test can vary between US-$1.00 and US-$6.00
Criterion 4	Market readiness.	Test kits are not produced locally and must be imported. As RDT's are very affordable, private and public institutions would have a higher likelihood of willingness to purchase.
Criterion 5	Protection & Ecosystem benefit.	No notable benefits.
Criterion 6	Risk of maladaptation.	Very low risks aside from the shelf life of RDT's.
Criterion 7	Climate benefit.	No notable benefits.
Criterion 8	Social Benefit	Reduces the duration of stay at medical posts and facilities. Faster than traditional testing. Can contribute to gender mainstreaming and unemployment crisis by offering training to housewives, young entrepreneurs, college graduates/students providing medical training for point-of-care use. In cases of viral outbreaks, it can quickly and accurately test patients resulting in quicker response, reduction in outbreaks and better management to victims and overall healthcare.
Criterion 9	Synergy benefits.	No notable benefits.

WATER- Technology Fact Sheet

Technology: Water Metering.		
Sector: Water		
Technology Characteristics		
Description.	Water metering in the practice of measuring water use. Water meters measures the volume of water used by residential and commercial purposes that are supplied with water by public water supply system. They are also used to determine billing.	
Criterion 1	*Ease of Implementation.*	Fluctuation in pressure can damage meters to the extent that meters in cities in developing countries become non-functional. Installation of metering systems are non-invasive to current infrastructure compared to completely reworking water network.
Criterion 2	Sustainability of technology.	Also, some types of meters become less accurate as they age, and under-registering consumption leads to lower revenues if defective meters are not regularly replaced. Maintenance teams will need to be employed and trained.
Criterion 3	Relative cost.	Investment such as costs to purchase, install and replace meters are relatively low compared to other methods. Recurring costs to read meters and issue bills based on consumption instead of bills based on monthly flat fees. While the cost of purchasing residential meters is low, the total life cycle costs of metering are high. For example, retrofitting flats in large buildings with meters for every flat can involve major and thus costly plumbing work.
Criterion 4	Market readiness.	Equipment and materials will need to be imported. Many areas may not welcome the inconvenience of installation of metering systems as well as the change in operation of water services.
Criterion 5	Protection & Ecosystem benefit.	Metering results in reduction in water wastage. Encourages water conservation on long term basis.
Criterion 6	Risk of maladaptation.	Many types of meters also register air flows, which can lead to over-registration of consumption, especially in systems with intermittent supply. There is disagreement as to the effect of metering and water pricing on water consumption. The price fluctuation of metered water demand varies greatly depending on local conditions. Households on low incomes are less able to invest in water efficiency measures and may experience water poverty.
Criterion 7	Climate benefit.	Long term water metering and management can increase water conservation and reducing drought risks. Adaptation to regulated supplies can be used to study the impact of climate change and contribute to action plans.
Criterion 8	Social Benefit	Metering in conjunction with volumetric pricing provides an incentive for water conservation. Metering helps to detect water leaks in the distribution network. Reducing wastage and non-revenue water. It can be a method for quantity-targeting of water subsidies to the poor. Can also contribute to economic diversification. Can contribute to gender mainstreaming and unemployment crisis by offering training to young entrepreneurs, college graduates/students providing technical training.
Criterion 9	Synergy benefits.	Metering systems can intersect public and institutions by managing and prioritizing the deficit in water supply such as hospitals, schools, government buildings, private businesses, and agricultural plantations.

Technology: Agro-Hydro-Meteorological Monitoring.		
Sector: Water		
Technology Characteristics		
Description		This consists of agrometric and hydrometric networks that monitor and convey data based on meteorological, hydrological and agricultural data on variations in the environment such as weather patterns, lunar cycles, tidal movements and growth patterns. The system requires a network of sensors and databases.
Criterion 1	*Ease of Implementation.*	Requires the installation of meteorological, aquatic sensors and radar networks across wide area along with database. Requires trained specialist to operate and process information. Requires a method of distribution of data such as social media and M.E.T offices.
Criterion 2	Sustainability of technology.	Radar systems are specialized equipment that required specialists to calibrate and maintain.
Criterion 3	Relative cost.	Networks are very expensive to install and implement and becomes financially viable on a long-term basis.
Criterion 4	Market readiness.	M.E.T offices will be able to supplement and distribute information. Farmers as well as the public will gain more accurate data on water and agricultural conditions.
Criterion 5	Protection & Ecosystem benefit.	Reduced vulnerability to potential disaster events, as well as improved hazard mitigation.
Criterion 6	Risk of maladaptation.	There is an associated uncertainty to monitoring measuring systems due to the accuracy of the system or other phenomenon.
Criterion 7	Climate benefit.	In areas dependent on agricultural development as well as climate adaptation and mitigation institutes will gain a more accurate method of climate monitoring.
Criterion 8	Social Benefit	Improves the understanding of environmental factors and creates a more environmentally aware public. Hydrological studies can encourage the conservation of water use through a broader understanding of the water cycle. Can also contribute to economic diversification. Can contribute to gender mainstreaming and unemployment crisis by offering training to young entrepreneurs, college graduates/students providing technical training.
Criterion 9	Synergy benefits.	Data studies can supplement the agricultural and water sector through data sharing and understanding of environmental conditions.

Technology: Catchment-Based Tipping Rain Gauge Networks.		
Sector: Water		
Technology Characteristics		
Description		Rain-gauge networks are often used to provide estimates of area average rainfall or point rainfalls at ungauged locations at a geostatistical level. The level of accuracy a network can achieve depends on the total number and locations of gauges in the network.
Criterion 1	Ease of Implementation.	Variability is a basic feature of rainfall that makes it complex to measure. Both rain gauges and dendrometers only give you an idea of the rain that fell on them, but not on the surrounding areas or 20 km away. To create rainfall maps, which are maps with the amount of rain that has fallen over a given timespan at multiple locations, we need to rely on weather radars. Rainfall is extremely variable, both over time and between different locations, which makes it very difficult to measure.
Criterion 2	Sustainability of technology.	Radar systems are specialized equipment that required specialists to calibrate and maintain.
Criterion 3	Relative cost.	Catchment based equipment very simple and cost effective. Radar systems are very expensive to purchase, set up and maintain.
Criterion 4	Market readiness.	M.E.T offices will be able to supplement and distribute information.
Criterion 5	Protection & Ecosystem benefit.	Provides a warning system for endangerment of ecological system and aquatic habitats.
Criterion 6	Risk of maladaptation.	There is an associated uncertainty to catchment-based measuring systems due to the moderate accuracy of the system that can result in inaccurate results.
Criterion 7	Climate benefit.	Provides a method to understand climate variation and adaptation more accurately.
Criterion 8	Social Benefit	Provides a method of weather monitoring and flood prediction and supplement disaster preparedness. Can also contribute to economic diversification. Can contribute to gender mainstreaming and unemployment crisis by offering training to young entrepreneurs, college graduates/students providing technical training.
Criterion 9	Synergy benefits.	Rainfall monitoring can supplement agricultural growth and supplement season monitoring.

Technology: Flood-Proofing Drinking Water Systems.		
Sector: Water		
Technology Characteristics		
Description		Floodproofing in water management is common in wastewater treatment plants. Implementing floodproofing technology into drinking water systems is limited to treatment plants due to the design of water main systems.
Criterion 1	*Ease of Implementation.*	Water mains and connection are usually air and water-tight to prevent leaking and contamination. Water and wastewater treatment facilities and well as pumping stations will need to be protected by non-permeable barriers such as floodgates. Emergency Back-up power sources for facilities will need to be implemented such as renewable energy or fuel powered generators. All electrical equipment and essential systems will need to be elevated and isolated. Creating an emergency response plan to flooding such as isolation and decontamination according to federal regulations. Components such as pumping stations in areas vulnerable to flooding should be designed for submersible use.
Criterion 2	Sustainability of technology.	Maintenance limited to inspections and servicing of back-up power supplies in conjunction with regular plant and station maintenance.
Criterion 3	Relative cost.	Construction of floodwalls are expensive. Implementing submersible pumps are expensive and requires inconvenient water shut-off periods to install. Generators or independent renewable energy systems are costly to buy and install and only becomes financially viable in long term periods.
Criterion 4	Market readiness.	In low-lying and flood prone areas, water shortages re prevalent. Implementation of a flood measures will mitigate that and provide a safe water source for domestic use.
Criterion 5	Protection & Ecosystem benefit.	No notable benefits.
Criterion 6	Risk of maladaptation.	No notable risks.
Criterion 7	Climate benefit.	The use of renewable energies such as wind or solar powered pumping stations reduced the carbon footprint of treatment plants and pumping stations.
Criterion 8	Social Benefit	Isolation and decontamination of flooded water supplies results in better flood response. Can also contribute to economic diversification. Can contribute to gender mainstreaming and unemployment crisis by offering training to young entrepreneurs, college graduates/students providing technical training.
Criterion 9	Synergy benefits.	Improved water quality and supply during natural disaster such as floods supplements health sector by reducing risk of spreading diseases as well as providing clean water for sanitation.

Technology: Rainwater harvesting.		
Sector: Water production		
Technology Characteristics		
Description		Rainwater harvesting is the of catching and collection of rainwater. It can be used in dry weather regions where water supply is limited to help alleviate supply deficits. Its application has benefits to the agricultural, domestic, public facilities. Various methods of harvesting applicable to Trinidad and Tobago may include roof catchment, rock catchment, ground catchment and damming systems.
Criterion 1	Ease of Implementation.	Trinidad and Tobago is equipped with simple solutions to roof and rock catchment projects such transmission and storage as well as engineering and workforce experience with large scale projects such as ground catchment and damming. Local suppliers and contractors already provide supplies and engineering solutions.
Criterion 2	Sustainability of technology.	Systems for agricultural purposes require relatively low upkeep. Local farmers are already familiar with irrigation such as plumbing and pump systems. Local suppliers, contractors and quarries already exist to provide supplies and engineering solutions. Local environmental and engineering agencies and Universities can provide counseling and solutions to design and sustainability of such projects.
Criterion 3	Relative Cost.	Local companies produce and supplies such as conduit, storage tanks and aggregate needed eliminating high cost of importing. Roof and rock catchment systems have a relatively low initial capital depending on size with long term benefits to the ecosystem. Of the costs for installation, reservoirs as well as storage tanks represents the largest investment which can vary between 30-45% of the total cost of the system dependent on system size. A pump, a pressure controller and fittings in addition to plumber's labour represent other major costs of the investment.
Criterion 4	Market Readiness.	Trinidad and Tobago's agricultural sector is already searching for solutions to water deficits during the harsh seasons. In the past the public and private institutions such as schools, hospitals restaurants, etc. have felt the effects of low water reserves and inability operate all of which can benefit from rainwater harvesting.
Criterion 5	Protection and Ecosystem benefit.	Rainwater harvesting technology can help contribute and sustain natural ecosystems by relying less on natural waterways and reducing overharvesting in farming and public supply applications. It can also help provide water to the agricultural market to help maintain and increase production of local crops and plants.
Criterion 6	Risk of Maladaptation (unintended affects).	A study by the university of Arizona, in collaboration with Climate Assessment for the Southwest found that delipidated collection systems are at risk for becoming breeding grounds for mosquitoes which could inadvertently increase the spread of diseases. Heidi Brown, "Is adaptation mal-adaptation: an assessment of mosquitoes and water harvesting?" (https://climas.arizona.edu/research/adaptation-mal-adaptation-assessment-mosquitoes-and-water-harvesting) (April 2020) The use of fossil fuel burning equipment such as generators and pumps can contribute to the production of greenhouse gasses.
Criterion 7	Climate benefits.	Renewable energy such as solar wind can be used to power facilities and equipment and reducing the use of fossil fuels.
Criterion 8	Social Benefit.	Can contribute to livelihood sustainability by providing local food supplies. Creation of jobs and careers in water management and rainwater harvesting. Can also contribute to economic diversification. Can contribute to gender mainstreaming and unemployment crisis by offering training to, housewives and young entrepreneurs providing technical training.
Criterion 9	Synergy benefits with other sectors.	Rainwater harvesting can intersect public and institutions and supplementing the deficit in water supply such as hospitals, schools, government buildings, private businesses, and agricultural plantations.

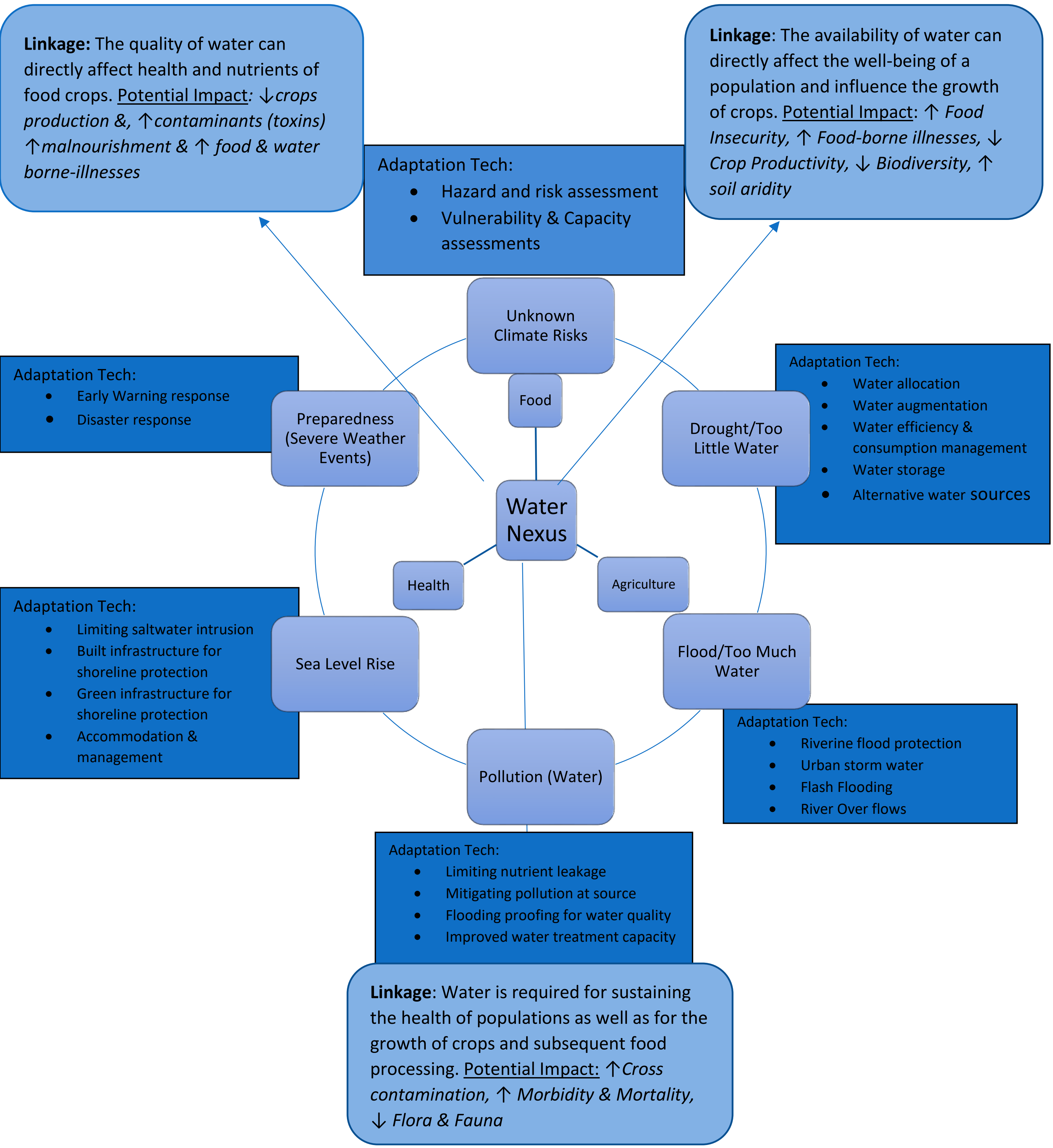
Technology: Managed Aquifer Recharge (M.A.R).		
Sector: Water		
Technology Characteristics		
Description		Managed aquifer recharge (MAR) involves building infrastructure and/or modifying the landscape to intentionally enhance groundwater recharge. Recharge is primarily done by allowing water to enter an aquifer using underground reservoirs. This method is used to regulate groundwater, sustain, or improve functioning ecosystems, improve the quality of groundwater, reduce risk of drought and control over extraction.
Criterion 1	*Ease of Implementation.*	Additional research is needed on the long-term physical and chemical impacts on aquifers, optimal management in different environments, uses of stormwater and reclaimed water, and institutional considerations. Detailed planning and assessment are required to determine whether MAR is a viable adaptation option. This may be carried out a national and watershed scale. The level of treatment needed for the source water generally depends on a risk assessment.
Criterion 2	Sustainability of technology.	Benefit and feasibility of constructing and operating a MAR scheme, including those associated with transporting the recovered MAR water to areas in demand needs to be evaluated. Operational issues in MAR schemes can include clogging of wells, stability of infrastructure under operating conditions, protection of groundwater quality, operation and management of the scheme, monitoring, loss of infiltrated/injected water. Road networks and infrastructure within cities prevents surface water from percolating into the soil, resulting in most surface runoff entering storm drains for local water supply.
Criterion 3	Relative cost.	Low technology schemes such as controlled flooding, catchment basins and sand dams are less expensive (about US$10 to US$50 per ML, ignoring pipeline costs) than, for example, borehole injection methods (in the order of US$100 to US$1,000 per ML).
Criterion 4	Market readiness.	Recharge in rural areas is heavily supported by precipitation, and this is opposite for urban areas. Effective operation requires training for operators, access to successful demonstrations of the technologies being deployed and integrated management of water resources.
Criterion 5	Protection & Ecosystem benefit.	Natural treatment processes in the aquifer can improve the quality of the water. Provide more stable water supplies during drought. Conserve and dispose of runoff and floodwaters. Reduction or seizure of saltwater intrusion
Criterion 6	Risk of maladaptation.	Managed aquifer recharge is only viable if there is a suitable aquifer that can accept a sufficient volume of water at a sufficient recharge rate to justify the costs of establishing the project. It is not recommended if the environmental risks cannot be reduced to an acceptable low level - taking all costs and benefits of the project into account. Poorly maintained/monitored systems can inadvertently spread diseases.
Criterion 7	Climate benefit.	Current studies show groundwater recharge rates has little to no impact on a climate of equal humidity and temperature. More research will need to be implemented.
Criterion 8	Social Benefit	Improved quality of life in arid areas. Increased job opportunities for local and international personnel in water management. Can also contribute to economic diversification. Can contribute to gender mainstreaming and unemployment crisis by offering training to young entrepreneurs, college graduates/students providing technical training.
Criterion 9	Synergy benefits.	MAR systems can intersect public and institutions and supplementing the deficit in water supply such as hospitals, schools, government buildings, private businesses, and agricultural plantations. Can also contribute to economic diversification. Can contribute to gender mainstreaming and unemployment crisis by offering training to, housewives and young entrepreneurs providing technical training.

Annex II - List of stakeholders consulted for the Technology Working Groups (TWG)

Organisation
Office of the Campus Principal, The University of the West Indies St. Augustine
Ministry of Agriculture, Land and Fisheries
Fisheries Division, Ministry of Agriculture, Land and Fisheries (MALF)
Trinidad and Tobago Meteorological Services
Ministry of Public Utilities
Institute of Marine Affairs
Ministry of Tourism
Council of Presidents for the Environment (NGO)
Environmental Management Authority
Ministry of Health
Office of Disaster Preparedness and Management
Ministry of Energy and Energy Industries
Ministry of Health
Ministry of Rural Development and Local Government
Office of the Prime Minister
The Energy Chamber of Trinidad and Tobago
Water Resources Agency
The Water and Sewerage Authority of Trinidad and Tobago (WASA)
The University of the West Indies (UWI)
The University of Trinidad and Tobago (UTT)

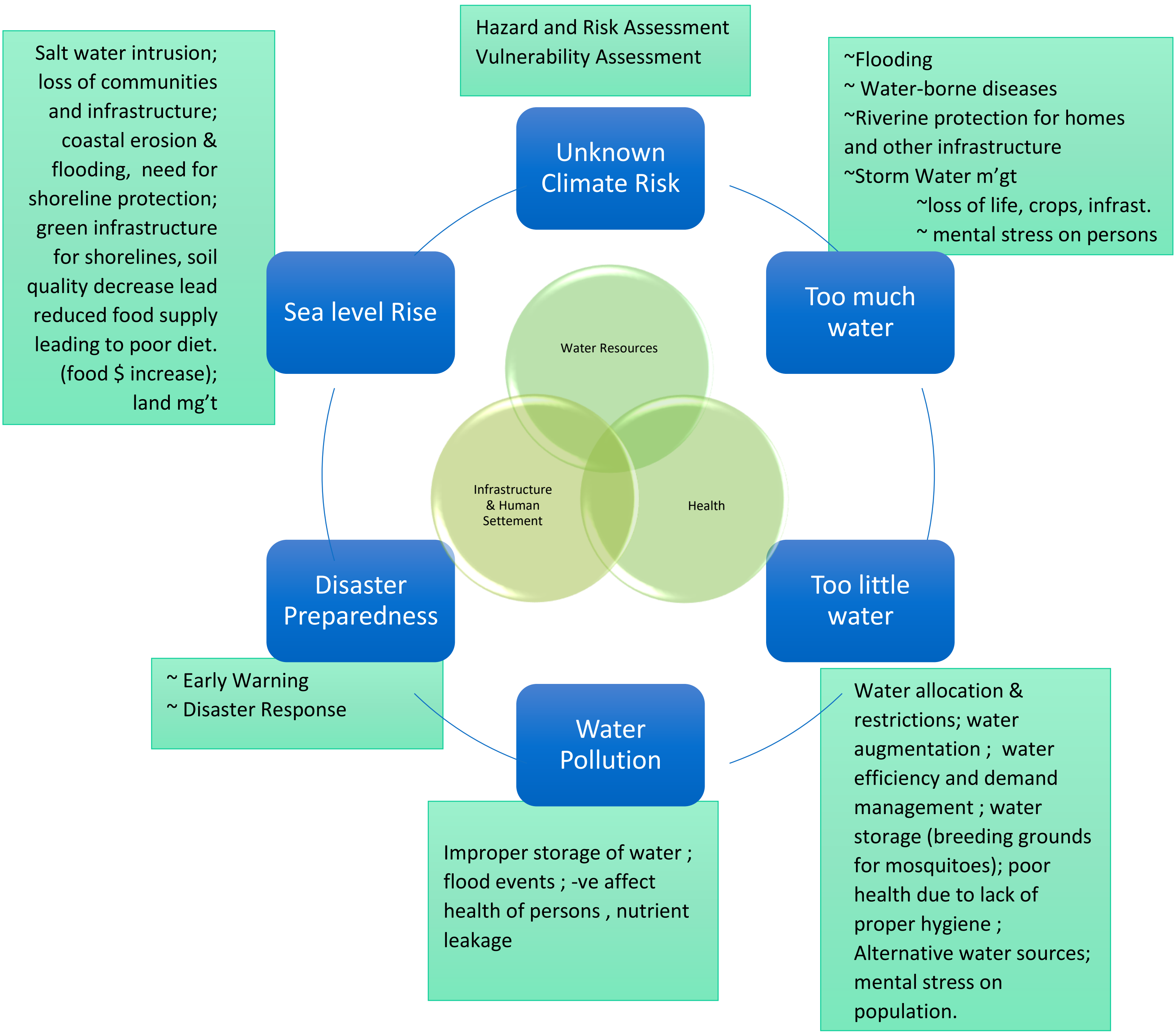
Annex III – Mapping Exercise Charts

Climate Change adaptation & water – Integrated Approaches to Adaptation Planning



Water- Health- Agriculture (Food) Nexus			
Implementable Technology Actions	*Linkage*	*Synergies/ Co-Benefits*	Trade-offs
Greening Infrastructure	Water-Health-Agriculture(food)	- ↑ Water retention and ↓ wasted run-off. - ↑ Air quality - ↑ Small scale food production	- ↓ Surface water & aquifer recharge - ↑ Vector borne diseases through the introduction of favorable niches. - ↓ Aquifer recharged that can be used for food and agriculture.
Early Warning alerts	Water-Health-Agriculture(food)	- ↑ Diversion of excess water. - ↑ Preparedness thereby ↓ incidence of morbidity & mortality. - ↓ Potential damages of crops	- False alarms where anticipated damages are expected can result inaction. (I.e. *The Boy who cried wolf!)*
Structural barriers	Water- Health-Agriculture (food)	- ↓ Damages to infrastructure - ↓ Morbidity & Mortality - ↓ Damages to crops and live stock	- ↑ Erosion of river banks. - ↓ Biodiversity of natural flora and fauna. - N/A
Riparian Buffers	Water- Health-Agriculture	- ↑ Marine water quality - ↓ Impact of wave abrasion - ↑Biodiversity & Flora and Fauna	- N/A - N/A - ↑ Likelihood of invasive species

Water Resources, Human Settlement and Health



Annex IV - Raw data from multi-criteria analysis scoring for each sector

Agriculture sector scoring

Weighting %	5%		10%		10%		5%		15%		15%		20%		10%		10%		100%	---
List of criteria	Ease of implem	Normalised	Technical Su	Normalised	Cost	Normalised	Market re	Normalised	Environmenta	Normalised	Risk of Malad	Normalised	Climate ben	Normalised	Social B	Norma	Synergy	Norma	Combined	Ranking
Crop breeding	70.0	50.0	55.0	16.7	40.0	0.0	75.0	80.0	80.0	100.0	65.0	20.0	70.0	50.0	70.0	40.0	80.0	75.0	47.67	4th
Pressurized irrigation technologies	80.0	75.0	70.0	66.7	60.0	50.0	80.0	100.0	75.0	75.0	80.0	80.0	75.0	75.0	85.0	100.0	70.0	50.0	73.67	1st
Protective Structure Cooling Systems – Caterpillar tunnel	60.0	25.0	80.0	100.0	80.0	100.0	75.0	80.0	75.0	75.0	70.0	40.0	65.0	25.0	80.0	80.0	55.0	12.5	56.75	2nd
E-livestock managemen	50.0	0.0	50.0	0.0	55.0	37.5	60.0	20.0	60.0	0.0	60.0	0.0	80.0	100.0	70.0	40.0	50.0	0.0	28.75	5th
Virtual Soils Lab	60.0	25.0	60.0	33.3	65.0	62.5	55.0	0.0	70.0	50.0	65.0	20.0	60.0	0.0	60.0	0.0	60.0	25.0	23.83	6th
Establishment of early	90.0	100.0	65.0	50.0	75.0	87.5	65.0	40.0	60.0	0.0	85.0	100.0	65.0	25.0	65.0	20.0	90.0	100.0	52.75	3rd

Health sector scoring

Weighting %	5%		10%		10%		5%		15%		15%		20%		10%		10%		100%	---
List of criteria	Ease of implementation	Normalised Score	Technical Sustainability	Normalised Score	Cost	Normalised Score	Market readiness	Normalised Score	Environmental Sustainability	Normalised Score	Risk of Maladaptation	Normalised Score	Climate benefit	Normalised Score	Social Benefit	Normalised Score	Synergy	Normalised Score	Combined Score & weight	Ranking
Solar powered backup	80.0	75.0	75.0	50.0	85.0	100.0	90.0	100.0	80.0	85.7	85.0	100.0	70.0	66.7	60.0	28.6	70.0	60.0	73.8	1st
e-Health – for diagnosis and disease prevention	65.0	0.0	65.0	0.0	50.0	0.0	50.0	0.0	65.0	42.9	60.0	0.0	80.0	100.0	85.0	100.0	75.0	80.0	44.4	3rd
Disease Surveillance and Early Warning data	70.0	25.0	70.0	25.0	65.0	42.9	60.0	25.0	85.0	100.0	65.0	20.0	70.0	66.7	80.0	85.7	80.0	100.0	59.2	2nd
Rapid diagnostic test	85.0	100.0	85.0	100.0	70.0	57.1	85.0	87.5	50.0	0.0	75.0	60.0	50.0	0.0	50.0	0.0	55.0	0.0	34.1	4th

Water sector scoring

Weighting %	5%		10%		10%		5%		15%		15%		20%		10%		10%		100%	---
List of criteria	Ease of implementation	Normalised Score	Technical Sustainability	Normalised Score	Cost	Normalised Score	Market readiness	Normalised Score	Environmental Sustainability	Normalised Score	Risk of Maladaptation	Normalised Score	Climate benefit	Normalised Score	Social Benefit	Normalised Score	Synergy	Normalised Score	Combined Score & weight	Ranking
Solar powered backup	80.0	75.0	75.0	50.0	85.0	100.0	90.0	100.0	80.0	85.7	85.0	100.0	70.0	66.7	60.0	28.6	70.0	60.0	73.8	1st
e-Health – for diagnosis and disease prevention	65.0	0.0	65.0	0.0	50.0	0.0	50.0	0.0	65.0	42.9	60.0	0.0	80.0	100.0	85.0	100.0	75.0	80.0	44.4	3rd
Disease Surveillance and Early Warning data	70.0	25.0	70.0	25.0	65.0	42.9	60.0	25.0	85.0	100.0	65.0	20.0	70.0	66.7	80.0	85.7	80.0	100.0	59.2	2nd
Rapid diagnostic test	85.0	100.0	85.0	100.0	70.0	57.1	85.0	87.5	50.0	0.0	75.0	60.0	50.0	0.0	50.0	0.0	55.0	0.0	34.1	4th