The Republic of Trinidad & Tobago

BARRIER ANALYSIS AND ENABLING FRAMEWORK FOR CLIMATE CHANGE TECHNOLOGIES
ADAPTATION & MITIGATION
February, 2022

Supported by:

Table of Contents

List of Tables

List of Figures

Executive Summary

BARRIER ANALYSIS AND ENBABLING FRAMEWORK FOR ADAPTATION & MITIGATION TECHNOLOGIES TRINIDAD & TOBAGO

The Ministry of Planning and Development in partnership with the UNEP Danish Technical University Partnership (UDP) undertook a joint multi-country project entitled "Technology Needs Assessment (TNA) - Phase III" with funding from the Global Environment Facility (GEF). This report is the continuation and second output of the TNA process that builds on the first outcome of the TNA report that was purposed for identifying and prioritizing both mitigation and adaptation technologies for selected sectors. Thus, the Barrier Analysis and Enabling Framework (BAEF) is the second of three deliverables that Trinidad and Tobago will submit to complete the TNA process. The chosen technologies within the respective sectors were selected on the basis of outcomes of the technology needs assessment for mitigation and adaptation, as well as synergizing national development across the various sectors to exploit the co-benefits from the selected technologies and enhance overall climate resiliency in Trinidad and Tobago. Particularly, the BAEF is in alignment with the approach taken under the TNA regarding prioritization of nationally determined contribution (NDC), and climate risk sectors for mitigation and adaptation respectively, drawing on the NDC and completed vulnerability and climate risk studies. The technologies chosen were also identified based on their mutual complementarity and reinforcing value-added.

This BAEF Report identifies and summarises potential barriers to the deployment and diffusion of adaptation technologies identified for agriculture, water resources, and the health sector in Trinidad and Tobago. For the health sector, solar powered backup power generation systems were omitted from this analysis given that activities to deploy this technology were already underway at the Toco Health Facility; thus only one technology was used from this sector. In addition, the report also covers prioritized mitigation technologies from the final TNA report detailing the following sectors: power generation, industry and transportation (NDC sectors).

It is important to note that during the preparation of the BAEF, certain policy decisions were taken and implemented in respect of e-mobility, and utility scale solar power generation. Therefore, there was not strict alignment of the BAEF with the TNA. Particularly referenced here is the development of an e-mobility policy and the implementation of fiscal incentives announced in October 2021, to encourage uptake of electric vehicles, as well as the establishment of a 112 MW utility scale solar generation plant. At the time of preparing the BAEF, arrangements for construction were being finalised. Accordingly, some barriers were included as identified during the implementation of these policies and projects. These are specifically identified to provide context with the TNA.

In total, the top two (one in the health sector) prioritized technologies within the six sectors covered a total of eleven technologies for both adaptation and mitigation. These sectors were identified by the Technology Needs Assessment Team from predecessor activities which are laid out and derived from the Vulnerability Capacity Assessment and Carbon Reduction Strategy of Trinidad and Tobago and NDC, respectively. The National Climate Change Policy provides the overall framework for the decision context and guided the stakeholder consultation processes. The first step in the TNA process was the identification of technologies to meet both adaptation and mitigation interventions for the selected technologies within their respective sectors. The climate technologies identified and prioritized via the TNA Multicriteria Analysis are laid out in the table below with their respective market categorization as recommend by Nygaard and Hansen, (2015).

Table 1: Prioritized technologies for climate change adaptation and mitigation for Trinidad and Tobago with their respective market category.

Sector	Prioritised Technology	Technology market Categorization
ADAPTATION		
Agriculture	1. Pressurized Irrigation System powered by solar. 2. Caterpillar Tunnels (i.e., greenhouses)	• Consumer Good (Goods targeting the mass market; households, business, and institutions) • Consumer Good
Water	3. Rainwater harvesting 4. Water metering	• Consumer Goods • Publicly Provided Good (Technologies in this category are often publicly owned, and production of goods and services are available (free or paid) to the public.)
Health	5. Disease Surveillance via early warning signs for climate associated health risks such as: vector borne diseases, waterborne diseases, and extreme heat events.	• Publicly Provided Good
MITIGATION		
Power Generation	1. Utility scale solar 2. Energy Audits and Efficiency improvements of the supply side	• Publicly Provided Good
Industry	3. Carbon capture and storage technology 4. Biofuels	• Public Provided Good • Public Provided Good
Transportation	5. Electric Vehicle in the transportation system (Public and private vehicles) 6. ICT for intelligent traffic management systems	• Mixed Public Goods • Other Public Goods

Adapted from: Nygaard and Hansen (2015)

Barriers to prioritized technologies

For adaptation, the barrier analysis and enabling frameworks identified economic, financial, technical, and regulatory impediments to the development and transfer of the prioritized technologies through the sectors. Within the economic and financial categories, the report revealed that the access to financial loans, grants and funding opportunities were consistently ranked highest amongst other barriers. In the technical and regulatory categories, it was seen that targeted groups for the prioritized technology may lack the adequate level of skills which can be compounded by insufficient legal and regulatory frameworks that impacts the rapid deployment of the needed technologies.

For the selected mitigation technologies, the report identified the following barriers to the development and transfer of the prioritized technologies: economic and financial, policy, legal and regulatory, and technical skills to deploy the technologies. Given the scale and magnitude of the technologies recommended for deployment, the report showed that greater institutional capacity is required to strengthen the regulatory process and build technical capacity within the local workforce to foster these largescale mitigation projects. The report also underscored the need for greater capacity building throughout the various implementing agencies with adequate resources to carry out their respective mandates.

1.0 Introduction

This Barrier Analysis and Enabling Framework addresses adaptation and mitigation technologies for the following sectors in Trinidad and Tobago: agriculture, health and water (adaptation) and transportation and industry (mitigation). These sectors were identified and prioritised based on a Vulnerability Capacity Assessment conducted in 2018 under the “Technical Assistance to the Environment Programme in Trinidad and Tobago” (adaptation), and the actions/technologies identified in the Nationally Determined Contribution (NDC) Implementation Plan. This report analyses the market conditions for each of the prioritized technologies within each sector, identifies the barriers to market penetration, and the use and diffusion of technologies.

Barriers and enablers were identified based on the methodology and categorisation as outlined in the TNA Guidebook on “Overcoming Barrier for the Transfer and Diffusion of Climate Technologies" (Nygaard and Hansen, 2015). This is a standardized process of categorization that has been adopted by the Technology Executive Committee (TEC) of the United Nations Framework Convention on Climate Change (UNFCCC) for work on TNA processes as well as the subsequent barrier analysis and enabling framework. Thus, the overall outcome of the TNA project will be a component necessary for NDC implementation through the application of the prioritized technologies, as well as integrating climate risks into national development using a pathways approach to adaptation, as the national policy approach.

The identification process for the barriers encompassed: a literature review, virtual round robin with regional subject matter experts and four technical working group meetings with key Ministries relating to their respective sectors. Stakeholder workshops were established and facilitated by the national consultant to guide the discussion around the barrier analysis. Stakeholders were awarded the opportunity to voice concerns, provide input and, clarify any misconceptions of the process undertaken to execute the barriers analysis. As an illustration for adaptation, a total of five well defined technologies were prioritized across the three sectors with a focus on the measures/interventions that can overcome these barriers. The analysis was divided into three sectors; agriculture, water, and health, covering a total of five technologies that were market categorized as seen in Table 2 below. A similar approach was undertaken for mitigation technologies.

Table 2: Prioritised climate change adaptation technologies in Trinidad and Tobago

Sector	Prioritised Adaptation Technologies	Technology market Categorization
Agriculture	1. Pressurized Irrigation System powered by solar. 1. Caterpillar Tunnels (greenhouses)	• Consumer Good • Consumer Good
Water	2. Rainwater harvesting 3. Smart Water metering (CTCN, Water Metering)	• Consumer Goods • Publicly Provided Good
Health	4. Disease Surveillance via early warning signs for climate associated health risks such as: vector borne diseases, waterborne diseases, and extreme heat events.	• Publicly Provided Good

Adapted from: Nygaard and Hansen (2015)

To obtain a complete understanding of the context of this report, reference is given to a predecessor activity of direct relevance to this barrier analysis which was implemented from 2016 to 2018, whereby the Government of Trinidad and Tobago received support from the European Union (EU) under the Technical Assistance to the Environment Programme in Trinidad and Tobago to provide a comprehensive overview of the impacts of climate change, climate variability and projected climate change impacts on the country, and facilitate decision-making on climate change risk management by key agencies. As part the TNA process, work was built on the Vulnerability and Capacity Assessment (VCA), with consideration of the key outputs of the assessment:

- *a preliminary climate change vulnerability assessment at the sectoral level;*
- *a climate change risk assessment at the sectoral level;*
- *a climate change adaptive capacity assessment of key ministries and agencies that are involved in climate change adaptation.*

For the Barrier Analysis, stakeholders were identified and contacted based on their involvement in adaptation planning in the relevant four sectors and in the VCA project. These persons were contacted via email and asked to identify challenges and barriers associated with specific adaptation technologies and potential enablers to overcome issues of deployment and adoption.

A similar approach was undertaken for the mitigation technologies drawing on consultations already undertaken for the development of the NDC Implementation Plan.

1.1 Prioritisation of Barriers

1.1.1 Selection and categorization*:* A qualitative Likert-type Scale was developed to classify barriers in term of their importance as: 1. Insignificant, 2. Less important, 3. Important, 4. Crucial and 5. Critical/killer/non-starter. This was important as different barriers have different levels of impacts on the deployment and adoption of technologies. Additionally, some barriers may be more significant than others or may be interrelated given the type of market categorisation.

1.1.2 Ranking Barrier*:* Using a Likert scale from 1 to 5, with 1 being insignificant/non-essential and 5 being most critical, the barriers were ranked for further analysis. A Logical Problem Analysis, involving problem trees (see Annexes for details), was used as a tool in the analysis of critical/starter barriers for different technologies as applicable and where information was available. All identified problems were ordered in a hierarchy of cause-effect relations with the starter problem in the centre and the direct cause below it and direct effects above. The problem tree was used to screen barriers which were decomposed and presented for consultations and comments by stakeholders.

1.1.3 Enabling framework

The process followed in the development of the “enabling framework” involved literature reviews to learn from the success stories and best practices of the selected technologies within the country and regionally, as well as similar situations from other Small Island Developing States. According to the series of TNA guidance documents, barriers can be decomposed according to broad categories encompassing; financial, non-financial, market goods and non-market goods for analysis[1]. After a breakdown of the barriers, the report proposes measures to overcome the barriers. The measures focus on creating an enabling environment for the transfer and diffusion of prioritized technologies to lead Trinidad and Tobago's economy on a pathway of decarbonisation and increased climate resilience.

According to Nygaard and Hansen (2015), the requirements for the diffusion of consumer goods may include: cost benefit analysis, market surveys, financial, market condition, technical training amongst other incentives to stimulate the local economy. Whereas publicly provided goods consist of large infrastructure projects that require large investments and are generally funded by the state or government. Additionally, other non-market goods are subdivided into technologies provided by public institutions, institutional change (i.e., improved rural livelihood; and "behavioural change at the individual level (i.e. change of practise)"). Examples of the categorization of barrier and scenario-based ranking of the barrier market category are shown in Table 3.

Table 3: An example of the categorisation and ranking applied for the potential barriers.

Scenario-based Market Category	**Barriers**	**Criteria and Importance of Barriers for Technology Y**					**Rank**
	Economic & Financial	**1.Insignifcant (easy to overcome)**	**2. Less important/significant**	**3. Important**	**4. Crucial**	**5. Critical (Killer, Significant non-starter)**	
Consumer Goods	Barrier 1					x	5
Publicly Provided Goods	Barrier 2	x					1
Non-Financial							
Other non-market goods	Barrier 3			3			3

Keys steps undertaken for the barrier analysis that were agreed upon by stakeholders included:

1.) *Identify all possible barriers through literature survey, interviews and/or workshop brainstorms.*
2.) *Screen the list of barriers to select the most essential ones*
3.) *Classify the selected essential barriers into hierarchy of categories or market categories*
4.) *Provide enablers to address most essential barriers*

[1] Boldt, Jørgen & Nygaard, Ivan & Hansen, Ulrich & Trærup, Sara. (2012). Overcoming Barriers to the Transfer and Diffusion of Climate Technologies.

2.0 Agriculture Sector

2.1 Food Security & Agriculture

The Covid-19 virus has undoubtedly impacted Trinidad and Tobago, disruptions in global supply chains have become increasingly fragmented affecting the future discourse circulated around agricultural productivity creating a greater attention for food security. Like many Small Island Developing States (SIDs), Trinidad and Tobago satisfies a large proportion of its domestic food requirements through imports on the global market, estimated at roughly 5 billion Trinidad and Tobago Dollars (TTD) (CSO, 2019). This aggressive appetite for global goods and produce has been exacerbated by the success of the petroleum-based industry which inadvertently resulted into little diversification and investment channelling into the agriculture sector. As it stands, agricultural production is still in its infancy in terms of its contribution to national GDP (.3%) and employs roughly (3%-4%) of the national population (MALF, 2020). With rising food imports and increasing global food prices, food sovereignty that is backed by a resilient and productive agricultural sector must be at the fore front of development.

Two technologies were prioritised for further analysis during the first stage of the TNA project.

1. **Pressurized irrigation powered by solar**: This climate change adaptation is technology targeted for small households and small-scale commercial farmers to be encouraged to adopt pressurized irrigation systems supported by solar power. Though many farmers utilize variable types of irrigation for farming purposes, more sustainable and efficient methods of irrigations are needed to be promoted and adopted. This technology is a priority as it has the ability to be scaled up and adopted at community levels and can contribute by encouraging the use of renewable energy technology within the agriculture sector for the purpose of reducing climate vulnerability while diversifying household energy supply and increasing resilience in times of power outages. This reduces risk of crop failure while improving productivity, food security, conservation of water resources, and farmer livelihood.

2. **Caterpillar tunnels:** This climate change adaptation technology is targeted for users involved in food production. The technology can be a cost-effective means of reducing crops from weather extremes such as extreme heat and can help reduce exposure to pest. With added sun protection and reduced evapotranspiration, reducing water and heat stress on plants makes the technology favourable, particularly in light of increasing ambient temperatures. 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, allow excellent air flow. These tunnels can be adapted to small or large farms and are lower in cost than traditional built greenhouse structures. The technical working groups established during the VCA study, agreed that this technology should be included for prioritisation.

Increased use of both technologies can improve local food production and encourage food security.

2.1.1 Preliminary Targets for Technology Transfer and Diffusion in the Agricultural sector

This section provides insights into the target of the technologies and the potential benefits to users that are exposed to higher risk of impacts from a changing and warming climate.

The dry season period and the *Petit Carême* (a short period of little or no rainfall during the rainy season, typically occurring during Sept-Oct annually) in Trinidad and Tobago makes water availability a considerable challenge for agricultural irrigation. In 2004, the area equipped for irrigation was estimated at 7 000 ha, while the actually irrigated area is estimated at 5 000 ha[2]. Agriculture in Trinidad and Tobago is practiced essentially under rainfed conditions. Irrigation in Trinidad involves small diversions from creeks and streams at works built by private individuals. Irrigation by gravity flow is also practiced in the floodplains. This type of irrigation takes place on a small scale in the *Guanapo, Aripo* and *San Juan* rivers, and on a large scale in the *Caroni* and *South Oropouche* rivers[3]. The largest irrigation system is the Caroni system constructed to serve the surrounding rice fields. This system diverts water from the *Caroni River* and distributes the water over an area of about 1200 ha. Other irrigation systems are small-scale and are located in *St George, Nariva/Mayaro, St Andrew/St David, Victoria*, and *St Patrick*.

No systematic data are available on irrigated crops. However, paddy rice, root crops and vegetables (such as pumpkins, cucumber, tomatoes, hot and sweet peppers, cabbage, cauliflower, lettuce, beans, watermelon) are the major crops grown under irrigation. Investments in water management infrastructure for irrigation and drainage tend to be expensive and these investments are only justifiable to produce high value crops. As detailed in the TNA Report, with increases in ambient surface temperatures, rise in seal level and the intrusion of invasive species (pest and diseases)- all increase the competition for local water availability in the country. In this context the following technology targets are prioritized:

1. **Pressurized irrigation powered by Solar (At the residential/small-scale/farm levels):** Building resilience requires insulating the local communities against the impact of shortages and supply chain disruptions by having an adequate food supply. Addressing these challenges that threatened the food supply requires a fundamental change in the way agriculture is practised, specifically irrigation. To enhance the uptake of the technology, a target of 50 small scale farming plots over a five-year period, starting in 2022 would be purposed for the diffusion of the technology. Additionally, 25% of the pressurized irrigation will be supported with solar power for further adaptative capacity at the household/famer level.

[2] FAO. AQUASTAT Country profile – Trinidad and Tobago. Rome, Italy: Food and Agriculture Organization of the United Nations (FAO), 2015.

[3] FAO. AQUASTAT Country profile – Trinidad and Tobago.

2. **Caterpillar tunnels (farming community)**
   The project target for tunnel technology is to equip 80% of the small-scale farmers (in possession of 0.5 to 5 hectares of land) amounting to 100 project sites over a five-year period starting in 2022.

The adoption and diffusion of technologies through the agriculture sector were defined by technical working group and these targets informed the multi-criteria analysis (MCA) that were used for technology selection as seen in the *Fact Sheet* in the *TNA Report.* `

2.1.2 Barrier analysis and enabling measures for Pressurized Irrigation powered by solar.

2.1.2.1 General Description of Pressurized Irrigation

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 (Figure 1). This technology can be coupled with fertiliser application in the form of fertigation which can also reduce fertiliser cost through minimising wastage, as well as minimising on-point sources of pollution due to run-off after rain events. 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 pota*ble water supply (Figure 2). 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.

Figure 1: Hot Pepper Production Utilising Drip Irrigation

Adapted from: CARDI, 2011 Hot Pepper Production Manual for Trinidad & Tobago (Adams et al., 2011)
Source:http://www.cardi.org/wp-content/uploads/2011/02/Hot-Pepper-Production-Manual-for-Trinidad-and-Tobago-2011-reprint.pdf

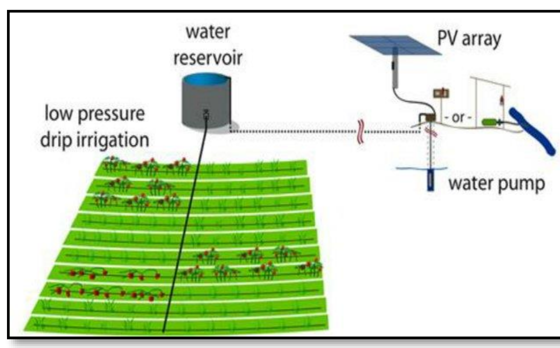


Figure 2: A schematic diagram of Solar Powered Drip irrigation

Retrieved from: (Sadhukan, 2012)
Source:https://www.researchgate.net/publication/283015200_Adaptability_of_drip_irrigation_in_coastal_and_hard_rock_terrain_of_west_bengal_India

In Trinidad and Tobago, a feasibility study was conducted which investigated the use of solar powered irrigation for food crop production within the Caroni region[4]. The work showed the requirements and feasibility for installation of the solar powered drip irrigation systems with a focus on growing hot peppers over a two-acre plot (Figure 1). Two major challenges associated with implementation of the solar powered drip system were high cost for initial equipment and space requirements to housing the solar panels.

An inherent risk to the application of solar powered irrigation systems (SPIS), is the indiscriminate use of water resources. According to the literature review, energy prices have had a regulating effect on water withdrawals. With SPIS, this becomes less of a hindrance as there is no cost per unit of power once the system is installed. Therefore, the risk of farmers over consuming more water than they did before the introduction of SPIS technology can result because of applying more water in field overall, expanding the area of land under irrigation, growing higher-value, but more water-intensive crops, and selling water to neighbouring farmers and communities. These particular issues in areas where groundwater resources are already overexploited and recharge rates are slow, can amplify existing deficits.

Notwithstanding, building adaptive capacity via solar power within drip and sprinkler systems allows farmers to improve the timing and distribution uniformity of irrigation, which can enhance crop yield, such that transpiration per hectare increases (FOA, 2018). The prospect of higher returns per hectare, however will encourage some farmers to expand planted areas or to switch to higher-value, more water intensive crops (Barbel, 2014).

The benefits of **solar powered- dripped irrigation** include:

- Greater resiliency against extreme heat, drought and varied rainfall patterns with the system through efficient water use. The water saved can be allocated in times of scarcity which increases food security.
- Useful in areas with a prolonged dry season that have reliable water source such as reservoirs.
- Reduced GHG emissions for water dispelling/pumping. The operation of the water pump in SPIS is free of GHG emission. In addition, the application allows for reduced pollution, more targeted fertiliser use, more precise irrigation and greater application technique for water conservation.
- Energy independence in remote areas.
- Access to water during dry-spells during dry season.
- Improvement of income, food security and nutrition

At the farm level, solar powered irrigation technology can constitute a reliable source for pumping of irrigation water in remote areas, particularly in areas that are not connected to the electricity grid or where regular supply of liquid fuels and maintaining service is not guaranteed. In areas such as Debe and other rural communities with inconsistencies with water supply and

[4] Persad, Prakash, et al. "Investigating the Feasibility of Solar Powered Irrigation for Food Crop Production: A Caroni Case." The Journal of the Association of Professional Engineers of Trinidad and Tobago 40.2 (2011): 61-65.

experience water scarcity, this technology can help buffer the effects of drought and to overcome water stress during dry seasons, when groundwater is the only available water source, or when surface water has to be hauled over long distances.

2.1.2.2 Identification of Barriers for the diffusion of pressurized Irrigation powered by solar technology

Pressurized irrigation supported with solar power was categorized under the category of market goods which are specifically intended for mass market, for household or small farming businesses. The market characteristics of pressurized irrigation is aimed at a high number of potential consumers. There is a number of suppliers than can provide the components for the pressurized irrigation components, however the solar powered components are not widely adopted given the relatively high cost of equipment. Tables 4 and 5 illustrates the financial and non-financial barriers for solar powered drip irrigation respectively.

Table 4: Financial barriers for solar powered drip irrigation

Barriers	Technology: Solar-Powered Irrigation Description	Score
Access to capital and market related barriers	• High initial investment cost that small holder farmers cannot afford or cannot tolerate the risk aligned with the investment of the technology. Specifically, investment required to purchase equipment (pipe, solar, fixtures and batteries).	5
	• Lack of suitable funding schemes/access to finance, and incentives to promote the use.	4
	• Lack of socio-economic analysis of use of pressurized irrigation powered with solar.	3
	• High fuel subsidy making electricity cheap and slowing the adoption of solar power.	5
	• Low subsidies and tax incentives to promote adoption.	2
	• New equipment like solar technology is vulnerable to theft and hence often coverage by insurance as a prerequisite for loan finance is expensive	3

Table 5: Non-financial barriers and scores for solar powered irrigation

TECHNOLOGY: ***Solar -Powered Irrigation*** ***Significant Barriers*** **Description**		**Score**
Institutional capacity	Limited technical capacity in administration of systems, research and development, including staff, infrastructure, and maintenance.	**4**

	Weak links between policy, enforcement, research and extension, and end-users. No extension specialist for technology to set up demonstration in farmers' fields.	**4** **3**
Technical	Need access to a reliable daily water supply and sun Inadequate water quality for irrigation. Inadequate well trained local technician/ skilled labour for design of irrigation system / network, layout and dripper line placement for uniform water and nutrient application placement and maintenance. Salt encrustation reduces system performance and can lead to complete failure Regular maintenance required[5]	**4** **3** **3** **3** **3**
Market	Limited number of suppliers of irrigation and solar equipment and lack of local competition. Inadequate availability of spare parts. i.e. batteries Poor marketing infrastructure/inadequate skilled worker trained in irrigation design system that can be powered with renewables.	**4** **4** **3**
	Main stakeholders unwilling to cooperate, share information and mis-trust	**3**
Social, cultural & behavioural	Resistance of farmers to change/ perception of complexity and fear of not being able to pay back. Reluctance based on available water from surface sources such as streams in agricultural areas Require increased grower management effort	**3** **2** **4**

[5] Solar panels require regular cleaning for dust to maximise solar irradiation, particularly in open areas such as agricultural fields.

2.1.3 Identified Measures- Pressurized Irrigation (Powered by solar)

The following measures may not be strictly categorised as purely financial or non-financial measures but may be cross-cutting measures, addressing sub-categories of barriers.

2.1.3.1 Economic and financial measures- Pressurized Irrigation (powered by solar)

From the above barriers hindering the adoption of pressurized irrigation systems by small scale farmers, the main economic and financial measures include:

- Implement appropriate fiscal incentives, including in appropriate arrangements with insurance companies and commercial banks to (policy framework set by the Ministry of Finance)
  - Provide preferential interest rates on loans and repayment terms, to finance solar irrigation systems, including the construction of irrigation infrastructure (dam, reservoir, and canals) and improve irrigation system conveyance to field and within fields (provision for new pipes, feeder canals and filter system) (commercial banks and Agricultural Development Bank);
  - Provide preferential insurance premiums for investments (insurance companies);

2.1.3.2 Non- financial measure- Pressurized irrigation (Powered by solar)

The non-financial measures identified to overcome the barriers to the adoption of efficient irrigation technologies are outlined below:

- Increased capacity of extension services to educate farmers on the benefits of solar drip irrigation systems, including on maintenance of systems (Ministry of Agriculture);
- Provide market conditions to facilitate greater penetration of relevant equipment (Agricultural Development Bank).

2.1.4 Barrier Analysis and possible enabling measures for Caterpillar Tunnels

2.1.4.1 General Description of Caterpillar Tunnel technology.

Caterpillar tunnels are miniature protective structures that produce a greenhouse like effect to facilitate crop production. The technology can be cost-effective, and can vary on the user's needs, size and shape. Typically, tunnel farming use plastics sheets as a roof covering and are reinforced with steel type bars to form hoops. These tunnel-like structures are placed over the crops to entrap carbon dioxide thereby enhancing photosynthetic activity and thus increasing crop productivity.

The idea behind tunnel farming is to shield crops from the harsh elements of the external environment such as extreme heat, ultraviolet radiation and rain exposure. The technology presents many co-benefits that can build resiliency in the agriculture sector as it addresses major barriers associated with chronic water shortages, low yield per acre and low value crop production[6].

Tunnel farming is an inexpensive technology option to deploy during the rainy season as it can extend grow times during unfavourable climatic conditions. Most tunnel farmers often custom fit the size of the tunnel area for their specific needs to match the farm's size and shape. Growers use mulching plastic and equip tunnels with bows which can be PVC pipe, electrical conduit, or galvanized steels hoops which are fastened onto the ground with stakes. The stakes are made from rebar or tubular steel, spaced optimally to reduce wind exposure.

Caterpillar Tunnels can contribute to climate adaptation and build local adaptive capacity in a number of ways:

- The tunnel/house can protect crops from climate change effects such as heavy rain, temperature extremes, and reduce likelihoods of pest as opposed to crops cultivated in an open field.
- The tunnel structure helps efficient use of scarce resources such as water, fertilizers, pesticides, and labour while providing thermal cooling for crops.
- Caterpillar technology can be synergised with drip/pressurized irrigation structure for efficient use of water during times of drought or dry periods.
- The tunnel technology also provides prolonged production periods and allows farmer to grow and harvest crops on a continuous basis, which increase crop productivity and income generation.

While other secondary potential barriers may also be identified for agricultural technologies in general, such as land rights affecting access to finance qualification, theft and praedial larceny, these are not widespread issues and therefore are not considered barriers to the deployment of the technology per se. The enabling environment requires wider, and more general approaches related to policy and governance.

The barriers identified for caterpillar tunnels are illustrated in Table 6 below.

Table 6: Main barriers and scores for caterpillar tunnels

Most Significant Barriers	Technology: Caterpillar tunnel technology Description	Score
Finance and Economics	Availability of affordable capital (high interest rates for unsecured loans)	**4**

[6] Lodhi, Ajay & Kaushal, A. & Singh, K.G. 2015. Low tunnel technology for vegetable crops in India. 10.1201/b18709.

	Lack of financial incentives for agricultural technologies for low value crops	**5**
Social/Culture	Lack of confidence in caterpillar technology, perhaps due to inadequate awareness and education. Farmer and operators fear that crop over heat within the structure. General lack of interest to invest. Farmer may express views that the technology has small economies of scale.	**5**
Institutional/Technical	Users may not have the technical requirements for proper construct of the technology to withstand environmental conditions such as gusty winds and torrential rainfall.	**5**

2.1.5 Identified interventions and enabling measures for overcoming the barriers

As illustrated in Table 6, the financial and non-financial barriers identified are similar to those for SPIS. Accordingly, the measures to overcome the barriers for SPIS are also applicable to caterpillar tunnels.

3.0 Water Sector

The impacts of climate change occur concurrently and interact with socioeconomic development factors that result in water stress. These factors include population growth, expansion of unplanned urban dwellings and irrigation for agriculture all of which dramatically and acutely affect supply and demand for water more than climate change. However, the threat of sea level from climate change is expected to cause the interface between freshwater and brackish water to move inland which will significantly impact the availability of ground water and increase the cost of treatment. Thus, vulnerable groups which reside within coastal zones will continue to be disproportionately affected from the increased salinity of estuarine surface water systems. Table 7 summarises the key impacts of climate change on the water sector.

Table 7: Key impacts of Climate Change on the Water Sector in Trinidad and Tobago

Climate Variability	Impacts on the Water Sector
Increase precipitation intensity	• ↑ Risk of flooding leading to infrastructure damages • ↓ water quality due to increase contamination • ↑ incidences of waterborne diseases • ↑ runoff, ↓ infiltration and recharge of ground water aquifers.
Increased precipitation variability	• ↑ Likelihood of droughts and bush fires. • In events where precipitation patterns are extreme are discussed above in "increase precipitation intensity"
Decreased Monthly rainfall	• ↑ water shortages, ↑ water stress • ↓ ground water recharges, ↓ water availability. • ↑ water quality issues from
Increase Sea Level rise	• ↑ saltwater intrusion and salinization of ground water, • ↓ water freshwater availability, • ↑ vulnerability of freshwater resources

Adapted from: Vulnerability & Capacity Assessment (VCA) Report Trinidad & Tobago
Source: Final TAEP Vulnerability and Capacity Assessment Report Jan 2019 (2).pdf

3.1 Preliminary Target for Technology Transfer and Diffusion in Water Resource sector

This section outlies the recommended technologies for the water sector which can address issues related to water augmentation/supply diversification, user accountability and increase overall water efficiency from both the demand and supply side. It is the intent that the technologies will reach the most vulnerable groups who do not have access to the adequate quality and quantity of water supplies. This technology can augment and address broader water availability issues for SPIS (see Table 5). Table 8 provides a short description on the preliminary targets for each of the respective technologies.

Table 8: Preliminary Targets and Market Categories of Prioritized Technologies in Water Resource Sector

Prioritized Technology	Preliminary Targets	Market Category
Water Augmentation & Water Supply Diversification		
Rain Water Harvesting (RWH) for rooftops	• Target 100 roof top rain water harvesting systems for schools, hospitals, government buildings in areas of the rural poor or vulnerable populations such a small holds and farmers over a 3-year period. • Farmers can be trained virtually on the online portal that is offered on the MALF webpage. • Formulate standards/ codes/certificates for roof top rainwater harvesting systems and a scheme for annual license; Formulate a clear mechanism to prioritize sites for interventions and collect necessary data (needs, rainfall data, quality of rainwater, urgency, and results of climate change modeling etc.).	**Consumer goods** *Intended for the mass market; households, business and institutions*
Water Efficiency and Demand Management		
Water Metering	• All Households and Businesses. Roll out the administration process to the general public and incentivize through sensitization of the benefits of the technology. Then target large users of domestic supplies while simultaneously addressing leakage issues.	**Publicly provided goods** *Where the provision of services is made available by government. Dependent on large scale deployment and large investments.*

3.2 Barrier analysis and possible enabling measures for Rainwater Harvesting (RWH) technology

3.2.1General Description of Rooftop Rainwater Harvesting (RWH)

Rooftop rainwater harvesting is a technology through which rain water is captured from the roof catchments and stored in storage containers or reservoirs. Stored rain water can be housed in an underground catchment to supplement household needs. The main objective of rainwater harvesting from roof tops is to make water available for future use, and reduce dependence on institutionalised potable demand.

RWH contributes to climate adaptation at the household level primarily through the diversification of household water supply and increase resilience to water quality degradation. Other co-benefits such as reduced pressure on surface and ground water resources by decreasing household demand that would have been derived from groundwater aquifers. In times of flood, rainwater harvesting can help alleviate flooding damages by capturing excess rainstorm runoff.

Figures 3, 4 and 5 illustrate the concept, potential sites and demonstrated projects respectively.

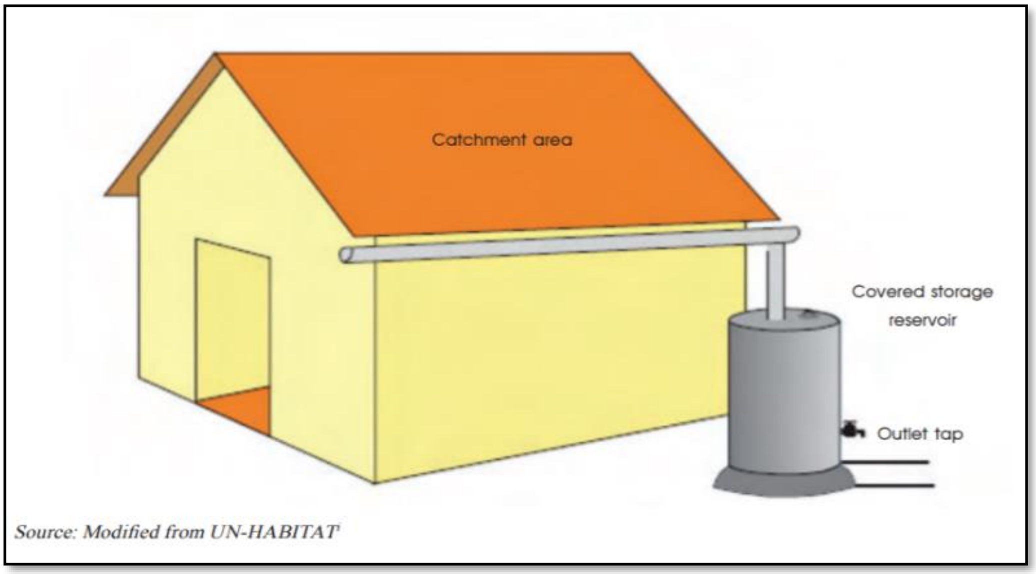


Figure 1: *Depiction of a schematic rooftop rain water harvesting system.*
Source:
Retrieved: https://tech-action.unepdtu.org/wp-content/uploads/sites/2/2021/03/jamaica-baef-final-report.pdf

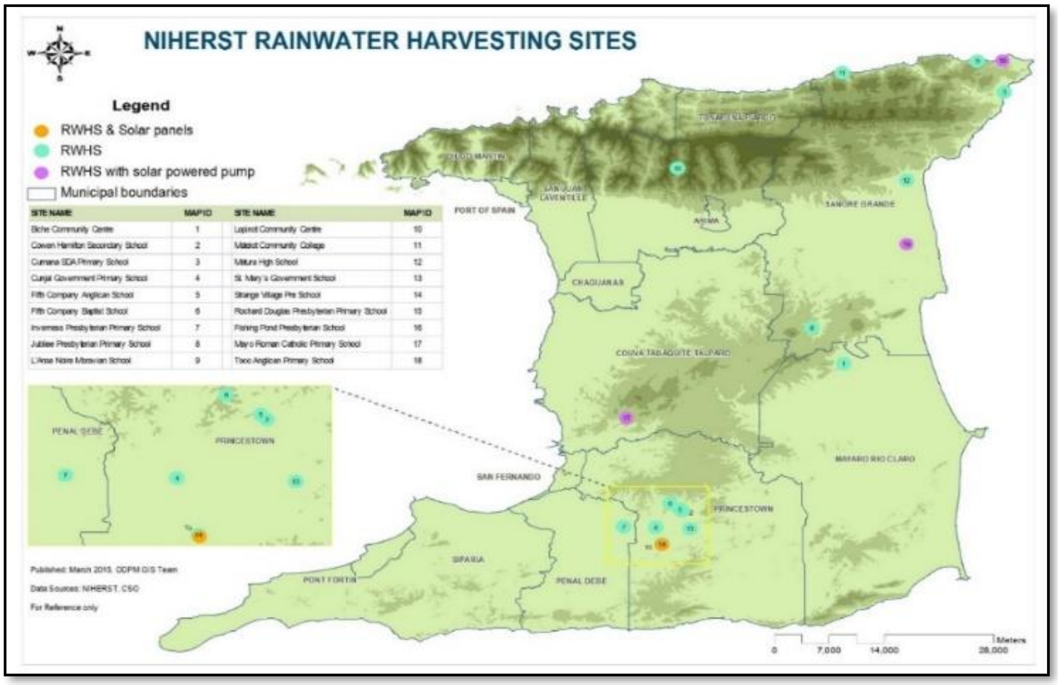


Figure 2: Rainwater harvesting sites in Trinidad and Tobago
(Source: NIHERST, 2021)
Retrieved: http://www.niherst.gov.tt/projects/projects-rainwater.html

Figure 3: *Rainwater Harvesting (RWH) system within the Fondes Amandes community in St. Ann's Trinidad, part of GWP Caribbean's contribution to the project Water for Life: The Trinidad and Tobago Initiative.*
Reference
Source: Rainwater Harvesting in Trinidad - GWP

3.2.2 Identification of Financial Barriers for the diffusion of Rainwater Harvesting

Tables 9 and 10 summarise the financial and on-financial barriers for RWH respectively.

Table 9: Identification of Financial Barriers for the diffusion of Rainwater Harvesting[7]

Financial Barriers	Technology: Rainwater Harvesting	Score
Economic/Financial	• Limited rainfall or unreliable rainfall patterns will negatively affect the effectiveness of the technology and subsequent ROIs. • Small household farmers are constrained due to the high upfront cost to purchase equipment. Limited capital options for initial investment for rainwater harvesting storage systems, pipes, storage and system requirements. • Limited benefit during extended dry seasons with respect to investment. • Large scale deployment will be costly due the type of catchment, conveyance and storage tank materials used.	5 5 4 5

Table 10: Non-financial barriers and scores for Rainwater Harvesting[8]

Non-Financial Barriers	*Technology: Rainwater Harvesting Technology*	Score
Technical/ Institutional/ Knowledge	• Rooftop incompatibility, and lack of storage options. • Ease of doing business can be a hindrance as small-scale farmer or small household may not have the technical requirements to implement technology. • Lack of reference projects in country. • Lack of data related to hydrology and geology. • Maintenance technical backstopping	4 3 3 4 2
	• Lack of practicality, and "how to" information for end users. Poor understanding of importance of RWH from rooftops as a water conservation method for water scarcity due to a changing climate.	3
	• Lack of trained professional and practitioners	4
	• Inadequate guidelines for adoption or policies.	2

[7] CTCN. 2021. Rainwater harvesting. https://www.ctc-n.org/technologies/rainwater-harvesting.
[8] CTCN. 2021. Rainwater harvesting. https://www.ctc-n.org/technologies/rainwater-harvesting.

Network	• Lack of access to trained and skilled personnel to aid with set up, design and sizing of storage tanks.	2
Policy Regulatory & Policy	• Insufficient regulatory/legislative/standards for RWH framework.	4
Social, cultural & behavioural	• Apprehension and risk of spreading vector-borne diseases.	3
Information and awareness	• Inadequate information/public awareness. • Lack of media interest in promoting technologies. • Lack of awareness about issue of climate change and technological solutions.	1 3 4

3.2.3 Identified measures for rooftop RWH

3.2.3.1 Economic and Financial measure

- Government to provide financial incentives in the form of soft loans (Ministry of Finance; Commercial Banks).
- Review water tariff so as to make RWH an attractive option (Ministry of Public Utilities).

3.2.3.2 Non-financial measures

- Enhance the institutional, policy and legal framework for RWH.
- Deploy Sensitization programs for the technology, and the associated benefits.
- Improve the awareness and knowledge on rooftop RWH of households.

3.3 Barrier Analysis and possible enabling measures for Smart Water Metering

3.3.1 General Description of Smart Water Metering

A smart water meter is a standard water meter that performs the same function however, what makes the technology "smart" is the attached device that allows communication electronic reading, storage, display and transfer consumption data (Randall and Koech, 2019) (see Figure 6). Water meter technology describes the equipment associated with end users and utility providers which tracks and provides accountability on water consumption rates that are often coupled with pricing charges. Smart Water Metering (SWM) facilitates water authorities such as WASA, to gain water-meter readings remotely and at aa higher frequency, and in a format that can be utilized for

Figure 4: *Water Metering technology utilised by WASA*
Reference: TTT, 2021
Source: (124) Water Metering Not A Priority At This Time, WASA Must Provide Water For All First - YouTube

various purposes including demand and consumption management, leakage detection and water conservation (Randall and Koech, 2019).

3.3.2. Identification of Financial Barriers for the diffusion of Water Metering Technology.

Table 11 identifies financial barriers, scores and enablers for metering technology, while Table 12 illustrates the non-financial barriers, scores and enablers.

Table 11: Financial Barriers, scores and enablers for Water Metering Technology

Financial Barrier	Description	Score	Enablers
Economic	• High initial investment and long pay-back periods. • Ongoing maintenance cost can be high. • Meter installation may require altering and/or rebuilding existing infrastructure. • A lack of understanding about the business case and the long-term economic gains.	5 4 5 5	Introduce water payments as a voluntary option targeting those in favour of the technology. - International/domestic finance (e.g. multilateral development banks, donors, domestic commercial banks etc.) - Servitization, - Pay-as-you-use billing. - Financing options for low-income households. - Guarantees and/ or risk sharing mechanisms to underwrite risk for lending to poorer household.

Table 12: Non-financial barriers, scores, and enablers for Water Metering Technology

Non-Financial Barriers	*Description*	Score	Enablers
Institutional capacity	Meters can be damaged and lose accuracy in areas with intermittent water supply due to sudden changes in pressure.	4	Deploy strategic training and awareness sessions. Provide assistance to relevant government agencies to prepare suitable management plans for sensitization and deployment of water metering.

			Deploy water pressure regularization valves to steady water pressure.
	Numerous claims of damaged pipelines. Large amounts of undetected leaks.	4	Capacity building workshops. Maintenance programming.
	Requires qualified persons to set up and administer the system for proper use. Large coordination amongst varied stakeholders.	3	
	Poor and old piping delivery infrastructure.	5	Replacement.
Network	Precise and system-wide accounting requires meters to be installed and functioning at majority of user points. Requires well established public water supply network.	4	International cooperation and support for water metering project plan, design and construct. Develop and strengthen inter-agency coordination and work. Establish phases to which the deployment with relevant stakeholders. New development complex should be targeted as well.
Regulatory & Policy	No regulatory enforcement for water conservation. Resources needed to police and enforce.	4	Increase water rates according to consumption thresholds. Taxing the larger users while incentives to encourage uptake.
	Meters may lose accuracy with time, requiring routine maintenance	2	Appropriate frequency programme of recalibration, as appropriate.
Social, cultural & behavioural	Additional cost and burden for end-users and consumers. Responsibility of citizen to report leaks and illegal connections. Lack of acceptance.	4	Establish what the local needs of communities are with regards to the technology. Engage a community development specialist to provide benefits of water metering to vulnerable groups.

4.0 HEALTH SECTOR

For human health, climate change impacts in Trinidad and Tobago include food and water insecurity, spread of water, and vector borne diseases, population displacement and heat stress. The Vulnerability and Capacity Assessment (VCA) Report assessed current and future direct and indirect health risks, vulnerability, and recommended adaptation measures.

4.1 Target areas for Technology Transfer and Diffusion in the Health sector

Table 13 illustrates the proposed intervention for the transfer and diffusion of the prioritized technologies for climate change adaptation for the health sector in Trinidad and Tobago.

Table 13: Target area for technology transfer and diffusion in the health sector.

Prioritized Technology	Preliminary Targets	Market Goods
Integrated surveillance and climate-informed health early warning systems	Provide actionable information to diverse groups for the provision of information at more appropriate spatial resolution, expanding ranges of variables, increasing lead time (because more local decision-makers can often act earlier to prevent crisis) and provide updated information at a range of lead times. Install station and tracker within capital hub for real time data collection and integration within 5 year period.	Publicly provided good

4.1.1 Barrier Analysis for Disease Surveillance of climate related health risks: (vector borne diseases, waterborne diseases and extreme heat events) and possible enabling measures

Climate-informed health early warning systems are integrated surveillance systems that incorporate multiple surveillance systems, to improve the use of information for detecting, investigating and responding to climate sensitive diseases. The system is designed to integrate data to improve the flow of surveillance information throughout the health system and general public which combines diseases surveillance and weather surveillance. Such systems afford the ability to provide upfront preventative measures as well as inform first responders to extreme climate events.

Table 14 identifies barriers to the diffusion of integrated surveillance and climate-informed health early warning systems (EWS). Table 15 shows non-financial barriers.

Table 14: Financial Barriers, and scores for the diffusion of integrated surveillance and climate-informed health early warning systems.

Technology: ***Integrated surveillance and climate -informed health early warning systems***		
Barrier Economic & Financial	***Description***	***Score***
Financial	• Cost to establish a fully operation climate change and health monitoring system, platform and deployment within rural communities. • Considerable use of resources and financial commitment for the dissemination of information as well as construction of the system for effective deployment. • The lifetime of the technology is long, however it depends on financing available for EWS maintenance and updating as well as maintenance of measurement network supporting the technology. • Lack of cost-benefit analysis to highlight the pros for establishment of health monitoring network and early warning systems for climate change impacts.	**5** **2** **2** **3**

Table 157: Non-financial barriers and scores, for climate-informed health early warning systems.

Technology: **Integrated surveillance and climate -informed health early warning systems**		
Non-Financial Barrier	**Description**	**Score**
Institutional	• Limited capacity of operators to use and apply data. • Limited arrangements at national and local levels to support the sustained development of public response capabilities. • Design and implementation of an early warning system typically requires 1 to 5 years, depending on climatic characteristics of the system.	**4** **3** **2**
Technical	• Limited knowledge and capacity to effectively interpret data related to climate change events and assess their sector/area/community specific potential impacts	**4**

	• Inadequate or underutilised systematic forecasting of climate hazards, analysis of risks and timely dissemination of warnings and climate risk.	**3**
Social/ Knowledge & awareness	• Public understanding of and trust in the system comes with knowledge and awareness on the part of the end user of the system, which may be challenging. • Limited reliable climate forecast for rural communities and regions. • Limited understanding of the fundamental climate /disease linkages for effective responses.	**3** **2** **2**

4.1.2 Identified interventions and enabling measures for overcoming the barriers

The following are proposed measures for overcoming identified barriers for deployment of early warning systems:

- Provide budgetary support for the establishment of early warning systems to appropriate stakeholders, integrating the existing meteorological data collection networks and early warning systems (Ministry of Finance).
- Utilize appropriate social media applications to disseminate information in a systematic manner through smart phones and other devices, as well as to enable feedback (Ministry of Health; Meteorological Services).
- Establish a central coordinating institution such as the Meteorological Services to manage climatic data interpretation and dissemination (Ministry of Health; Ministry with responsibility for local government bodies; Ministry with responsibility for the Meteorological Service).
- Building capacity of users of data/information (Meteorological Services; Ministry of Health; Ministry with responsibility for local government bodies).

Part II: Mitigation Technologies

The technology needs assessment (TNA) for mitigation was focused on the country's Nationally Determined Contribution (NDC) and its Implementation Plan (NDC IP) under the Paris Agreement as an area of priority implementation. The results of the MCA prioritised technologies in the listed order for the three sectors as illustrated in Table 16:

Table 8: Prioritised technologies for NDC sectors.

Sectors	Cross Cutting Technologies	Market Good
Power generation	1. Utility Scale: Solar power 2. Energy Audit and Efficiency improvement of supply side	• Other Non-market Goods • Other Non-market Goods
Industry	3. Carbon Capture and Storage (CCS)Technology 4. Biofuels	• Capital Goods • Capital Goods
Transportation	5. Electric Vehicles 6. ICT for intelligent traffic management systems	• Publicly provided Goods • Publicly provided Goods

5.0 Power Generation

The role of the power generation sector in Trinidad and Tobago is to provide access to reliable, secure and affordable electricity to all citizens as required. Trinidad and Tobago aims to reduce emissions in the power generation sector, given its substantial contribution to national greenhouse gas emissions. According to Trinidad and Tobago *Carbon Reduction Strategy* (CRS), the power sector contributes close to 20% of the total GHG emissions of the country.

5.1 Renewable Energy context

Work conducted by *Climatescope* conveys that Trinidad and Tobago, through 2017, has no renewable energy generation that is directly contributing to its electricity grid[9]. However, since then progress has been made to introduce small scale solar projects with one pilot project having grid

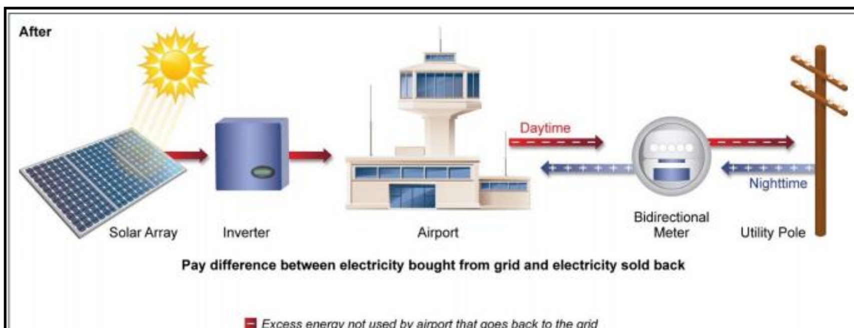


Figure 7: ***Pay difference between electricity bought from grid and electricity sold back***

[9] ICAO. 2018. Feasibility Study on the use of SOLAR energy at Piarco International Airport. ICAO.

connectivity. As mentioned earlier this is in part, due to low energy prices and a lack of legislation to incentivise solar and other RE development. The government has funded 25 PV projects at secondary schools and 1 at community centres.

Most notably, in 2018 the Government of Trinidad and Tobago undertook a feasibility study on the use of solar energy at Piarco International Airport for the purpose of utility scale power production. The primary objectives of the solar project were to limit carbon dioxide emissions consistent with national goals, reduce and stabilize long term power costs, and increase electricity reliability[10]. Work was undertaken to evaluate the airport's electricity consumption patterns and cost, in order to understand how much electricity could be provided by solar energy. The study also gave insight into emissions from current uses, both those originating from international aviation that could be offset by solar as well as the potential for grid generating electricity.

It is important to note that during the preparation of the TNA and the BAEF, the Government of Trinidad and Tobago initiated arrangements for the installation of a 112MW capacity solar power generation plant which will represent the largest such solar generation capacity in the Caribbean. Therefore, there was not strict alignment of the BAEF with the TNA, and some barriers were included as identified during the implementation of these policies and projects. These are specifically identified to provide context with the TNA.

5.1.1 Barrier Analysis for Utility Scale Solar Power Generation and possible enabling measures

Table 17 illustrates the financial barriers, with scores for utility scale solar power, while Table 18 provides the non-financial barriers and scores. Table 19 summarises the prioritized barriers and scores for utility scale solar generation.

Table 17: Financial Barriers and scores for the diffusion of Utility Scale Solar Powered Generation

Technology: Utility Scale Solar Powered Generation		
Barrier Economic & Financial	**Description**	**Score**

[10] ICAO. 2018. Feasibility Study on the use of SOLAR energy at piarco international airport. ICAO.

Financial	• Relatively high cost for solar equipment: Parts: Panels, Batteries and Storage Capacity. • Complexity in technical aspects such as plant design, and energy yield are directly linked to with efforts to access to permits/licenses and financing • Limited access to capital to finance utility scale solar project. • High perceived risk by investors in absence of government guarantee for payments and grid connectivity. • Economic feasibility given subsidised cost of electricity to the consumer	**5** **5** **3** **4** **4**

Table18: Non-Financial Barriers and score for the diffusion of Utility Scale Solar Powered Generation

Technology: Utility Scale Solar Powered Generation		
Barrier **Non-Financial**	**Description**	**Score**
Non-financial		
Regulatory	• Permits, licensing issues, EPC contract. • PV regulatory frameworks and specifics types of incentives/support mechanisms for the development does not exist to promote wide spread adoption. • Insufficient tariffs and other direct and indirect financial supports roles to play in the viability of the technology deployment and affect revenues streams. • Difficulty establishing Power Purchase Agreements (PPAs) to due complexity in the geopolitical environment.	**5** **5** **5** **4**
Technical/Market	• Difficulty in site selection: for compatibility of infrastructure and distribution lines. • Optimum power plant design: A key barrier to the development of the deployment of the technology is to design a PV power plant that balances cost and performance at the specific site. • Complexity in technical aspects such as plant design, and energy yield are directly linked to with efforts to access to permits/licenses and financing • Limited feasibility studies to understand key requirements need for utility scale deployment and the efficiency gains of the technology in current climate.	**4** **3** **4** **4**

Institutional	• No grid connection agreements/arrangements to foster the technology.	**4**
Environment/Social Other	• Social acceptability and scepticism on reliability of supply. • Negative affects on biodiversity and birds.	**3**

Table 19: Prioritized barriers for Utility Scale Solar Power Generation

Barriers	Description	Ranking
Economic/ Financial	**Lack of commercial viability for solar RE projects.** A sectoral business model for emerging solar RE sector has not been developed. No benchmarks for tariffs for solar RE generators of different scales have been established. Offtake agreements and tariffs that allow for reasonable rates of return to incentivize investment in solar RE plants at both the utility scale and distributed scale, are pending. **Limited financing** Commercial banks and other financing agencies have not been sufficiently engaged to facilitate the availability of sufficient funding at terms that correctly reflect project risk.	**5** **4**
Policy	**Lack of Solar RE policy** There is still no clear RE policy although there is some development taking place. **High Subsidies for fossil fuel generation** The existence of subsidies for fossil fuel electricity generation make solar generation unattractive and uncompetitive, thus there is little or no financial incentive to invest in solar.	**5** **5**
Legal and Regulatory	**Limitations in current legislation framework** There is no legislative barrier for the development of utility scale RE projects, however, current legislation does not accommodate interconnection of small-scale solar installations. **Lack of permitting regimes** There are no clear processes delineating how to develop solar RE sites and which agencies are responsible for granting permissions at the various stages. **Lack of clear rights to use a resource** The legal and regulatory framework does not outline clear processes for establishing the right to use solar RE resources.	**5** **4** **4**

	Inadequate regulatory framework Lack of rules to ensure that good quality of service is provided at a reasonable cost from solar RE developers. No defined regulatory body to develop such a framework.	**5**
Institutional Barriers	**Limited institutional capabilities and assignment of roles and responsibilities** There has not been a coordinated approach to institutional development in solar RE. Institutions involved in the sector lack adequate financial and human resources, and adequate skills in solar RE field, including technical expertise in assessing, installing, operating and maintaining, and inspecting solar projects. Roles and responsibilities across institutions and agencies have not been clearly delineated.	**5**
Information/Other	**Limited information on equipment availability** There is a lack of knowledge about the sufficiency of quality equipment at competitive prices. **Limited information and awareness** There is a lack of knowledge about the potential of solar RE in the country, the cost, benefits, and functioning of solar RE projects.	**4** **3**

Adapted from: Regulated Industries Commission (2019)

5.1.2 Identified interventions and enabling measures for overcoming the barriers in the Power Sector

Policy support for RE is a key factor that can create an enabling environment for the accelerated deployment of utility scale solar technology. Table 20 details policy consideration for the legislative and regulatory framework, institutional development and commercialization for funding utility scale RE integration in Trinidad and Tobago taken from work done by the Regulated Industries Commission.

Table 9: Description of enablers to overcome the deployment of utility scale solar power

Enabler	Description
Establish clear Policies, Targets and Strategy for Implementation	• Clearly articulate objectives and present a rationale for course of action. Define a role for small and medium scale RE installations. • Outline driver and benefits of solar RE development to the public, describing current situation of excess generation capacity. • Effectively map the underlying institutional framework for solar RE and broad plans to ensure the framework stays in place accompanied with a comprehensive solar RE resource assessment. • Consider the retirement age of existing generation fleet and forecast demand to show the risk of becoming a stranded asset. • Develop alternative energy mix/optimum energy mix. • Develop geographical installation target • Streamline administrative process for RE and solar applications. • Develop supply chains for Re and solar technology to facilitate development.

Institutional Capacity Building	• Capacity building is critical to the successful deployment of utility scale solar technology. Specific training will be required in planning for commercial integration of the technology and integrating generation from intermittent sources. • Enhance capacity and resource allocations to the various actor including policy makers (MEEI, MPU, MPD), regulators (RIC,EMA), utility engineers (T & TEC) and RE installers and other local content and service. • Consider establishing a National Renewable Energy Agency to have the responsibility for coordinating training across key entities to max resource efficiency.
Creating markets for/ Commercialization of utility scale RE	• Facilitate a market for small and medium scale RE by publicly stating the intended policy and pricing mechanism and permitting regimes that it intended to utilize to incentives such installations. • Provide policy mechanism to allow for reasonable payback period and a reasonable rate of return on investments. • Use auctions to finalize ongoing discussions of a FIT Policy to facilitate outcomes of material benefit. • Engage with local financial institutions in RE finance, to improve access to affordable clean energy.
Public Awareness and Information Sharing	• Develop a national strategy to raise awareness and boost understanding of solar RE sources and their benefits to the country and its citizens. • Local institutions and citizen must be enlightened about the job opportunities for their participation in solar RE projects. Information, including cost and energy output should be advertised from demonstration plants for commercial applications.
Limited Rollout of Commercial Small Scale/ Distributed Solar RE	• Create mechanisms to support the transitional phase between demonstration and commercial of solar and RE generation.

Adapted from: Regulated Commission Industries, 2019

It is important that management roles and responsibilities are clearly delineated across institutions and agencies to be identified for the deployment and commercial development of RE technologies such utility scale solar. This will ensure that the process is focused in nature facilitating a smooth bureaucratic application process for procedures. A proposed envisioned set of roles and responsibilities of key agencies for the deployment of utility scale solar power is presented in Table 21 below:

Table 2110: Key Agencies and responsibilities for utility scale RE development and deployment

Entity/Agency	Roles and Responsibilities
Ministry of Energy and Energy Industries	• Develop and publish RE policy/mandate: Vision, rationale, opportunity cost analysis • Targets of RE integration • Lead development of RE Act.

Create National Renewable Energy Agency	• Map RE resources and publish results. • Establish entry mechanisms/incentive scheme and permitting regimes for all scales of solar RE generation. • Establish funding mechanisms • Manage an RE fund which should be allocated to R&D, capacity building and payment of RE generators. • Establish framework and rules for procurement of RE • Establish licensing and permitting framework for solar RE generators for utility scale and small-scale generation • Assist with the development of license instruments and permits for RE generators.
Ministry of Public Utilities/ Electrical Inspectorate	• Award of utility scale RE licences. • Arbitration of interconnection disputes in conjunction with regulatory body. *Electrical Inspectorate*: • Inspecting RE installations. • Enforcing safety and operating standards
T&TEC – System planner, grid operator, off-taker	• Variable renewable grid integration study. • Develop rules and codes for interconnection. • Outline procedure for interconnection. • Develop PPAs.
Regulation Industries Commission	• Develop licence instruments and permits for
Trinidad and Tobago Bureau of Standards	• Inspection, testing and certification of equipment

Adapted from: Regulated Industries Commission, 2019

5.1.3 Non-Financial Measures:

Incorporate RE power generation into the energy mix:

- Develop wind resource assessment programmes (WRAPs) to explore the potential of wind energy for T&T (Ministry of Energy).
- Develop waste characterization study to explore the potential of waste to energy (Ministry of Energy; Ministry with responsibility for solid waste management).
- Develop Integrated Resource and Resilience Plan (IRRP) that identifies an appropriate balance of natural gas/renewable energy power generation and storage to ensure a reliable and affordable energy mix for the next 25 years (Ministry of Energy).
- Set the targets for RE penetration with a recommended minimum target being 30% of demand by 2030 (Overall Government development policy).
- Facilitate the uptake of RE power generation by residential and commercial establishments through appropriate policy and legislation such as feed-in-tariff (Ministry of Energy; Ministry of Public Utilities).
- Develop licensing regime for utility scale RE (Ministry of Public Utilities)

- Review and amend the electricity legislation to allow an appropriate mechanism for metering and to facilitate the deployment of RE power generation for utility, commercial and residential scales, and their associated integration into the grid (Ministry of Public Utilities).
- Fast track the T&TEC rate review currently planned/underway (Ministry of Public Utilities).
- Pursue further utility scale RE power generation to mitigate the expiration of the current fossil fuel PPAs with the IPPs (Ministry of Energy; Ministry of Public Utilities).

6.0 Industry

For the purpose of this report, the definition of *Industry* is adopted from the definition used with the Trinidad and Tobago's Carbon Reduction Strategy, which refers to heavy industry which includes petroleum exploration and production, pipeline operations, natural gas processing, refining, iron and steel processing, LNG production, cement manufacture, and petrochemical production. Important to note, electricity generation (power generation) and distribution is treated separately and activities related to food and beverages, printing and packaging are omitted. According to the local reports, the industrial sector is collectively the largest contributor to GHG emissions amounting to over 60 million tonnes roughly 74% of total national emissions.

Trinidad and Tobago's hydrocarbon sector moved from an oil dominant to a mostly natural gas-based sector in the early 1990s. Almost 90% of these CO2 emissions are attributed directly to the energy sector through petrochemical production (56%), power generation (30%) and flaring (3%) (MEEI, 2020).

6.1 Preliminary Targets for Technology Transfer and Diffusion in Industry

The National Climate Change Policy (NCCP) identifies carbon capture and storage (CCS) and alternative fuels as mitigation measures (see above context for biofuels). Trinidad and Tobago conducted pre-feasibility studies into CCS implementation in 2013 including preliminary estimates of the carbon dioxide storage capacities and capabilities of the hydrocarbon (oil and gas) reservoirs to allow for policy decisions. Trinidad and Tobago already generates all of its power with natural gas, and the country can therefore benefit from CCS as a means to reduce emissions mitigation from this sector as well as from the large petrochemical sector. Preliminary research shows that CCS is feasible in T&T, however this comes at a considerable cost. Nonetheless, as a maturing technology worldwide, further feasibility studies on CCS are needed, including the requisite policy and legislative enabling environment, as well as the monitoring technological requirements. Biofuels are included as a mitigation measure in so far as it provides a potential industrial development sector for alternative fuels more than a direct mitigation measure in the industrial sector per se.

Table 22 outlines prioritized technologies, and their categorization in the industrial sector.

Table 22: Prioritized technologies, and their categorization in the industrial sector

Prioritized Technology in Industry	Preliminary Targets	Non-market Goods
Carbon-capture and storage technology	- Developing detailed feasibility studies including reservoir capacity and stability, identifying suitable sources of carbon dioxide.	**Publicly provided goods**

	- Creating the policy and legislative framework for CCS.	
Biofuels	Feasibility studies and pilot demonstration projects for development of biofuels from food waste and other commercial kitchen waste. Biofuels and other alternative fuel could have a significant role to play to accelerate early decarbonisation action across the transport sector, particularly for heavy vehicles that currently use diesel.	**Publicly provided goods**

Climate Technology Centre & Network, 2021

6.1.1 Barrier analysis and possible enabling measures for Carbon capture storage technology

6.1.1.1 General description of carbon capture storage technology

CCS is a combination of technologies designed to prevent the release of carbon dioxide generated through conventional power generation and industrial production processes by injecting the carbon dioxide in suitable underground storage reservoirs. Basically, capture technology separates carbon dioxide emissions from the process, after which the compressed gas is transported to a suitable geological storage location and injected. Feasible methods of transporting carbon dioxide include both pipelines and shipping. Appropriate geological storage locations in Trinidad and Tobago for carbon dioxide include abandoned oil and gas fields, and deep saline formations. The dominant reason for exploring CCS technology is the potential for carbon dioxide emission reductions from industry and power generation. The deployment of CCS in the industrial and power generation sectors would allow fossil fuel use to continue as the country transitions to alternative energy with a significant decrease in emissions. However, a full CCS chain has yet to be implemented, and many technical, environmental and economic uncertainties remain (CTCN, 2021).

Table 23 provides and overview of the financial barriers and scores for CCS. Table 24 provides the non-financial barriers and scores.

Table 23: Financial Barriers and Scores for Carbon-Capture and Storage Technology

Barrier Economic & Financial	Description	Score
Financial	• Extensive capital requirements and associated cost may make the technology not economically feasible. • Lack of empirical data to estimate actual cost and creating baseline scenarios making access to capital more difficult. • High expense to retrofit existing stationary carbon dioxide point sources (LNG, Natural gas) to employ separation and storage.	**5** **4** **5**

Table 24: Non-Financial Barriers and Scores for Carbon-Capture and Storage Technology

Barrier Non- Financial	Description	Score
Regulatory	• Lack of regulatory environment related to issues of storage liability, monitoring responsibility and the transport of carbon dioxide.	**4**
Technical/Market	• Limited technical feasibility in respect of storage site capacity and associated geological features related to stability and permanence.	**4**
Awareness/ Consumers	• A general lack of awareness and understanding amongst the public. According to the research, CCS is currently viewed as high risk and have been associated with a high number of protest cases globally.	**4**
Environmental/Other	• High risk perception the captured carbon dioxide can be leaked from storage or leakage via transportation. • Additional fossil fuels demand may be required to operate the capture unit which may increase carbon dioxide emissions.	**3** **4**

6.1.1.2 Measures to address financial barriers

The main economic barrier is the high cost of investment. Accordingly, the major intervention measure identified was the provision of government incentives for investing in CCS.

It is to be noted that during the finalisation of the BAEF, the Government of Trinidad and Tobago has outlined tax credits/allowances for investment in CCS (including enhanced oil recovery)[11]. Additionally, the Government established an inter-sectoral committee to examine the various issues associated with carbon capture, utility and storage (CCUS) including policy and regulatory, technical, and financial.

6.1.1.3 Measures to address Non-financial Barriers

The existing legislative framework does not explicitly address liability for stored CO2 in the event of leakage. The Petroleum Act 1969 places the duty of environmental responsibility on the operator for example. This provides a sound precedent for placing the liability during the operation of a project and

[11] https://www.finance.gov.tt/wp-content/uploads/2021/10/2022-National-Budget-Statement.pdf

shortly after decommissioning on the operator; this is generally the approach taken in CCS regulation developed in other countries. In the absence of any explicit regulation, any liability requirements could be captured in a certificate of environmental clearance (CEC) requirement under the Environmental Management Act 2000 in the immediate to short term. In theory, there is nothing to prevent even long-term storage obligations (if placed on the operator) being addressed under a CEC. However, a more comprehensive enabling framework that facilitates industrial best practices would need to be developed that would address policy, legislative, administrative and institutional issues. It was the consensus of stakeholders that the Designated Activities (DAs) under the CEC Rules were sufficiently broad enough to capture the activities of a CCS project, particularly if the technology was retrofitted to existing sources, and/or associated with a new or existing EOR project.

Based on the analysis and consultation undertaken for this report, a number of issues have emerged as 'fore-running' issues that need to be considered in the first instance, including:

- Management of long-term liability of stored carbon dioxide (Ministry of Energy; Ministry of Legal Affairs);
- Potential inclusion of CCS as a specific Designated Activity under the Certificate of Environmental Clearance (Designated Activities) Order 2001 (Ministry with responsibility for the environment (Ministry of Planning and Development); Environmental Management Authority);
- Specific inclusion of carbon dioxide pipelines under the Pipelines Act 1933 (Ministry of Energy);
- Mechanisms for greater coordination in the regulatory regime for CCS (Ministry of Energy; Ministry of Planning and Development; Environmental Management Authority);

6.1.2 Barrier analysis and possible enabling measures for Biofuels

6.1.2.1. General description of Biofuels

Biofuel includes fuels ranging from ethanol to diesel, as long as organic matter (biomass) is used as a chemical starting point to produce it. Methods of producing the fuels can include the formation of alcohols by fermentation of biomass in bioreactors containing microorganisms and the gasification of biomass in reactors to form syngas (carbon monoxide and hydrogen mixture), which can then be used to produce numerous hydrocarbon fuels such as diesel. The biomass used in these processes can potentially range from sugarcane and switchgrass to algae to biodegradable waste (such as waste cooking oil), with different raw materials providing better product yields dependent on production method. Ethanol which can be produced from sugarcane or imported can be blended with gasoline to produce a cleaner burning fuel, thereby releasing less carbon dioxide, or waste cooking oil esterified to produce biodiesel.

Figure 8: *Biofuel Processor*

Notwithstanding that the sugar industry has been closed in Trinidad and Tobago, Table 25 provides the potential of biofuel production in the Caribbean, including Trinidad and Tobago, which can provide some insight into a potential revitalisation of the sugar industry for biofuel production.

Table 25: Percentage of biofuel potential by crop and fuel based on total current production in Trinidad and Tobago

Percentage of Biofuel potential by crop and fuel based on total current production in the Caribbean Region

Country	Ethanol			Bio-Diesel					Bio-Power				
	Sugar	Corn	Sorghum	Coconut	Cotton seed	Palm kernels	Sesame	Soy	Sugar cane	Rice	Coffee	Coconut	Wood
Antigua/ Barbuda	-	100	-	-	100	-	-	-	-	-	-	-	-
Bahamas	97.1	2.9	-	-	-	-	-	-	52.0	-	-	-	48.0
Barbados	99.7	0.3	-	100	-	-	-	-	95.0	-	-	1.1	4.0
Cuba	92.8	7.2	0	100	-	-	-	-	65.5	4.2	0.1	0.7	29.4
Dominican Republic	96.9	3.1	0	63.1	-	36.9	-	-	57.6	19.0	1.5	4.2	17.6
Grenada	83.6	16.4	-	99.4	0.6	-	-	-	33.0	-	-	67.0	-
Haiti	55.7	43.5	0.8	70.1	2.7	-	27.1	-	13.1	3.9	1.0	0.7	81.4
Jamaica	99.8	0.2	-	100	-	-	-	-	41.5	0.0	0.1	7.6	50.8
St. Kitts/Nevis	100	-	-	99.5	0.5	-	-	-	98.8	-	-	1.2	-
St. Lucia	-	-	-	100	-	-	-	-	-	-	-	100	-
St. Vincent/ Grenadines	85.5	14.5	-	100	-	-	-	-	74.4	-	2.0	23.7	-
Trinidad & Tobago	97.6	2.4	-	100	-	-	-	-	65.1	1.1	0.2	4.5	29.1
Caribbean Avg.	92.0	7.9	0	83.6	0.3	13.8	2.3	-	55.4	6.1	0.4	2.0	36.1
Belize	88.9	11.1	0	91	-	-	-	9.0	65.6	1.9	0.0	0.1	32.3
Costa Rica	98.5	1.5	0	3	0.02	96.9	0.0	-	18.6	3.8	1.7	0.2	75.6
El Salvador	63.4	36.5	0.1	89.3	2.6	-	6.4	1.7	25.8	0.4	1.1	1.2	71.5
Guatemala	78.1	21.8	0	16.4	0.2	60.4	20.7	2.2	26.5	0.2	0.9	0.1	72.3
Honduras	66.2	33.8	0	1.8	0.1	97.6	0.4	0.1	13.5	0.1	0.7	0.1	85.6
Nicaragua	65.9	34.1	0.1	10.3	1.5	45.7	37.9	4.6	17.5	3.2	0.7	0.1	78.6
Panama	81.5	18.5	0	24.2	-	75.1	0.6	0.1	24.7	15.1	0.4	0.5	59.3
Cent. Am. Avg.	74.6	25.3	0	9.1	0.2	84.2	5.8	0.7	22.1	1.6	0.9	0.3	75.1

UN Biofuels Initiative 2006

Adapted from: (Nathanie, 2010) The Implementation of a Sustainable Biodiesel Industry in Trinidad and Tobago

6.1.2.2 Identification of financial barriers to deployment of Biofuels

Table 26 provides an overview of the financial barriers and scores for biofuels, and Table 27 provides an overview of the non-financial barriers and scores.

Table 26: Description and scores of financial barriers for the deployment of Biofuels

Barrier Economic & Financial	Description	Score
Financial	• Cost of equipment and infrastructure required to convert waste materials to biofuel.	**5**
	• With current subsidies in place, it is difficult for a technology such as biofuels to become competitive economically.	**4**
	• Investors in biofuel technology are not likely to be attracted given little chance of commercial viability.	**5**
	• Low foreign attraction on international investments in general	**4**
	• Limited acreage of arable land results in low economies of scale, although abandoned sugar cane lands can provide a solution.	**5**

Table 27: Non-financial barriers and Scores for the deployment of Biofuels

Barrier	Description	Score
Non-financial		
Regulatory/institutional	• Uncertain legal and regulatory framework • Lack of production incentives	**4** **3**
Awareness/ Consumers	• No awareness campaigns for the promotion of biofuels. • Limited feasibility studies to assess economic viability for users. • Insufficient market information for investors	**4** **5** **5**
Environmental/Other	• Potential to reduce food security through competition for arable lands. • Competition for water and other resources • Risk of depleting remaining forest lands, pastures and rainforest.	**4** **4** **4**

6.1.2.3 Identified Financial measures for Biofuels

Provision of fiscal incentives for the development of a viable biofuel industry, including leasing of state lands for growing suitable crops amenable to biofuel production such as sugar cane on favourable terms and conditions (Ministry of finance; Ministry of Agriculture; Agricultural Development Bank).

6.1.2.4 Identified Financial Non-financial measures for Biofuels

The development of the requisite policy, legislative, institutional and administrative enabling environment is a necessary first step to the development of any biofuel industry. This would include the following:

1. Revision/updating of land use policies to incorporate biofuel production from crops such as sugar cane and corn (Ministry of Planning and Development; Ministry of Agriculture).
2. Exploring use of waste cooking oil for conversion at scale of biodiesel (Ministry with responsibility for the environment (Ministry of Planning and Development; Environmental Management Authority).

7.0 Transportation Sector

Over the past 20 years, the number of registered vehicles on the Trinidad and Tobago's roads has more than doubled, due to the fact that the primary mode of transportation is via privately-owned vehicles. An unreliable public transport system has also contributed to this, although the bulk of the public transportation system comprises privately-owned and operated mini buses. As at July 2019, this figure stood at approximately 914,000 vehicles, which translates into Trinidad and Tobago having one of the highest vehicle ownership per capita in the world. In addition, fuel for transportation has historically been subsidized. The effect is onerous from a cost perspective and also in terms of congestion on the nation's roads, leading to productive working hours lost and energy wastage.

The government has decided that CNG is the initial solution for decreasing the islands' energy intensity in an economically reasonable manner. This initiative required large scale investments in infrastructure, as lack of CNG filling stations was one of the major factors currently limiting consumer interest. Since then, the introduction of the CNG technology has resulted in many consumers converting over to CNG as a low carbon alternative because of the monthly savings on fuel expenditure. Notwithstanding, the Government has recognised that CNG is a transitionary transport fuel and the ultimate policy objective is one of sustainable transport. To this end, both medium- and long-term climate targets advocate for the deployment of EV vehicles which can be adopted in a fashion of CNG given the success.

7.1 Preliminary Targets for Technology Transfer and Diffusion in Transportation Sector

Table 28 summarises the prioritized technologies for the transportations sector.

Table 28: Prioritized Technologies for the Transportation Sector

Prioritized Technology	Preliminary Targets	Other non-market goods
Electric Vehicles	Development of an e-mobility policy. Implement suitable fiscal incentives such as removal of taxes and duties to facilitate the penetration of electric vehicles in the transportation mix.	**Publicly provide goods**
Information Communication Technology (ICT) for the land transport system	Development of a modern and well-maintained ICT system for land transportation which would allow for the following within 3 years: • Increased transport availability • Improved speed in connectivity • Increased affordability of telecommunication and broadcasting services to end users including real time scheduling • A stable, open and enabling climate that encourages confidence in ICT within land transport	**Publicly provide goods**

7.1.1 General Description of Electric Vehicles

There are three basic types of electric vehicles that can be deployed onto the local market: battery-base electric vehicles (BEVs), plug-in hybrid EVs (PHEVs) ad hybrid EVs (HEVs) (Coningsloy and Behan, 2018). BEVs run entirely on an electric motor and use on-board electric motors alone. PHEVs make use of both an on-board motor and a small internal combustion engine, drawing on that engine when more power is required or when battery life is low. Hybrid EV use a conventional internal combustion engine and electric drive, but differ from plug-in hybrid EV. According to IEA (2018), the difference of the two is that all the energy for propulsion is generated from fuel, with electric energy generated by a built-in alternator or regenerative braking systems.

In light of recent policy approaches for e-mobility such as the government's policy objective of sustainable transport, the global trend of phasing out ICE vehicles, the ongoing development of an e-mobility policy, this section of the report therefore focuses on BEVs.

Table 29 provides a description of the financial and non-financial barriers along with associated scores, for electric vehicles.

Table 29: Financial and Non-Financial Barriers, and Scores for Electric Vehicles

Barrier	Description	
Economic/ Financial	• High capital cost. • Lack of financial instruments to make economically viable to the average consumer.	**Score** **5** **2**
Institutional	• Lack of skilled person to work and repair EV as well as access to parts for replacements.	**4**
Technical/Market	• Relatively new technology to Trinidad and Tobago. • Inadequate network of charging stations	**3** **3**
Knowledge and Awareness	• Limited knowledge and awareness among consumers on EVs	**3**

It should be noted that while Government has instituted fiscal incentives in 2022 for increasing the penetration of EVs in the transportation mix such as removal of all taxes (import duties, value added tax) in order to bring cost parity with ICE vehicles and thereby increase competitiveness and encourage uptake, there remains some non-financial barriers associated with cultural acceptability, charging infrastructure, misinformation etc.

7.1.2 Identified interventions and enabling measures for overcoming Barriers in the Transportation sector

In order to facilitate the successful deployment of EV vehicles onto the local market, the requisite enabling environment for the adoption of the technology has to be established[12]. To mainstream the electrification of the transportation sector or deploy EV, a combination of EV charging infrastructure, consumer education and awareness about cost savings on EV should be well portrayed to the general public. Table 30 identifies interventions and enabling measures to overcome barriers to EV uptake.

[12] Regulated Industries Commission. "Energy Road Map Series." RIC Staff Discussion Paper. 2019.

Table 30: Identified interventions and enabling measures of overcoming EV Barriers

Priorities	Recommended Enablers	Description/responsibility
Policy Framework & Appropriate Institutional Structure	Appropriate policy and institutional framework to oversee the implementation of policy recommendations. Charging station network based on experiences from the compressed natural gas fuel switching programme as similar challenges were faced.	• Develop and adopt an e-mobility policy (Ministry of Planning and Development; Ministry of Energy). • Establish optimal charging station network (Ministry of Energy).
Financial/Non-Financial	Fiscal incentives to facilitate uptake such as tax breaks, import duties etc. to achieve price parity and competitiveness with ICE vehicles, arrangements with commercial banks for targeted loans at peppercorn interest rates.	• Develop and implement fiscal measures (Ministry of Finance). • Reassess the mass transit (public bus transit as well as privately-owned public transport) model to enhance efficiencies and associated costs so as to incorporate EV public transport, drawing on the lessons learned in the CNG conversion programme (Ministry of Energy; National Gas Company)
Knowledge and Awareness	Public awareness campaigns	• Develop frequently asked questions (FAQs) to dispel misconceptions of EVs (Ministry of Planning and Development; Ministry of Energy)

Adapted/derived from Regulated Industries Commission, (2019)

7.2 Barrier Analysis and enabling measures for Information Communication Technology (ICT) for intelligent traffic management systems

7.2.1 General Description of Information Communication Technology (ICT) for intelligent traffic management systems

The term "Information and Communication Technologies (ICT)" is used to delineate the various telecommunications and information technologies used within the transportation sector. These can include a number of technologies and systems in various stages of development from research prototypes to commercially viable products and applications. These include devices, networking components, applications and systems that when combined allow people and organisations to interact in the digital world to facilitate sustainable transportation. The promotion of ICT technologies is expected to avoid the need to travel, reduce emissions and foster changes in modalities for a more efficient means of transportation that reduces traffic and increases traffic coordination while reducing time lost in traffic.

The Ministry of Works and Transport (MOWT) has historically been charged with jurisdiction over the management of coastal erosion, drainage, bridges, construction, roads and highways, traffic management, national transportation, ports and public transport. Additionally, the Ministry partners with its statutory authorities, state enterprises and relevant boards under its portfolio to ensure the provision of additional air, land and sea infrastructure and services.

7.2.2 Identification of Barriers for Information Communication Technology (ICT) for intelligent traffic management systems

Tables 31 provides a description and scores for financial and non-financial barriers for information communication technology (ICT) for intelligent traffic management systems respectively, while Table 32 describes intervention measures.

Table 31: Description and scores of Financial and Non-Financial Barriers for the deployment of Information Communication Technology (ICT) for intelligent traffic management systems

Barrier	Description	
Economic/ Financial	• Budgeting constraints	**Score** **4**
Institutional	• The roles of transportation planning, transportation demand management, and public transit management are carried out disjointedly by various stakeholders. • Limited capacity for digitization	**4**
Policy	• National transportation policies are not updated.	**3**
Regulatory	• Inadequate legal and regulatory framework for eBusiness, e-commerce and e-services	**5** **4**

Table 32: Intervention measures for Information Communication Technology (ICT) for Intelligent Traffic Management Systems

Priorities	Recommended Enablers	Description/responsibility
Economic/Financial	Provision of adequate financing to effect ICT solutions	• Include adequate resources in the national budgetary process (Ministry of Finance; Ministry of Digital Transformation, Ministry of Works and Transport).
Institutional/Policy/Regulatory	- Design and implement coordination systems among relevant institutions. - Digitize relevant government institutions. - Update transportation policies to incorporate digital and ICT approaches to traffic management.	• Create the enabling environment to equip ministries and relevant agencies with capacity to digitally monitor issues related to traffic management, including in real time. (Ministry of Works and Transport; Ministry of Public Administration, Ministry of Digital Transformation).
Knowledge and Awareness	Public awareness campaigns	• Develop frequently asked questions (FAQs) to dispel misconceptions of EVs (Ministry of Planning and Development; Ministry of Energy)

List of References

Adams, H., Umaharan, P., Braithwaite, R., & Mohammed, K. (2011). *Hot Pepper Production Manual for Trinidad and Tobago.* The Caribbean Agricultural Research and Development Institute. Retrieved from CARDI.

Adeyanju, A., Manohar, K., & Ramnath, A. (n.d.). Statistical Analysis of Electric Vehicle Adoption in Trinidad and Tobago. *Innov Ener Res, 7*(216).

Arniella, E. F. (2017). *Evaluation of Smart Water Infrastructure Technologies (SWIT).* IDB.

Centre for Climate and Energy Solutions. (n.d.). *Carbon Capture*. Retrieved from Centre for Climate and Energy Solutions: https://www.c2es.org/content/carbon-capture/

Clarke, J., de Berdt Romilly, G., McCue, J., Pinder, S., Pounder, C., Campbell, D., . . . Khan, K. (2019). *Vulnerability and Capacity Assessment (VCA) Report.* Germany: Particip GmbH.

CTCN. (2021). *Rainwater harvesting*. Retrieved from Climate Technology Centre and Network: https://www.ctc-n.org/technologies/rainwater-harvesting

CTCN. (2021). *Water metering*. Retrieved from Climate Technology Centre and Network: https://www.ctc-n.org/technologies/water-metering

Energy and Climate Partnership of the Americas. (2018, June 28). *Paving the Way to Electromobility in Trinidad and Tobago*. Retrieved from Energy and Climate Partnership of the Americas: https://ecpamericas.org/newsletters/paving-the-way-to-electromobility-in-trinidad-and-tobago/

FAO. (2015). *AQUASTAT Country profile – Trinidad and Tobago.* Rome, Italy: Food and Agriculture Organization of the United Nations (FAO).

Fraas, A., Buffa, V., & Rich, L. (2021). *Establishing Utility-Scale Solar Projects: Federal Involvement.* Resources for the Future.

Halder, S., Sadhukhan, D., & Verma, R. (2021). Adaptability of drip irrigation in coastal and hard rock terrain of West Bengal, India. 2-14.

ICAO. (2018). *Feasibility Study on the use of SOLAR energy at piarco international airport.* ICAO.

International Finance Corporation. (2015). *Utility-Scale Solar Photovoltaic Power Plants: A project Developer's Guide.* Washington: International Finance Corporation.

Mpa.gov.tt. 2022. [online] Available at: <http://www.mpa.gov.tt/sites/default/files/file_upload/publications/ICT%20BLUEPRINT%20JULY%202019.pdf>

Mpa.gov.tt. 2022. [online] Available at: <http://www.mpa.gov.tt/sites/default/files/file_upload/publications/ICT%20BLUEPRINT%20JULY%202019.pdf>

Metz, B., Davidson, O., de Coninck, H., Loos , M., & Meyer , L. (2005). *IPCC Special Report on Carbon Dioxide Capture and Storage.* Intergovernmnetal Panel on Climate Change. New York: Cambridge University Press.

Ministry of Health; Ministry of Planning and Development. (2020). *HEALTH & CLIMATE CHANGE COUNTRY PROFILE 2020.*

Morton, J. (2012). *CARBON CAPTURE AND STORAGE REGULATORY REVIEW FOR TRINIDAD AND TOBAGO.* Global CCS Institute. Global CCS Institute.

Persad, P., Sagster, N., Cumberbatch, E., Ramkhalawan, A., & Maharajh, A. (2011, November). Investigating the Feasibility of Solar Powered Irrigation for Food Crop Production: A Caroni Case. *The Journal of the Association of Professional Engineers of Trinidad and Tobago, 40*(2), 61-65.

Regulated Industries Commission. (2019). *Energy Road Map Series.* Regulated Industries Commission.

UNEP DTU Partnership. (n.d.). Retrieved from Technological Needs Assessment: https://tech-action.unepdtu.org

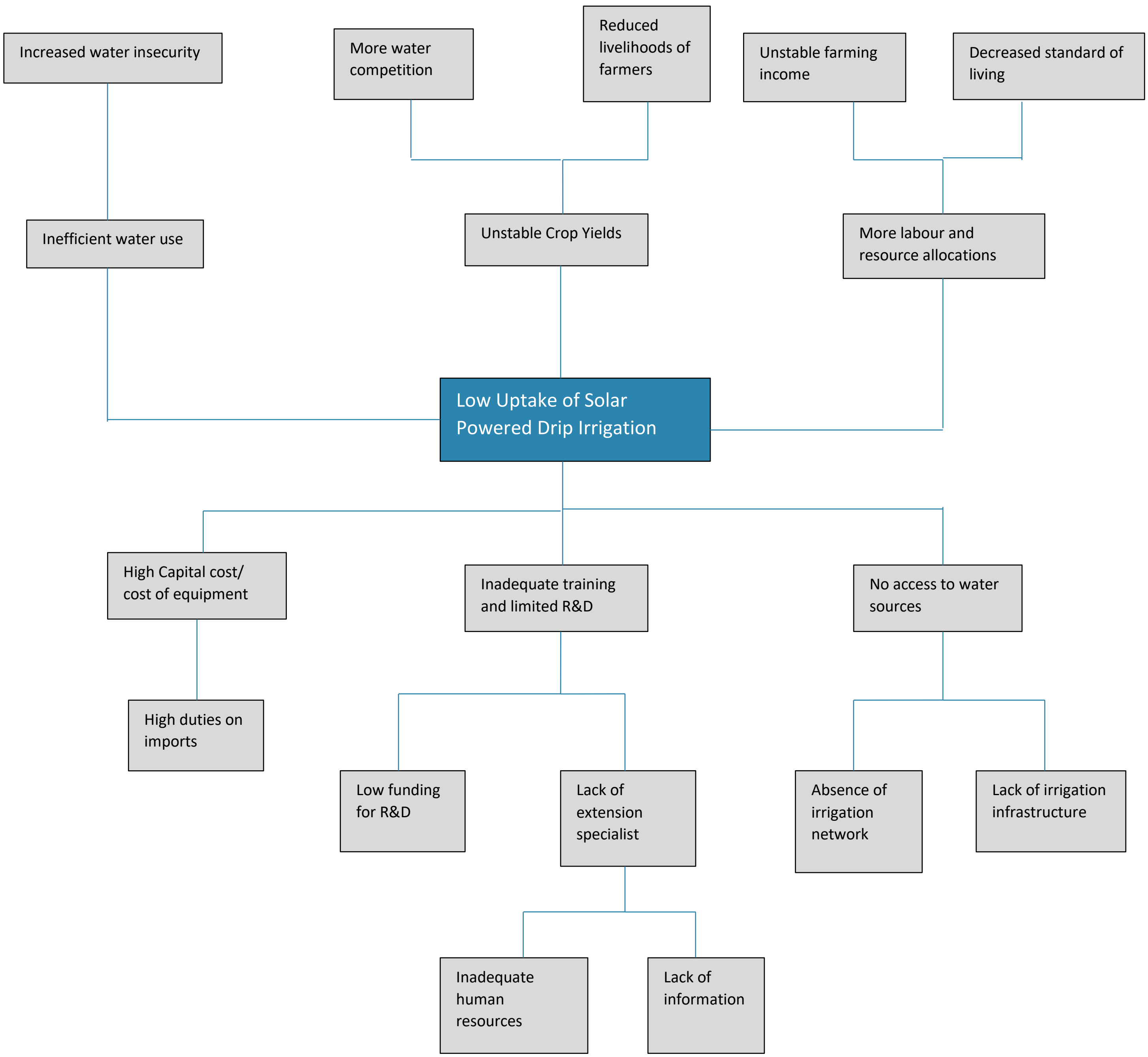
UNEP DTU Partnership. (n.d.). *Technology Fact Sheet for Adaptation.* Retrieved from TNA Report - Technology Needs Assessment for Climate Change Adaptation – Zambia: https://www.ctc-n.org/sites/www.ctc-n.org/files/UNFCCC_docs/ref05x06_35.pdf

UNEP DTU Partnership. (n.d.). *Wetland restoration and rehabilitation*. Retrieved from Climate Technology Centre and Network: https://www.ctc-n.org/technologies/wetland-restoration-and-rehabilitation

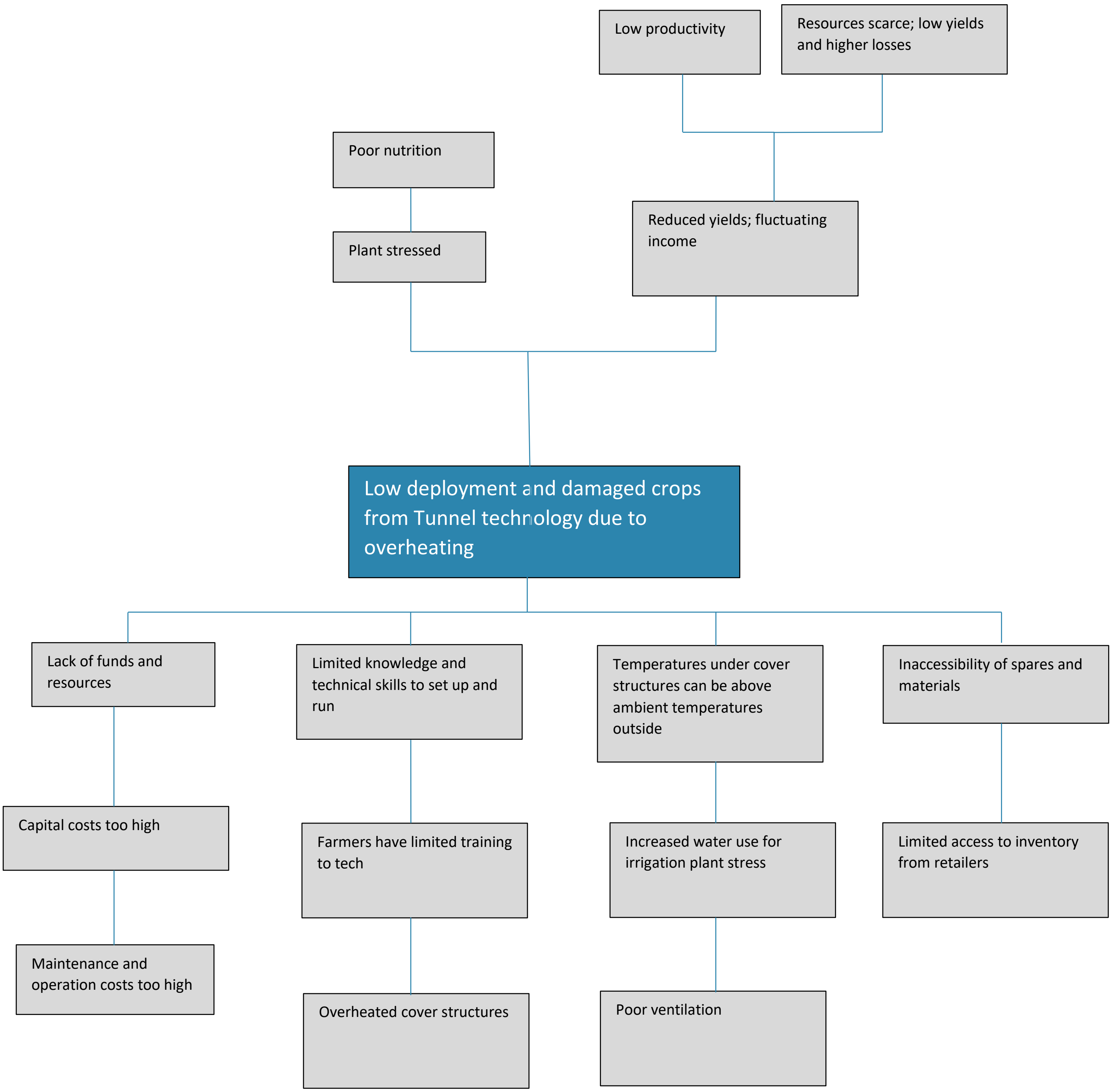
Writer, S. (2018, February 8). *Electric Vehicles and Oil Price*. Retrieved from The Energy Chamber of Trinidad and Tobago: https://energynow.tt/blog/electric-vehicles-and-oil-price

Annex I

Problem Tree: Solar Powered Drip Irrigation System

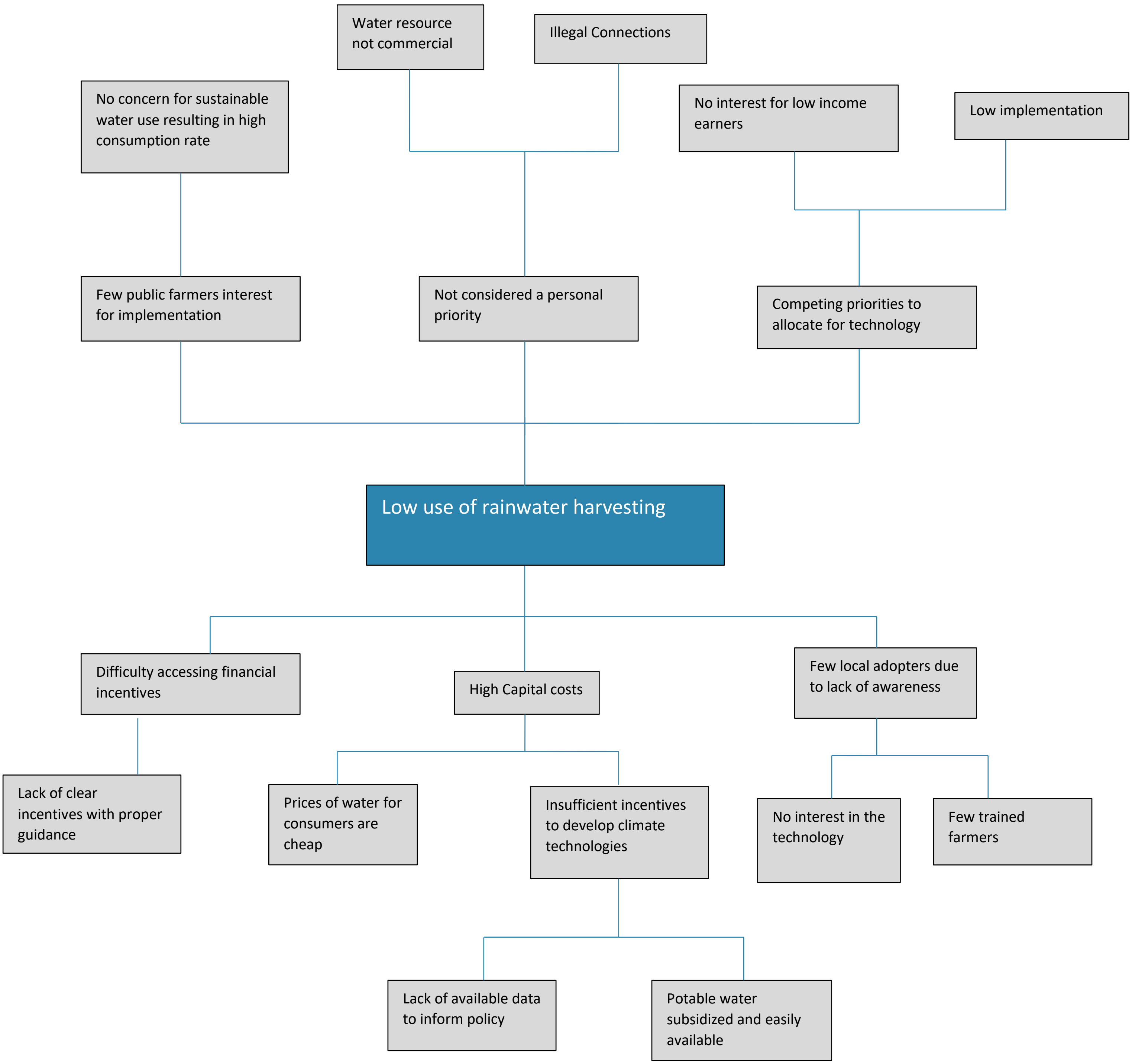


Problem Tree: Caterpillar Tunnel Technology

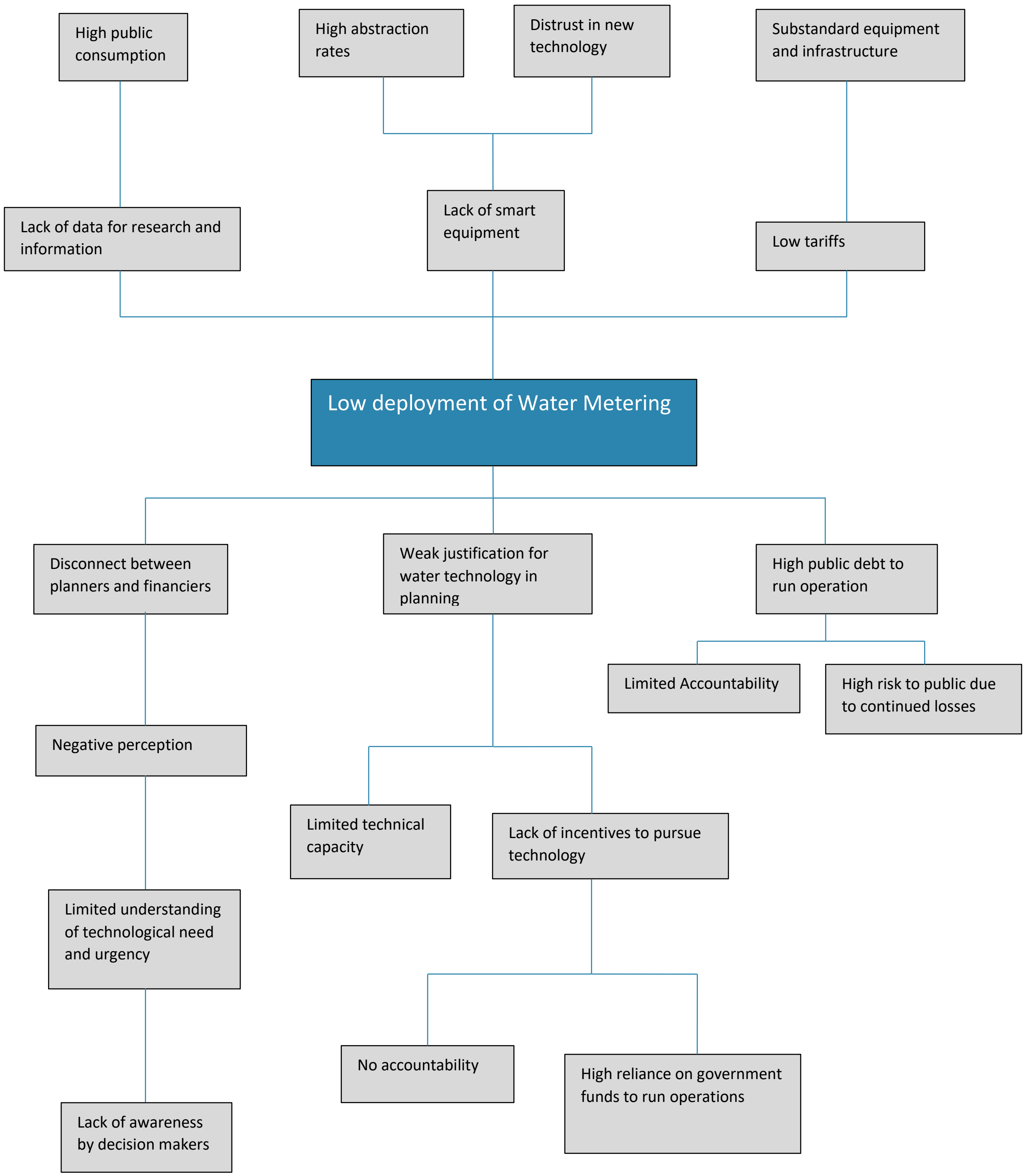


Annex III:

Problem Tree: Rainwater Harvesting

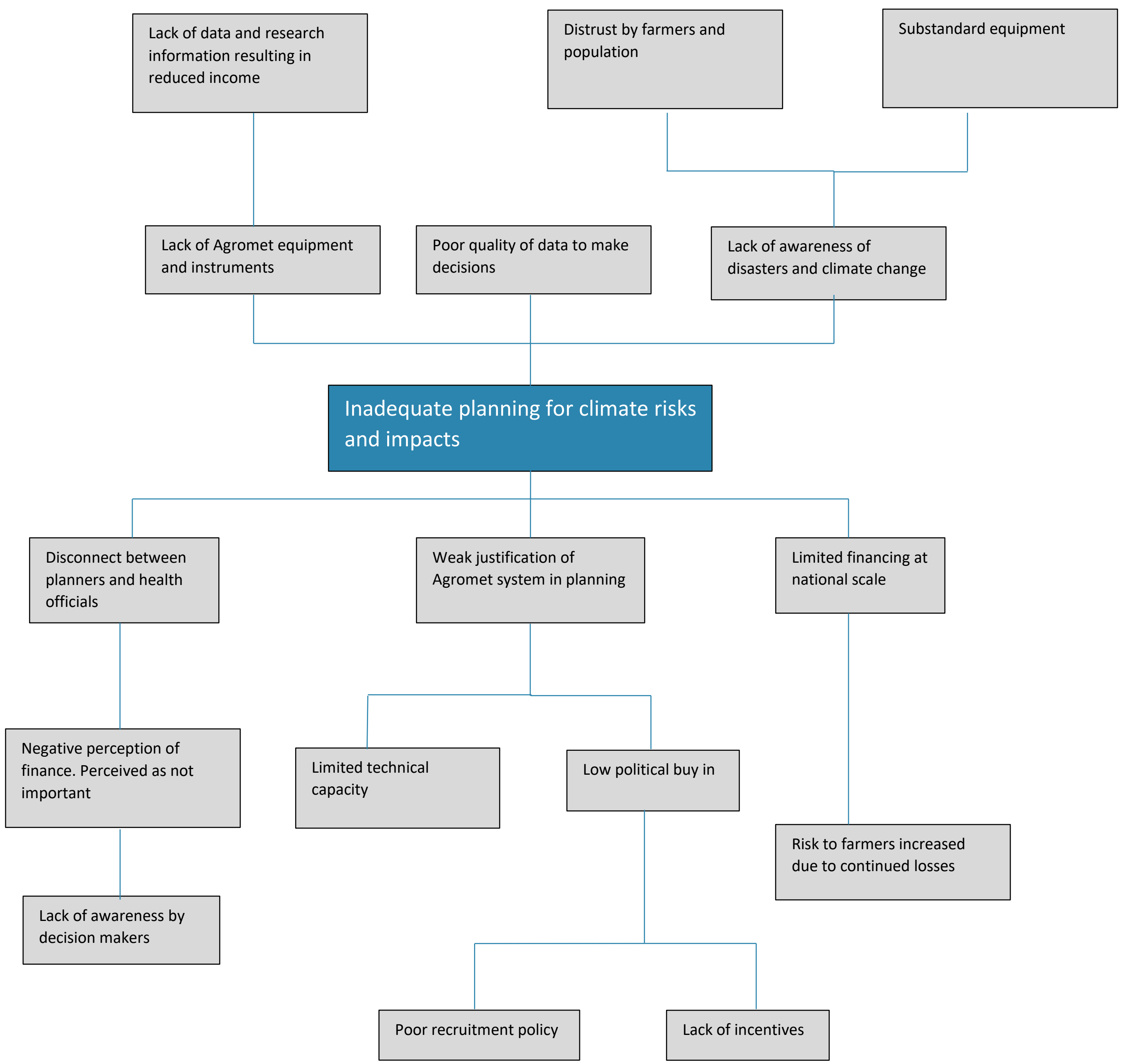


Problem Tree: Water Metering Technology



Annex V:

Problem Tree: Early Warning Signals for climate related hazards



Annex VI: List of Stakeholders

Mitigation

1. Atlantic LNG
2. BP Trinidad and Tobago
3. Desalination Company of Trinidad and Tobago (DESALCOTT), Limited
4. Environmental Management Authority (EMA)
5. Factor Ideas Integral Services
6. General Electric
7. Heritage Petroleum
8. Institute of Marine Affairs (IMA)
9. Inter-American Institute for Cooperation on Agriculture (IICA)
10. Mayaro/Rio Claro Regional Corporation
11. Methanex Trinidad Limited
12. Ministry of Agriculture, Land and Fisheries
13. Ministry of Education
14. Ministry of Energy and Energy Industries
15. Ministry of Health
16. Ministry of Planning and Development
17. Ministry of Public Utilities
18. Ministry of Rural Development and Local Government
19. Ministry of Tourism
20. Ministry of Works and Transport
21. National Infrastructure Development Company (NIDCO)
22. Nucor Corporation/Nu-Iron Unlimited
23. Office of Disaster Preparedness and Management
24. Office of Prime Minister, Government of Trinidad and Tobago
25. Port of Spain City Corporation
26. Point Lisas Nitrogen Limited
27. Princess Town Regional Corporation
28. PROMAN//Methanol Holdings Trinidad Limited (MHTL)
29. Public Transport Service Company (PTSC)
30. Shell Trinidad and Tobago Limited
31. South West Regional Health Authority (SWRHA)
32. Trinidad and Tobago Civil Aviation Authority
33. Trinidad and Tobago Solid Waste Management Company (SWMCOL)
34. Trinidad Cement Limited, TCL Group
35. The Tobago House of Assembly (THA)
36. The University of the West Indies
37. Trinidad and Tobago Airport Authority
38. Trinidad Generation Unlimited (TGU)
39. University of Trinidad and Tobago (UTT)
40. Water and Sewerage Authority (WASA)
41. Yara Trinidad Limited

Adaptation:

1. Ministry of Agriculture, Land and Fisheries
2. Fisheries Division, Ministry of Agriculture, Land and Fisheries
3. Trinidad and Tobago Meteorological Services
4. Ministry of Public Utilities
5. Institute of Marine Affairs
6. Ministry of Tourism
7. Council of Presidents for the Environment (NGO)
8. Environmental Management Authority
9. Ministry of Health
10. Office of Disaster Preparedness and Management
11. Ministry of Energy and Energy Industries
12. Ministry of Rural Development and Local Government
13. The Energy Chamber of Trinidad and Tobago
14. Water Resources Agency
15. The Water and Sewerage Authority of Trinidad and Tobago (WASA)
16. The University of the West Indies (UWI)
17. The University of Trinidad and Tobago (UTT)