REPUBLIC OF TRINIDAD AND TOBAGO

TECHNOLOGY ACTION PLAN

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Contents

List of Abbreviation and Acronyms

BAEF	Barrier Analysis and Enabling Framework
BAU	Business as usual
BAT	Best Available Technology
CEC	Certificate of Environmental Clearance
CNG	Compressed Natural Gas
CRS	Carbon Reduction Strategy
EMA	Environment Management Authority
EV	Electric Vehicle
GCM	General Circulation Models
GDP	Gross Domestic Product
GEF	Global Environment Facility
GHG	Greenhouse gas
GORTT	Government of the Republic of Trinidad and Tobago
IDB	Inter-American Development Bank
ICT	Information Communications Technology
ICZM	Integrated coastal zone management
ITCZ	Intertropical convergence zone
LECB	Low emission capacity building
MCA	Multi-Criteria Analysis
MEEI	Ministry of Energy and Energy Industries
MOWT	Ministry of Works and Transport
MTI	Ministry of Trade and Industry
MPD	Ministry of Planning and Development
NDC	Nationally determined contributions
NDCIP	Nationally determined contributions Implementation Plan
NGO	Non-Governmental Organisations
PAHO	Pan American Health Organisation
RCM	Regional climate models
SIDS	Small island developing states
SLR	Sea level rise
SPIS	Solar Powered Irrigation Systems
TAC	Technology needs assessment advisory committee
TAP	Technology action plan
TNC	Third National Communication
T&TEC	Trinidad and Tobago Electricity Commission
TWG	Technology Working Group
TNA	Technology needs assessment
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme

UNEP-CCC	UNEP Copenhagen Climate Centre
UNESCAP	United Nations Economic and Social Commission for Asia and the Pacific
UNFCCC	United Nations Framework Convention on Climate Change
VCA	Vulnerability and capacity assessment
WHO	World Health Organisation

List of Tables

Executive Summary

The Technology Needs Assessment (TNA) Project in Trinidad and Tobago is focused on the Carbon Reduction Strategy (CRS), the Nationally Determined Contribution (NDC), and its Implementation Plan under the Paris Agreement (mitigation), and the Climate Risk Vulnerability Assessment study (adaptation). These documents were developed based on the issues requiring attention, and on that basis, the TNA for their implementation was deemed a priority. Through the stakeholder consultation process, the sectors chosen for technology prioritisation were as follows: For adaptation, the agriculture, health, and water sectors because of their interlinkages, inter-dependency, and importance in the planning and management disaster risk reduction for a small island developing states.

For mitigation:
Electricity generation:

- Energy Audit and Efficiency improvements of the Supply Side,
- Designing and Implementing utility scale Solar RE.

Industry:

- Renewable sources of fuel,
- Carbon capture storage and use.

Transportation:

- ICT for intelligent traffic management systems,
- Electric vehicles (EV)
- Hybrid electric vehicles (HEV).

The Technology Action Plan basically derives from the technology selection and prioritization as outlined in the TNA process and the subsequent barrier analysis. Notably, the TAP also builds on policy developments during the preparation of the TAP related to electric vehicles, and the proposed establishment of a utility-scale solar generation plant. The TAP addresses two mitigation and two adaptation technologies.

For the NDC (mitigation) these are:

(i) Electric Vehicles
(ii) ICT for intelligent traffic management;

For adaptation:

(i) pressurized irrigation technologies
(ii) protective structure cooling systems – caterpillar tunnels

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.

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. **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.

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.*

Mitigation: The main barriers associated with the deployment of electric vehicles are summarized in the table below as taken from the TNA and the Barrier Analysis and Enabling Framework (BAEF) report.

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

The 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. However, there remains some non-financial barriers associated with cultural acceptability, charging infrastructure, misinformation etc. The identified interventions and measures to overcoming the remaining barriers are summarized in the table below, as identified in the BAEF report.

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	• Develop and implement fiscal measures (Ministry of Finance).

	competitiveness with ICE vehicles, arrangements with commercial banks for targeted loans at peppercorn interest rates.	• 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)

The barriers identified in the BAEF for ICT are shown in the table below.

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

Identified interventions and measures for ICT is shown below.

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	• 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).

	digital and ICT approaches to traffic management.	
Knowledge and Awareness	Public awareness campaigns	• Develop frequently asked questions (FAQs) to dispel misconceptions of EVs (Ministry of Planning and Development; Ministry of Energy)

Intervention options and measures were identified through a consultative process which ensured that the key stakeholders participated in the decisions (See Annex 1), that developed the action plans.

Adaptation: The main barriers associated with pressurized irrigation technology are listed in the table below.

Barriers	**Technology: Solar-Powered Irrigation Description**
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). • Lack of suitable funding schemes/access to finance, and incentives to promote the use. • Lack of socio-economic analysis of use of pressurized irrigation powered with solar. • High fuel subsidy making electricity cheap and slowing the adoption of solar power. • Low subsidies and tax incentives to promote adoption. • New equipment like solar technology is vulnerable to theft and hence often coverage by insurance as a prerequisite for loan finance is expensive
Institutional capacity	Limited technical capacity in administration of systems, research and development, including staff, infrastructure, and maintenance. Weak links between policy, enforcement, research and extension, and end-users. No extension specialist for technology to set up demonstration in farmers' fields.

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[1]
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.
	Main stakeholders unwilling to cooperate, share information and mis-trust
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

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

The barriers identified for caterpillar tunnels are listed in the table below.

Barriers	Technology: Caterpillar tunnel technology Description
Finance and Economics	Availability of affordable capital (high interest rates for unsecured loans) Lack of financial incentives for agricultural technologies for low value crops
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.
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.

1.0 Introduction

The TNA reports (mitigation and adaptation), and the BAEF were developed in alignment with the relevant national development policy documents, and underscore the need to ensure that the TAP also resonates with national development strategies. The National Climate Change Policy is the framework for the decision context in this report as it charts the way forward for both climate mitigation and building resilience for Trinidad and Tobago. on including the Vulnerability and Capacity Assessment (VCA) conducted in 2018 and the Nationally Determined Contributions (NDC) Implementation Plan completed in 2020 in Trinidad and Tobago.

2.0 Technology Action Plan for Mitigation

2.1 Electric Vehicles

The Government of Trinidad and Tobago has prioritized the implementation of the NDC, and in particular has already taken policy steps to facilitating the deployment of this technology. IN this regard, fiscal incentives have been introduced in 2022 for tax exemptions on the import of electric vehicles. This follow from a State-funded programme of fuel switching to compressed natural gas (CNG), and in recognition that CNG is a transitionary fuel, has aggressively embarked on measures to facilitate the deployment of EVs, This is coupled with the ultimate policy objective of sustainable transport, i.e. EVs charged with renewable energy. Notwithstanding, there remain various barriers to these measures, related to *inter alia:*

- Lack of skilled person to work and repair EV as well as access to parts for replacements;
- Inadequate network of charging stations;
- Limited knowledge and awareness among consumers on EVs

In this regard, the government of Trinidad and Tobago has drawn on the lessons learned from the CNG fuel-switching programme which posed similar challenges and barriers, including insufficient CNG filling stations, technical backstopping, and adequate public awareness of the technology. In addition to these lessons, the objective of sustainable transportation poses additional challenges/barriers in respect of renewable energy infrastructure.

2.1.1 Policy and Institutional Actions

As the GORTT continues to institute appropriate measures to catalase the deployment of EVs, an overarching policy framework is required to cover all aspects. Accordingly, the development of a comprehensive policy framework to inform nay necessary legislative changes that will facilitate EV deployment is a necessary first step, given that legislative amendments and developments follow the process of establishing a policy basis first. Accordingly, the first step is to develop an e-mobility policy in consultation with stakeholders that would set the policy framework in order to facilitate the necessary actions, including legislative changes that may be required.

2.1.2 Barriers to the Technology Diffusion

A major challenge remains adequate charging stations, particularly in rural areas. This would include fast-charging stations drawing on the lessons learned by the challenges posed in the CNG fuel switching programme where refilling time was identified as a major barrier to the widespread uptake of the technology. The barriers to the technology are summarized in the table below.

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

2.1.3 Description of the Technology

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) and hybrid EVs (HEVs). 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. 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.

However, 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 recognition that CNG is a transition fuel, and the ongoing development of an e-mobility policy, the focus is on BEVs.

2.1.4 Target for Transfer and Diffusion

It is intended that the transfer and diffusion of the technology will be done over a phased period in tandem with consumer uptake. This will depend on various issues related to consumer confidence such as technical backstopping and maintenance, as well as public awareness and education. The target populations are the commuting pubic, whether those that are private vehicle owners or users of public transportation.

Since there has been some initial addressing of the economic/financial barriers through the exemption of taxes etc., the proposed action plan responds to the other barriers identified in the BAEF. Accordingly, the following actions have been identified:

1. Development of an e-mobility policy to establish the policy and legal framework and enabling environment;
2. Identify suitable sites for the establishment of charging stations, including those charged with renewable energy, particularly those in rural areas;
3. Develop a training programme in collaboration with the technical universities for EV maintenance in order to inspire consumer confidence and create green jobs;
4. Identify funding sources and opportunities for financing charging stations with renewable energy;
5. Develop a comprehensive public awareness and education programme.

2.2 Information Communication Technology (ICT)

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. This will not only redound to climate and mitigation benefits, but benefits will also accrue to socio-economic well-being by virtue of a concomitant reduction in stress and anxiety, increase in productivity and economic savings to the consumer.

2.2.1 Policy and Institutional Actions

The GORTT has embarked on a digitalization drive across ministries and agencies through its Ministry of Digitalization. It is expected that as this progresses, digital capacity will be improved to facilitate the implementation of actions. Nonetheless, there is inadequate overall policy framework governing national transportation to guide the implementation of actions.

2.2.2 Barriers to the Technology Diffusion

The barriers to technology diffusion range from economic/financial to policy/legislation. Additionally institutional capacity for implementing actions pose a significant challenge. The barriers are summarized in the table below.

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

2.2.3 Description of the Technology

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.

2.2.4 Target for Transfer and Diffusion

It is intended that the digital transformation across ministries and agencies would provide the operational tools to effectively and efficiently deploy ICT given the nuances and synergies among them. As ICT is not hard technology but rather a tool for application, the simultaneous deployment is seen as fairly straightforward.

The following actions have been identified to address the barriers:

1. Create the enabling environment to equip ministries and relevant agencies with capacity to digitally monitor issues related to traffic management, including in real time;
2. Digitize relevant government institutions;
3. Update transportation policies to incorporate digital and ICT approaches to traffic management.

Table 1 Summary of Action Plan for Mitigation – EVs and ICT

Action/ Measure	***Why Action***	***Responsible Agent(s)/ Responsibilities***	***Period***	***Cost (USD)***	***Source of Funding***	***Indicator of Success***	***Challenges***
1. Establishing at least 90 EV charging stations across the country charged with renewable energy (based on lessons learned in the implementation of the CNG fuel-switching programme)	In many instances, prospective EV owners experience "range anxiety", which is the fear of running out of electricity either along a journey or at a location without charging facilities. As the number of electric vehicles grow, more charging infrastructure is required and hence, higher demands for electrical energy. This is also consistent with the sustainable transportation	Ministry with responsibility for transport; Ministry of Public Utilities for possible grid connection where required (renewable energy can feed into the national grid when not charging EVs)	2023 – 2028	Average cost of $109,444.00 per charging station. Total: 9,850,000.00	Multilateral and International Financial Institutions including the Green Climate Fund. Bilateral programmatic funding as may be appropriate and available	80% of the facilities completed within 5 years.	- Availability of feasible sites – acreage to accommodate renewable power requirements; - Retrofitting existing sites - roof integrity of existing sites; - electrical wiring requirements

2. Create the enabling environment to equip ministries and relevant agencies with capacity to digitally monitor issues related to traffic management, including in real time	ICT capacity is fundamental to implementation of the technology.	Coordinated by the Ministry with responsibility for transport.	2022 – 2027	Costs not assessed. Scale to be determined in tandem with policy update, as part of the intervention measures.	GORTT Multilateral and International Financial Institutions including the Green Climate Fund. Bilateral programmatic funding as may be appropriate and available	80% ICT capacity developed.	- Human capacity - Finance

3. Training and skills development for maintenance and technical backstopping for EVs	There is need for skilled EV technicians to provide maintenance of EVs and boost consumer confidence	Ministry of Planning and Development University of Trinidad and Tobago	2023 – 2025	500,000.00 for training equipment	Multilateral and International Financial Institutions including the Green Climate Fund. Bilateral programmatic funding as may be appropriate and available	Operationalisation of the training programme	- Availability of finance

Total				$10,350,000.00			

3.0 Project Ideas for Transportation Sector – Establishment of Solar Electric Vehicle Charging Stations

3.1 Background

Trinidad and Tobago's first Nationally Determined Contribution (NDC) seeks to achieve a reduction in cumulative greenhouse gas emissions by 15% relative to a business as usual baseline by 2030 in the transportation, power generation and industry sectors. In implementing actions towards this end, synergies across sectors are being explored to be optimized. In this regard, it has been identified that electric vehicle charging stations in remote areas can be established using renewable energy power that will contribute to the long-term policy objective of sustainable transport or absolute emissions-free transport. This will enhance synergy between efforts to reduce emissions in both the power generation and transport sectors.

3.2 Objectives

The objectives of the project is the establishment of electric vehicle solar charging stations in remote areas of Trinidad and Tobago to support the acceleration of the transition away from internal combustion engine vehicles, to support owners of electric vehicles in these areas, and address issues related to range anxiety.

3.3 Outputs

The establishment of at least 20 solar electric vehicle charging stations at pre-determined optimally located sites.

3.4 Relationship to Sustainable Development Priorities

Trinidad and Tobago's National Development Plan – VISION 2030[2] - fully incorporates the sustainable development goals, and more explicitly speaks to reducing the country's carbon footprint through relevant mitigation actions. Additionally, the NDC Implementation Plan[3] also addresses actions that include those in the transportation and power generation sectors. The project aims to create a sustainable transport system that would continue to accrue emissions reductions over time well beyond the project period.

3.5 Project Deliverables

In addition to the establishment of at least 20 charging stations, the demonstration value of solar power against the backdrop of Trinidad and Tobago's oil and gas based economy, is expected to serve to heighten public sensitization and acceptance of alternative renewable energy sources, and by extension serve to catalyse solar photo-voltaic systems at the household level, congruent with the feed in tariff policy, as well as increase consumer confidence in electric vehicles. In addition to reducing emissions, and contributing to the country's achievement of its NDC and National Climate Change Policy (NCCP), as well as contributing to mitigating global climate change, the shift to absolute emissions-free transportation will improve air quality by reducing pollution resulting from particulates, oxides of nitrogen, and generation of ground-level ozone, and indirectly improve human health and reduce costs

[2] https://www.planning.gov.tt/sites/default/files/Vision%202030-%20The%20National%20Development%20Strategy%20of%20Trinidad%20and%20Tobago%202016-2030.pdf
[3] https://transparency-partnership.net/system/files/document/200114_GPD_Trinidad_and_Tobago_RZ.pdf

of providing health care by the state. This will indirectly contribute to achieving the Sustainable Development goals (SDGs).

3.6 Project Scope

The project will aim to be a pilot/demonstration project at already established service stations, at pre-determined optimally/strategically located sites.

3.7 Project Activities

In order to achieve these results, the following activities are envisioned:

Outcome 1: Assessment of identified sites

Activity 1.1 Identification of suitable sites

Notwithstanding that indicative sites have been identified based on the experiences and lessons learned from the state-sponsored CNG fuel-switching programme, this activity is aimed at assessing the potential of the site to accommodate solar chargers including acreage, roof integrity, and identification of alternatives;

Activity 1.2 Design PV array

Based on activity 1.1, design the PV specifications and array to adapt to the identified sites, including climate-resiliency to climate risks, and make suitable recommendations.

Activity 1.3 Develop recommendations for deployment and operations & maintenance

Based on the above activities 1.1 and 1.2, recommendations for installation, operations and maintenance of the charging stations would be developed.

A suitable consultant(s) will be recruited for Activities 1.1 – 1.3 and in consultation with relevant stakeholders.

Outcome 2: Installation of solar charging stations

Activity 2.1 Installation and operation

Installation and operation of the solar chargers through relevant and applicable procurement procedures will follow the recommendations from **Outcome 1.** A suitable consultant will be recruited to oversee this Activity and Outcome.

3.8 Timelines

It is expected that once financing is secured, installation can take place over a two year period.

3.9 Budget/Resource Requirements

The estimated cost of the project is 10 million USD, which is expected to be sourced from multilateral funding sources such as the Green Climate Fund (GCF)

3.10 Measurement/Evaluation

Monitoring the execution of the project will involve a team of relevant stakeholders from various ministries including Ministry of Works and Transport, Ministry of Energy, Ministry of Public Utilities as well as regulatory divisions/agencies within the government such as the electrical Inspectorate and the Environmental Management Authority that will form part of the overall project Steering Committee as well as provide technical advice to support the execution of project activities.

3.11 Possible Complications/Challenges

Possible complications/challenges may be the acreage required for solar panels installations to provide sufficient power for ultra-fast charging stations; electrical system integrity; roof strength integrity to support the load of solar panels. These are expected to be addressed during the initial set of activities (see above).

3.12 Responsibility and Coordination

See response under Measurement/Evaluation above.

4.0 Technology Action Plan for Adaptation

4.1 Pressurized irrigation powered by solar

This adaptation technology addresses interlinked issues across the climate vulnerability landscape, including the nuances of water conservation, human health, food security, food nutrition, and emissions reductions in the power generation sector. There are ready benefits to rural farmers who depend on fossil-fuel powered irrigation pumps often resulting in wastage and greater agricultural run-off (nutrients from fertilizers, and pesticides) which contributes to deterioration of water quality. There are therefore several socio-economic benefits to be derived from the deployment of this technology.

4.1.1 Policy and Institutional Actions

Given the economic dependence of Trinidad and Tobago on the oil and gas, and petrochemical sectors, agriculture remains uncompetitive. Notwithstanding, the national development plan to 2030 (VISION 2030) points to modernization of agriculture as a crucial factor for the economy's international competitiveness. The technology is also supported by policies aimed at water conservation and management such as the Integrated Water Resources Management Strategy[4].

4.1.2 Description of the technology

Pressurized irrigation system using sprinkler or drip irrigation can deliver water directly to the plants' roots, and can aid in providing an ideal moisture level for plants. Unlike flooding techniques, drip systems enable farmers to deliver water directly to the plants' roots drop by drop, nearly eliminating reducing or even eliminating water waste, it is suitable for clay soils and can be set up to operate with gravity flow. This technology can be coupled with fertiliser application in the form of fertigation which can also reduce fertiliser cost through minimizing 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 rainwater harvesting mechanisms to have independent water supply and irrigation for small holder farmers.

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 rainwater harvesting mechanisms to have independent water supply and irrigation for small holder farmers. The use of solar power can truly make these systems independent and the technology can be adapted to the size of the farm and the climatic conditions from season to season and can also be operated independent of the national potable water supply.

Additionally, 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. 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.

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.

[4] https://www.mpu.gov.tt/wp-content/uploads/2021/09/Final-Draft-NIWRMP.pdf

- 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 many rural communities with inconsistencies with water supply and 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.

4.1.3 Barriers to the Technology Diffusion

There is a range of barriers identified for SPIS as outlined in the table below.

Barriers	**Technology: Solar-Powered Irrigation** **Description**
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). • Lack of suitable funding schemes/access to finance, and incentives to promote the use. • Lack of socio-economic analysis of use of pressurized irrigation powered with solar. • High fuel subsidy making electricity cheap and slowing the adoption of solar power. • Low subsidies and tax incentives to promote adoption. • New equipment like solar technology is vulnerable to theft and hence often coverage by insurance as a prerequisite for loan finance is expensive
Institutional capacity	Limited technical capacity in administration of systems, research and development, including staff, infrastructure, and maintenance. Weak links between policy, enforcement, research and extension, and end-users. No extension specialist for technology to set up demonstration in farmers' fields.
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]
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.
	Main stakeholders unwilling to cooperate, share information and mis-trust
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

The following actions have been identified to address the barriers:

1. Implement appropriate fiscal incentives, including in appropriate arrangements with insurance companies and commercial banks to:
    i. 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);
    ii. Provide preferential insurance premiums for investments (insurance companies);

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

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

4. Develop a pilot/demonstration project involving an initial target of 50 small-scale farmers selected from vulnerable rural areas to illustrate viability and affordability.

4.1.4 Target for Transfer and Diffusion

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.

4.2 Caterpillar tunnels

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

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.

4.2.1 Policy and Institutional Actions

The policy and institutional framework for caterpillar tunnel technology are largely the same as for SPIS, drawing on the nexuses and nuances across vulnerable sectors that impact on agricultural production.

4.2.2 Description of the 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

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

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.

4.2.3 Barriers to the Transfer and Diffusion of the Technology

The barriers as identified in the BAEF are illustrated in the table below.

Barriers	**Technology: Caterpillar tunnel technology** **Description**
Finance and Economics	Availability of affordable capital (high interest rates for unsecured loans) Lack of financial incentives for agricultural technologies for low value crops
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.
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.

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.

The barriers identified are similar to those for SPIS. Accordingly, the measures to overcome the barriers for SPIS are also applicable to caterpillar tunnels.

4.2.4 Target for Transfer and Diffusion

As with SPIS, 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.

Table 2: Summary of Action Plan for SPIS and Caterpillar Tunnels

Action/ Measure	*Why Action*	*Responsible Agent*	*Period*	*Cost*	*Sources of Funding*	*Indicator of Success*	*Challenges to success*
Construction of 50 SPIS systems	Rural farmers continue to face challenges for water and utilise fossil fuel diesel pups for irrigation which result in wastage. The project will also serve as a demonstration project for wider deployment.	Ministry of Agriculture and Extension Services for oversight and project coordination	2023-2027	$5,000 SPIS system Total $250,000	GORTT Multilateral and International Financial Institutions including the Green Climate Fund. Bilateral programmatic funding as may be appropriate and available	80% of systems being functional.	Lack of awareness Local suppliers of the technology
Construction of 50 caterpillar tunnels	Increased ambient temperatures, extreme rainfall add to demand for irrigation and protection of crops	Ministry of Agriculture and Extension Services for oversight and project coordination	2023 – 2027	$8,000 per tunnel Total: $400,000	GORTT Multilateral and International Financial Institutions including the Green Climate Fund.	80% of baseline documented systems being functional.	Lack of awareness

5.0 Project Ideas for the Agricultural Sector

5.1 Background

Trinidad and Tobago's vulnerability capacity assessment (VCA)[7] identifies the agricultural and water resource sectors as vulnerable to climate risks and climate change. Climate models project that Trinidad and Tobago is expected to receive less cumulative precipitation over time, while experiencing more intense precipitation episodes. Accordingly, these projections are expected to manifest in less available water for irrigation purposes, as well as potential flooding due to more rainfall in less time. Coupled with increasing ambient temperatures, soil aridity is also expected to increase and therefore increased demand for irrigation water. The two projected impacts means that with less water availability and increased demand, adaptation approaches to address both water management from a supply-side perspective as well as water demand and agricultural and food production sustainability from a demand-side perspective would need to be reconciled and addressed. Additionally, Trinidad and Tobago's first Nationally Determined Contribution (NDC) seeks to achieve a reduction in cumulative greenhouse gas emissions by 15% relative to a business as usual baseline by 2030 in the transportation, power generation and industry sectors. In implementing actions towards this end, synergy across mitigation and adaptation sectors are being explored to be optimized. In this regard, solar powered drip irrigation systems provide opportunities to maximize that synergy.

5.2 Objectives

The objectives of the project is the establishment of solar powered drip irrigation systems at subsistence farmers' sites, that will serve as demonstration projects for the feasibility of these systems in remote farming locations.

5.3 Outputs

The establishment of at least 50 solar powered drip irrigation systems at pre-determined optimally located sites.

5.4 Relationship to Sustainable Development Priorities

Trinidad and Tobago's National Development Plan – VISION 2030[8] - recognizes the role of agriculture in economic diversification away from oil and gas and towards contributing to food security, as the majority of food is imported. This is clearly articulated in Goal 3 which aims to reverse the decline in agricultural production.

5.5 Project Deliverables

In addition to the establishment of at least 50 solar drip irrigation systems, the demonstration value of solar power against the backdrop of Trinidad and Tobago's oil and gas based economy, is expected to serve to heighten public sensitization and acceptance of alternative renewable energy sources, and by extension serve to catalyse solar photo-voltaic systems at the household level as well as agricultural applications. In addition to reducing emissions, and contributing to the country's achievement of its NDC and National Climate Change Policy (NCCP), as well as contributing to mitigating global climate change,

[7] https://www.planning.gov.tt/content/vulnerability-and-capacity-assessment-report-trinidad-and-tobago-jan-2019
[8] https://www.planning.gov.tt/sites/default/files/Vision%202030-%20The%20National%20Development%20Strategy%20of%20Trinidad%20and%20Tobago%202016-2030.pdf

the deployment of solar drip irrigation systems will improve air quality and conserve water by reducing pollution resulting from the use of diesel powered, inefficient water pumps now in use.

5.6 Project Scope

The project will aim to be a pilot/demonstration project at rural farming sites where water availability is a challenge and where inefficient diesel powered water pumps are currently in use.

5.7 Project Activities

In order to achieve these results, the following activities are envisioned:

Outcome 1: Assessment of identified sites

Activity 1.1 Identification of suitable sites

In collaboration with the Ministry of Agriculture and its extension officers, rural farmers that fit pre-determined criteria would be selected for installation of solar powered drip irrigation systems. The size and scale of the systems would also be determined at this stage if necessary. Based on activity 1.1, design the solar drip irrigation systems to suit the identified sites, including climate-resiliency to climate risks, and make suitable recommendations.

Activity 1.3 Develop recommendations for deployment and operations & maintenance

Based on the above activities 1.1 and 1.2, recommendations for installation, operations and maintenance of the systems would be developed. A suitable consultant(s), if identified as warranted, will be recruited for Activities 1.1 – 1.3 and in consultation with relevant stakeholders.

Outcome 2: Installation of solar drip irrigation systems

Activity 2.1 Installation and operation

Installation and operation of the solar drip irrigation systems through relevant and applicable procurement procedures will follow the recommendations from **Outcome 1.** A suitable consultant will be recruited to oversee this Activity and Outcome.

5.8 Timelines

It is expected that once financing is secured, installation can take place over a two year period.

5.9 Budget/Resource Requirements

The estimated cost of the project is 250,000.00 USD, which can be sourced from the national Green Fund or other multilateral funding sources such as the Green Climate Fund (GCF).

5.10 Measurement/Evaluation

Monitoring the execution of the project will involve a team of relevant stakeholders from various ministries including Ministry of Agriculture, Ministry of Energy, Ministry of Public Utilities as well as regulatory divisions/agencies within the government such as the Electrical Inspectorate and the Environmental Management Authority that will form part of the overall project Steering Committee as well as provide technical advice to support the execution of project activities.

5.11 Possible Complications/Challenges

Possible complications/challenges may be the acreage required for solar panels installations to provide sufficient power for the irrigation system depending on determined scale; proximity of available water sources; buy-in from farmers. These are expected to be addressed during the initial set of activities (see above).

12 Responsibility and Coordination

See response under Measurement/Evaluation above.

Annex I. 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)