Government of the Republic of Trinidad and Tobago

THIRD NATIONAL COMMUNICATION

of the Republic of Trinidad and Tobago

TO THE UNITED NATIONS FRAMEWORK CONVENTION ON CLIMATE CHANGE

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MINISTRY OF PLANNING AND DEVELOPMENT

Third National Communication on Climate Change to the United Nations Framework Convention on Climate Change

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FOREWORD

HON. CAMILLE ROBINSON-REGIS

THE REPUBLIC OF TRINIDAD AND TOBAGO as a small island developing state recognises the global climate emergency and the existential threat that it poses. Trinidad and Tobago is already experiencing the adverse impacts of climate change such as sea level rise, increased ambient temperature and extreme weather systems, and is fully aware that climate change has the potential to undermine its priority sustainable development objectives such as poverty eradication, a healthy environment, health care and leaving no one behind. Trinidad and Tobago therefore recognises that climate change is a national development issue and is building climate resiliency in its development planning and developmental paradigm by integrating climate risks into sectoral strategies and action plans, as well as by pursuing a low carbon development pathway, as envisioned in its National Climate Change Policy (NCCP) and VISION 2030 national development plan.

The global climate policy framework provides for each country to play a part in contributing to the global climate problem, and Trinidad and Tobago is taking proactive action. Trinidad and Tobago was among the first set of countries to submit its Nationally Determined Contribution (NDC) under the Paris Agreement and has continued to advance the national climate agenda. In this regard, Trinidad and Tobago has developed a functional monitoring, reporting and verification system for tracking its national greenhouse gas emissions and the achievement of the NDC; an NDC financial investment and implementation plan; and instituted a state-funded compressed natural gas (CNG) fuel switching programme in the transportation sector, which is already yielding greenhouse gas reductions in that sector.

At the domestic policy level, the Government is creating the requisite policy, legislative, administrative and institutional enabling environment as part of its climate action agenda. This includes, inter alia, updating the NCCP to include the provisions of the Paris Agreement; facilitating renewable energy as an increasing part of the energy mix; the development of an e-mobility policy as CNG is a transition fuel and the long-term objective is sustainable transportation; development of a just transition of the workforce policy to address socio-economic challenges that may arise; and development of a legal framework for mandatory reporting of greenhouse gas emissions and mitigation plans.

Trinidad and Tobago therefore continues to play its responsible role in the multilateral policy framework to constructively collaborate with the international community and international partners in order to foster sustainable solutions to climate change.

Hon. Camille Robinson-Regis
Minister of Planning and Development
TRINIDAD AND TOBAGO

TABLE OF CONTENTS

ACRONYMS AND ABBREVIATIONS

ADP	Ad hoc Working Group of the Durban Platform
AECID	Spanish Agency for International Development Cooperation (Agencia Española de Cooperación Internacional para el Desarrollo
AGLA	Ministry of the Attorney General and Legal Affairs (Trinidad and Tobago)
AF	Adaptation Fund
AFD	French Development Agency (Agence Française de Développement)
AFOLU	Agriculture Forestry and Other Land Uses
AR5	Assessment Report (Fifth)
ATTIC	Association of Trinidad and Tobago Insurance Companies
AV	Aviation
AWOS	Automated Weather Observing System
BaU	Business as Usual
BaUC	Business as Usual Conservative
BaUO	Business as Usual Optimistic
BOD	Biological Oxygen Demand
BMZ	Federal Ministry for Economic Cooperation and Development (Bundesministerium für wirtschaftliche Zusammenarbeit und Entwicklung)
CAF	Development Bank of Latin America (Corporación Andina de Fomento)
CARIRI	The Caribbean Industrial Research Institute
CBA	Cost-Benefit Analysis
CBD	Central Business District
CC	Climate Change
CCA	Climate Change Adaptation
CCCCC	Caribbean Community Climate Change Centre
CCS	Carbon Capture and Storage
CDB	Caribbean Development Bank
CDF	CARICOM Development Fund
CEA	Cost-Effectiveness Analysis
CEC	Certificate of Environment Clearance
CH_4	Methane
CIF	Climate Investment Fund
CNC	Caribbean Nitrogen Company (Trinidad and Tobago)
CNG	Compressed Natural Gas
CPU	Coastal Protection Unit

Co_2	Carbon Dioxide
COD	Chemical Oxygen Demand
CO_2e	Equivalent Carbon Dioxide
CoG	Centre of Government
COP	Conference of Parties
CRS	Carbon Reduction Strategy
CRU	Climate Research Unit
CSA	Climate Smart Agriculture
CSO	Central Statistical Unit (Trinidad and Tobago)
DE	Dynamic Equilibrium
DER	Direct Electricity Replacement
DFI	Development Finance Institutions
DMU	Disaster Management Unit
DOC	Degradable Organic Carbon (fraction
DRM	Disaster Risk Management
DSSAT	Decision Support for Agrotechnology Transfer
DTM	Digital Terrain Model
EbA	Ecosystem-based Adaptation
ECCE	Early Childhood Care and Education (Trinidad and Tobago)
ECHAM4	European Centre Hamburg Model, version 4
ECHAM5	European Centre Hamburg Model, version 5
ECIAF	The Eastern Caribbean Institute of Agriculture and Forestry
EIA	Environmental Impact Assessment
EIB	European Investment Bank
EMA	Environmental Management Authority
ENSO	El Niño-Southern Oscillation
EPA	United States Environmental Protection Agency
EPPD	Environmental Policy and Planning Division
EU	European Union
EWS	Early Warning System
FAO	The Food and Agriculture Organization
FOD	First Order Decay
FAOSTAT	The Food and Agriculture Organization of the United Nations Statistics Division
GCF	Green Climate Fund

GCPF	Global Climate Partnership Fund
GDP	Gross Domestic Product
GEF	Global Environmental Facility
GFCS	Global Framework for Climate Services
GHG	Greenhouse Gas
GIS	Geographic Information System
GIZ	German Development Cooperation (Deutsche Gesellschaft fuer Internationale Zusammenarbeit (GIZ) GmbH)
GNI	Gross National Income
Gg	Gigagrams
GoRTT	Government of the Republic of Trinidad and Tobago
GWP	Global Warming Potential
HadCM3	Hadley Centre Coupled Model, version 3
HDI	Human Development Index
HOV	High Occupancy Vehicle
ICT	Information and Communication Technology
ICTZ	Integrated Coastal Zone Management
IDB	Inter-American Development Bank
IE	Included Elsewhere
IFAD	International Fund for Agricultural Development
IFC	The International Finance Corporation
IICA	Institute for Cooperation on Agriculture
IKI	International Climate Initiative (Internationale Klimaschutzinitiative)
IMA	Institute of Marine Affairs
IMF	International Monetary Fund
INSMET	Instituto de Meteorologí́a de Cuba
IPCC	The Intergovernmental Panel on Climate Change
IPP	Independent Power Producer
IPPU	Industrial Processes and Product Use
IRENA	International Renewable Energy Agency
ITCZ	Intertropical Convergence Zone
JICA	Japanese International Cooperation Agency
KMS	Knowledge Management System
KPI	Key Performance Indicator
LARPDU	Local Area Regional Planning & Development Unit (Trinidad and Tobago)

LBS	Land Based Sources
LCDF	Least Developed Countries Fund
LED	Light Emitting Diode
LNG	Liquefied Natural Gas
MALF	Trinidad and Tobago Ministry of Agriculture, Land and Fisheries
MCA	Multi-Criteria Analysis
MCM	Circular Mils
MC	Methane Correction Factor
MCF	Methane Correction Factor
MEA	Multilateral Environmental Agreements
MEAU	Multilateral Environment Agreements Unit (Trinidad and Tobago)
MEEI	Ministry of Energy and Energy Industries (Trinidad and Tobago)
MET	Meteorological Services
MHHW	Mean Higher High Water
MOU	Memorandum of Understanding
MiC	Mitigation Conservative
MiO	Mitigation Optimistic
MPD	Ministry of Planning and Development (Trinidad and Tobago)
MPD/ EPPD	Ministry of Planning and Development, Environmental Planning and Policy Division (Trinidad and Tobago)
MPU	Ministry of Public Utilities (Trinidad and Tobago)
MRV	Monitoring, Report and Verification
MSDaFS	Ministry of Social Development and Family Services
MSW	Municipal Solid Waste
N_2O	Nitrous Oxide
NA	Not available
NAMAs	Nationally Appropriate Mitigation Actions
NAM-DEVCO	The National Agricultural Marketing and Development Corporation
NASA	National Aeronautical and Space Administration
NDC	Nationally Determined Contributions
NE	Not estimated
NO	Not occurring
NGC	The National Gas Company of Trinidad and Tobago Limited
NDC	Nationally Determined Contributions

NGOs	Non-Governmental Organisations
NICFI	Norway's International Climate and Forest
NMS	National Management System
NMVOC	Non-methane Volatile Organic Compounds
NPDP	National Physical Development Plan
NRF	National Response Framework
NO2	Nitrogen Oxides
NPV	Net Present Value
NWRMP	National Integrated Water Resources Management Policy
ODA	Official Development Aid
ODPM	Office of Disaster Preparedness and Management
ODS	Ozone Depleting Substances
OECD	Organization for Economic Co-operation and Development
PAYD	Pay-As-You-Drive
PBB	Polybrominated Biphenyls
PBDE	Polybrominated Diphenyl Ethers
P-E	Potential Evapotranspiration
PG	Power Generation
PMR	Partnership for Market Readiness
PoS	Port of Spain
PPA	Power Purchase Agreement
PSIP	Public Sector Investment Programme
PTSC	Public Transport Service Corporation
QA/QC	**Quality Assurance/ Guilty control**
RA	Reference Approach
RAC	Regional Activity Centres
RCP	Reciprocal Concentration Pathways
RE	Renewable Energies
REED	Reducing Emissions from Deforestation and Forest Degradation
REDER	Renewable Energy and Direct Electricity Replacement
REM	REDD Early Movers
RIC	Regulated Industries Commission (Trinidad and Tobago)
RNG	Renewable Natural Gas
SAP	Strategic Action Plan

SCCF	Special Climate Change Fund
SDG	Sustainable Development Goals
SLR	Sea Level Rise
SPI	Standardised Precipitation Index
SRES	Special Report Emissions Scenario
SST	Sea Surface Temperature
SWDS	Solid Waste Disposal Sites
SWMCOL	Solid Waste Management Company Limited (Trinidad and Tobago)
SWOT	Strengths, Weaknesses, Opportunities, and Threats
T&TEC	Trinidad and Tobago Electricity Commission
TAOS	Total Arbiter of Storms
TCP	Town and Country Planning (Trinidad and Tobago)
TEMA	Tobago Emergency Management Agency
THA	Tobago House of Assembly
TNC	Third National Communication
ToR	Terms of Reference
TT	Trinidad and Tobago
TTBS	Trinidad and Tobago Bureau of Standards
TTD	Trinidad and Tobago Dollars
TTMS	Trinidad and Tobago Meteorological Service
UN	United Nations
UNDP	United Nations Development Programme
UNEP	United Nations Environmental Programme
UNFCC	United Nations Framework Convention on Climate Change
USD	United States Dollar
UTT	The University of Trinidad and Tobago
UWI	The University of the West Indies
V&A	Vulnerability and Adaptation
VCA	Vulnerability and Capacity Assessment
WASA	Water and Sewerage Authority Trinidad and Tobago)
WBG	World Bank Group
WMO	World Meteorological Organisation
WRA	Water Resources Agency (Trinidad and Tobago)

CHEMICAL TERMS

CH_4	Methane
CO_2	Carbon dioxide
CO_2e	Carbon Equivalent
CO_x	Carbon oxide
DOC_f	Fraction of degradable organic carbon (DOC) that can decompose
Gg	Gigagrams
MCF	Methane correction factor
Mt CO_2e	Metric tonnes of carbon dioxide equivalents
N_2O	Nitrous Oxide
HFC	Hydrofluorocarbons
PFCs	Perfluorocarbons
SF_6	Sulfur hexafluoride
NO_2	Nitrogen dioxide

MEASUREMENT UNITS

bcm	Billion cubic metres
BTU	British Thermal Unit
Ceq	Estimated annual carbon input at equilibrium
Gg	Gigagrams
GWh	Gigawatt-hours
MSCF	Thousand Standard Cubic Feet
ha	Hectare
hm	Hectometer
km^2	Square kilometres
kW, kWh	Kilowatt, kilowatt-hour
kV	Kilovolt
l	Litres
m^3	Cubic metre
MIGD	Million imperial gallons of water per day
Mmcf	Million cubic feet
Wp	Watt-peak

GLOSSARY OF KEY TERMS

This glossary defines some specific terms used in climate change science. The definitions are taken from the following resources (unless otherwise specified) which are available online.

1. The IPCC "Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty".
Source: IPCC, 2018: Annex I: Glossary [Matthews, J.B.R. (ed.)]. In: Global Warming of 1.5°C. An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty [Masson-Delmotte, V., P. Zhai, H.-O. Pörtner, D. Roberts, J. Skea, P.R. Shukla, A. Pirani, W. Moufouma-Okia, C. Péan, R. Pidcock, S. Connors, J.B.R. Matthews, Y. Chen, X. Zhou, M.I. Gomis, E. Lonnoy, T. Maycock, M. Tignor, and T. Waterfield (eds.)]. In Press.
Available at: https://www.ipcc.ch/site/assets/uploads/sites/2/2019/02/SR15_AnnexI_Glossary.pdf

2. IPCC "Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change"
Source: IPCC, 2014: Annex II: Glossary [Mach, K.J., S. Planton and C. von Stechow (eds.). In: Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, R.K. Pachauri and L.A. Meyer (eds.). IPCC, Geneva, Switzerland, pp. 117-130.
Available at: https://www.ipcc.ch/site/assets/uploads/2019/01/SYRAR5-Glossary_en.pdf

3. National Oceanic and Atmospheric Administration (NOAA), 2014. Glossary of Hydrologic Terms
Available at: https://www.nws.noaa.gov/om/hod/SHManual/SHMan014_glossary.htm

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Available at: https://www.coris.noaa.gov/glossary/#/

5. American Meteorological Society, 2015. Glossary of Meteorology
Available at: http://glossary.ametsoc.org/wiki/Main_Page

6. U.S. Department of the Interior, Bureau of Reclamation, Reclamation Glossary.
Available at: https://www.usbr.gov/library/glossary/index.html. Accessed, 16 May, 2019

ADAPTATION
In human systems, adaptation is the process of adjustment to actual or expected climate and its effects, in order to moderate harm or exploit beneficial opportunities. In natural systems, it is the process of adjustment to actual climate and its effects; human intervention may facilitate adjustment to expected climate and its effects (IPCC, 2018, p.542)

ADAPTIVE CAPACITY
Adaptive capacity is the ability of systems, institutions, humans and other organisms to adjust to potential damage, to take advantage of opportunities or to respond to consequences. This glossary entry builds from definitions used in previous IPCC reports and the Millennium Ecosystem Assessment (MEA, 2005; IPCC, 2018, p. 542).

ALGAL BLOOM
An algal bloom is a sudden spurt of algal growth that can indicate potentially hazardous changes in local water chemistry (NOAA, 2014a).

ANOMALY
An anomaly is the deviation of temperature, precipitation and other atmospheric variables in a given region over a specified period from the normal value for the same region (NOAA, 2014a).

CALCIFICATION
Calcification is the process by which corals and calcareous algae extract calcium from seawater and produce it as calcium carbonate (NOAA, 2014a).

CLIMATE
Climate in a narrow sense is usually defined as the average weather, or more rigorously, as the statistical description in terms of the mean and variability of relevant quantities over a period of time ranging from months to thousands or millions of years. The classical period for averaging these variables is 30 years, as defined by the World Meteorological Organization. The relevant quantities are most often surface variables such as temperature, precipitation and wind. Climate in a wider sense is the state, including a statistical description, of the climate system (IPCC, 2018, p.544).

CLIMATE CHANGE
Climate change refers to a change in the state of the climate that can be identified (for example, by using statistical tests) by changes in the mean and/or the variability of its properties, and which persists for an extended period, typically decades or longer. Climate change may be due to natural internal processes or external forcings such as modulations of the solar cycles, volcanic eruptions and persistent anthropogenic changes in the composition of the atmosphere or in land use. Note that the United Nations Framework Convention on Climate Change (UNFCCC), in its Article 1, defines climate change as: "a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods." The UNFCCC thus makes a distinction between climate change attributable to human activities altering the atmospheric composition and climate variability attributable to natural causes (IPCC, 2018, p.544).

CLIMATE EXTREME (EXTREME WEATHER OR CLIMATE EVENT)
Climate extreme is the occurrence of a value of a weather or climate variable above (or below) a threshold value near the upper (or lower) ends of the range of observed values of the variable. For simplicity, both extreme weather events and extreme climate events are referred to collectively as 'climate extremes'. See also EXTREME WEATHER EVENT (IPCC, 2018, p.544).

CLIMATE MODEL
A climate model is the numerical representation of the climate system based on the physical, chemical and biological properties of its components, their interactions and feedback processes, and accounting for some of its known properties. The climate system can be represented by models of varying complexity; that is, for any one component or combination of

components a spectrum or hierarchy of models can be identified, differing in such aspects as the number of spatial dimensions, the extent to which physical, chemical or biological processes are explicitly represented, or the level at which empirical parameterizations are involved. There is an evolution towards more complex models with interactive chemistry and biology. Climate models are applied as a research tool to study and simulate the climate and for operational purposes, including monthly, seasonal and interannual climate predictions (IPCC, 2018, p.545).

CLIMATE PROJECTION
A climate projection is the simulated response of the climate system to a scenario of future emission or concentration of greenhouse gases (GHGs) and aerosols, generally derived using climate models. Climate projections are distinguished from climate predictions by their dependence on the emission/concentration/radiative forcing scenario used, which is in turn based on assumptions concerning, for example, future socio-economic and technological developments that may or may not be realised (IPCC, 2018, p.545).

CLIMATE VARIABILITY
Climate variability refers to variations in the mean state and other statistics (such as standard deviations, the occurrence of extremes, etc.) of the climate on all spatial and temporal scales beyond that of individual weather events. Variability may be due to natural internal processes within the climate system (internal variability), or to variations in natural or anthropogenic external forcing (external variability). See also CLIMATE CHANGE (IPCC, 2018, p.546).

CLIMATE VARIABLE (OR CLIMATIC VARIABLE)
A climatic variable is any climate parameter that changes over a period of time; for example, temperature, rainfall, humidity (NOAAa, 2014b).

(COASTAL) UPWELLING
Coastal upwelling is the rising of water from between 200 and 400 metres to the surface along coastlines where an alongshore blowing wind has the coast on its left in the Northern Hemisphere or on its right in the Southern Hemisphere (American Meteorological Society, 2015).

CORAL (OR THERMAL) BLEACHING
Coral bleaching is the process in which a coral polyp, under environmental stress, expels its symbiotic zooxanthellae from its body. The affected coral colony appears whitened (NOAA, 2014a).

DISASTER
Disasters are severe alterations in the normal functioning of a community or a society due to hazardous physical events interacting with vulnerable social conditions, leading to widespread adverse human, material, economic or environmental effects that require immediate emergency response to satisfy critical human needs and that may require external support for recovery (IPCC, 2018, p.547).

DOWNSCALING
Downscaling is a method that derives local to regional-scale (up to 100 km) information from larger scale models or data analyses. Two main methods exist: dynamical downscaling and empirical/statistical downscaling. The dynamical method uses the output of regional climate models, global models with variable spatial resolution, or high-resolution global models. The empirical/statistical methods are based on observations and develop statistical relationships that link the large-scale atmospheric variables with local/regional climate variables. In all cases, the quality of the driving model remains an important limitation on quality of the downscaled information. The two methods can be combined, e.g., applying empirical/statistical downscaling to the output of a regional climate model, consisting of a dynamical downscaling of a global climate model (IPCC, 2018, p.547).

DROUGHT
A drought is a period of abnormally dry weather long enough to cause a serious hydrological imbalance.

Drought is a relative term, therefore any discussion in terms of precipitation deficit must refer to the particular precipitation-related activity that is under discussion. For example, shortage of precipitation during the growing season impinges on crop production or ecosystem function in general (due to soil moisture drought, also termed agricultural drought), and during the runoff and percolation season primarily affects water supplies (hydrological drought). Storage changes in soil moisture and groundwater are also affected by increases in actual evapotranspiration in addition to reductions in precipitation. A period with an abnormal precipitation deficit is defined as a meteorological drought. (See also SOIL MOISTURE.) A megadrought is a very lengthy and pervasive drought, lasting much longer than normal, usually a decade or more (IPCC, 2018, p.547).

EMISSION PATHWAYS

The modelled trajectories of global anthropogenic emissions over the 21st century are termed "emission pathways".

EMISSION SCENARIO

An emission scenario is a plausible representation of the future development of emissions of substances that are radiatively active (for example: greenhouse gases (GHGs), aerosols) based on a coherent and internally consistent set of assumptions about driving forces (such as demographic and socio-economic development, technological change, energy and land use) and their key relationships. Concentration scenarios, derived from emission scenarios, are often used as input for a climate model to compute climate projections (IPCC, 2018, p.548).

EXPOSURE

Exposure refers to the presence of people; livelihoods; species or ecosystems; environmental functions, services, and resources; infrastructure; or economic, social, or cultural assets in places and settings that could be adversely affected (IPCC, 2018, p.549).

EVAPOTRANSPIRATION

Evapotranspiration is the combination of evaporation from free water surfaces and transpiration of water from plant surfaces to the atmosphere (NOAA, 2014b).

EXTREME WEATHER EVENT

An extreme weather event is an event that is rare at a particular place and time of year. Definitions of rare vary, but an extreme weather event would normally be as rare as or rarer than the 10th or 90th percentile of a probability density function estimated from observations. By definition, the characteristics of what is called extreme weather may vary from place to place in an absolute sense. When a pattern of extreme weather persists for some time, such as a season, it may be classed as an extreme climate event, especially if it yields an average or total that is itself extreme (for example, drought or heavy rainfall over a season) (IPCC, 2018, p.549).

HYPOXIA

Hypoxia is a condition that may occur in aquatic environments as the concentration of dissolved oxygen becomes reduced to a level harmful to aquatic organisms. In physiology, hypoxia is the condition where oxygen concentrations are below normal physiological limits in a specific tissue (NOAA, 2014a).

LIQUEFACTION

Liquefaction occurs when a solid form is turned into a liquid form. During an earthquake, low density materials act like water and lose their supporting strength (Bureau of Reclamation, 2019).

LIVELIHOOD

Livelihood refers to the resources used and the activities undertaken in order to live. Livelihoods are usually determined by the entitlements and assets to which people have access. Such assets can be categorised as human, social, natural, physical or financial (IPCC, 2018, p.553).

NEAP TIDE

A neap tide is a tide that occurs when the difference between high and low tide is at its least with the lowest level of high tide. Neap tide comes twice a month, in the first and third quarters of the moon (NOAA, 2014a).

OCEAN ACIDIFICATION

Ocean acidification refers to a reduction in the pH of the ocean over an extended period, typically decades or longer, which is caused primarily by uptake of carbon dioxide (CO2) from the atmosphere, but can also be caused by other chemical additions or subtractions from the ocean. Anthropogenic ocean acidification refers to the component of pH reduction that is caused by human activity (IPCC, 2011, p. 37; IPCC, 2018, p.555).

POTENTIAL EVAPORATION (PE) OR POTENTIAL EVAPOTRANSPIRATION (PET)

Potential evaporation or potential evapotranspiration is the amount of moisture that, if it were available, would be removed from a given land area by evaporation and transpiration (American Meteorology Society, 2015.)

PROJECTION

A projection is a potential future evolution of a quantity or set of quantities, often computed with the aid of a model. Unlike predictions, projections are conditional on assumptions concerning, for example, future socio-economic and technological developments that may or may not be realised (IPCC, 2018, p.556).

QUANTILE CHANGES

Quantile changes are the variation of the ranges of the selected climate variables (temperature and rainfall) over time. The quantile change essentially demonstrates the shifts (in days) of the ranges of the climate variables. For rainfall, for example, it shows the changes in rainfall for the different ranges of rainfall (0-20 mm/day, 20-40mm/day...). This essentially reflects the future (2030 and 2050) variability of rainfall of different frequencies and amounts.

REPRESENTATIVE CONCENTRATION PATHWAYS (RCPS)

Representative Concentration Pathways are scenarios that include time series of emissions and concentrations of the full suite of greenhouse gases (GHGs) and aerosols and chemically active gases, as well as land use/land cover (Moss et al., 2008). The word "representative" signifies that each RCP provides only one of many possible scenarios that would lead to the specific radiative forcing characteristics. The term "pathway" emphasizes the fact that not only the long-term concentration levels but also the trajectory taken over time to reach that outcome are of interest (Moss et al., 2010; IPCC, 2018, p.555-556).

RESILIENCE

Resilience is the capacity of social, economic and environmental systems to cope with a hazardous event or trend or disturbance, responding or reorganizing in ways that maintain their essential function, identity and structure while also maintaining the capacity for adaptation, learning and transformation. This definition builds from the definition used by Arctic Council (2013; IPCC, 2018, p.557).

RISK

Risk is the potential for adverse consequences where something of value is at stake and where the occurrence and degree of an outcome is uncertain. In the context of the assessment of climate impacts, the term risk is often used to refer to the potential for adverse consequences of a climate-related hazard, or of adaptation or mitigation responses to such a hazard on lives and livelihoods; health and well-being; ecosystems and species; economic, social and cultural assets; services (including ecosystem services); and infrastructure. Risk results from the interaction of vulnerability (of the affected system), its exposure over time (to the hazard), as well as the (climate-related) hazard and the likelihood of its occurrence. (IPCC, 2018, p.557).

SCENARIO

Scenario refers to a plausible description of how the future may develop based on a coherent and internally consistent set of assumptions about key driving forces (for example, rate of technological change, prices) and relationships. Note that scenarios are neither predictions nor forecasts, but are used to provide a view of the implications of developments and actions (IPCC, 2018, p.557).

SEA LEVEL CHANGE (SEA LEVEL RISE/SEA LEVEL FALL)

Sea level refers to a change, both globally and locally (relative sea level change) due to (1) a change in ocean volume as a result of a change in the mass of water in the ocean; (2) changes in ocean volume as a result of changes in ocean water density; (3) changes in the shape of the ocean basins and in the Earth's gravitational and rotational fields; and (4) local subsidence or uplift of the land (IPCC, 2018, p.557).

STANDARDISED PRECIPITATION–EVAPOTRANSPIRATION INDEX (SPEI)

The SPEI is a multi-scalar drought index based on climatic data. It can be used for determining the onset, duration and magnitude of drought conditions with respect to normal conditions in a variety of natural and managed systems such as crops, ecosystems, rivers, water resources, etc. (Source: http://spei.csic.es/index.html).

STANDARDISED PRECIPITATION INDEX (SPI)

The Standard Precipitation Index is an index developed by McKee et al (1993) to quantify precipitation deficit at a given location for multiple timescales. Standardised precipitation is the difference of precipitation from the mean for a specified time divided by the standard deviation, where the mean and standard deviation are determined from the climatological record (American Meteorological Society, 2015).

STORM SURGE

Storm surge is the temporary increase, at a particular locality, in the height of the sea due to extreme meteorological conditions (low atmospheric pressure and/or strong winds). The storm surge is defined as being the excess above the level expected from the tidal variation alone at that time and place (IPCC, 2014).

(THERMAL) STRATIFICATION

Thermal stratification is the formation of layers of different temperatures in bodies of water (Bureau of Reclamation, 2019).

VULNERABILITY

Vulnerability is the propensity or predisposition to be adversely affected. Vulnerability encompasses a variety of concepts and elements, including sensitivity or susceptibility to harm and lack of capacity to cope and adapt (IPCC, 2018, p.560).

INDEX OF FIGURES

INDEX OF TABLES

INTRODUCTION

Trinidad and Tobago is pleased to present its Third National Communication to the United Nations Framework Convention on Climate Change (UNFCCC). The report has been prepared in accordance with the UNFCCC Guidelines for the Preparation of National Communications from non-Annex I Parties (decision 17/CP.8) Article 4, paragraph 1 and Article 12, paragraph 1.

EXECUTIVE SUMMARY

Trinidad and Tobago faces the twin challenge of having a relatively high carbon emission profile for a small island developing state, and high vulnerability to the impacts of climate change. Although it produces less than one percent of global greenhouse gas emissions, its emissions per capita is high due to its fossils-based economy which has made it the most industrialised economy of the Caribbean.

Trinidad and Tobago is vulnerable to the impacts of climate change with significant consequences that include, but are not limited to:

- extreme weather events ranging from droughts to more frequent and intense storms;
- reduced precipitation and increased evaporation affecting the water supply as well as the health, agriculture, tourism and other sectors;
- sea level rise and storm surge events with the potential to disrupt the national economy which relies on the energy, industrial and tourism sectors largely concentrated along the coast; damage coastal ecosystems including beaches, mangrove forests, coral reefs and sea grasses; and undermine coastal infrastructure such as ports, harbours, access roads and bridges, resorts, housing settlements and other buildings;
- disruption of the delicate balance of the terrestrial and marine bio-diversity with the attendant threats to eco-systems and the risk of disease;
- more frequent and intense forest fires with the possible destruction of natural attractions, increased flooding and damage to critical infrastructure;
- changes in soil quality with negative consequences for agriculture.

Trinidad and Tobago recognises climate change as a national development issue that requires the integration of climate resiliency into the national development planning process. Its approach to this is guided by the National Climate Change Policy which recognises the need to address the challenge in accordance with the United Nations Framework Convention on Climate Change (UNFCCC). The policy's key objectives include:

- the protection of the natural environment and human health;
- reduction or avoidance of greenhouse gas (GHG) emissions from all emitting sectors;
- increased utilisation of cleaner energy-efficient technologies;
- enhanced agricultural production and food security; and
- the provision of a sustainable supply of potable water.

In 1994 Trinidad and Tobago was among the first countries to sign and ratify the UNFCCC as it joined the global movement to stabilise and reduce atmospheric concentrations of greenhouse gases which threaten its future and that of the planet.

Since presenting its Second National Communication in 2013, Trinidad and Tobago has recorded systematic progress in addressing climate change and implementing the measures necessary for meeting its obligations under the UNFCCC. The required capacity and institutional architecture are being put in place to record, report and devise intervention options for minimising greenhouse gas emissions and verifying reductions.

The country's mitigation efforts are driven by its national Carbon Reduction Strategy which was adopted by the Parliament of Trinidad and Tobago in 2015 and provided the basis for the country's Nationally Determined Contribution (NDC) to the global reduction of GHG emissions.

In 2016, T&T signed the Paris Agreement committing to an overall reduction in cumulative emissions of 15 percent (103 million tonnes) by 2030 from its three major emitting sectors—power generation, transport and industry—and an unconditional reduction in public transportation emissions by 30 percent (1.7 million tonnes) by 2030.

To monitor and track the reduction of greenhouse gas (GHG) emissions, a National GHG Inventory was compiled for the period 2006–2018 and a GHG Mitigation Plan was developed based on emission projections for the period 2018–2050.

In March 2019 Trinidad and Tobago reached a major milestone when it publicly unveiled the Knowledge Management System (KMS), a data management platform for tracking carbon emissions and mitigating impacts, which is the central database of the National Climate Mitigation Monitoring, Reporting and Verification (MRV) System.

An overview of Trinidad and Tobago's national GHG emission levels and the methodology, strategies and institutional framework for the GHG Inventory are outlined in Chapter 2. The information is presented in accordance with the accounting principles of Transparency, Accuracy, Consistency, Completeness and Comparability (TACCC) as stated in article 4.13 of the Paris Agreement.

Chapter 2 also describes in detail Trinidad and Tobago's MRV System for facilitating the collection, analysis and transparent reporting of accurate and reliable information and data on GHG emissions, its efforts to mitigate them and the resources/support being devoted to enabling these efforts. Between November 2019 and January 2020 the MRV System was subjected to rigorous testing in a pilot project. The findings were used for evaluating the system and for further refining and improving it. A GHG Certification Programme was also developed and implemented to ensure that Trinidad and Tobago has access to qualified experts and to support the submission of high-quality data for its international climate change reporting and implementation of domestic policy.

Using the GHG Inventory as baseline data, the project moved to the next stage of building a forecasting model to assess T&T's emissions trend from 2018 to 2050 as the basis for analysing causative factors and developing mitigating actions for the five economic sectors of the GHG Inventory: power generation, industry, transport, waste and wastewater, and AFOLU (agriculture forestry and other land use).

Chapter 3 presents an in-depth analysis of mitigation measures and options based on a study of the emissions portfolio for Trinidad and Tobago which projected potential climate change scenarios for meeting the convention's objectives. A total of 40 existing and planned mitigation measures were identified by the Mitigation Analysis.

Chapter 4 assesses the country's climate risk and vulnerability to the future impact of climate change and sea-level rise on Trinidad and Tobago by 2030 and 2050. The vulnerability assessment is focused on the coastal zones where the bulk of the country's socio-economic and natural features is concentrated.

Based on this analysis, adaptation measures are proposed which seek to reduce the country's climate risk vulnerability in the short, medium and long terms to the projected impact of more extreme temperatures and weather patterns combined with more intense storm surges on coastal and low-lying areas, and coastal erosion.

Other information considered relevant to achieving the objectives of the Convention is presented in Chapter 5 which reports on the progress made by Trinidad and Tobago in meeting its emission targets. It also cites barriers to implementing the recommended mitigation actions while identifying areas of strength and opportunities for surmounting them.

Despite recording steady progress, Trinidad and Tobago's path towards meeting its emissions reduction targets is constrained by data gaps and financial, technical and capacity-building needs. These are outlined in Chapter 6.

A major theme across all chapters is the need for greater public education and awareness of climate change, the impact of carbon emissions and the power of the individual to make a difference through conservation, technological innovation, policy, legislation and investment in change.

To this end, Trinidad and Tobago is focusing on building an alliance of partners involving stakeholders from all sectors, including civil society, industry and government.

1

NATIONAL CIRCUMSTANCES

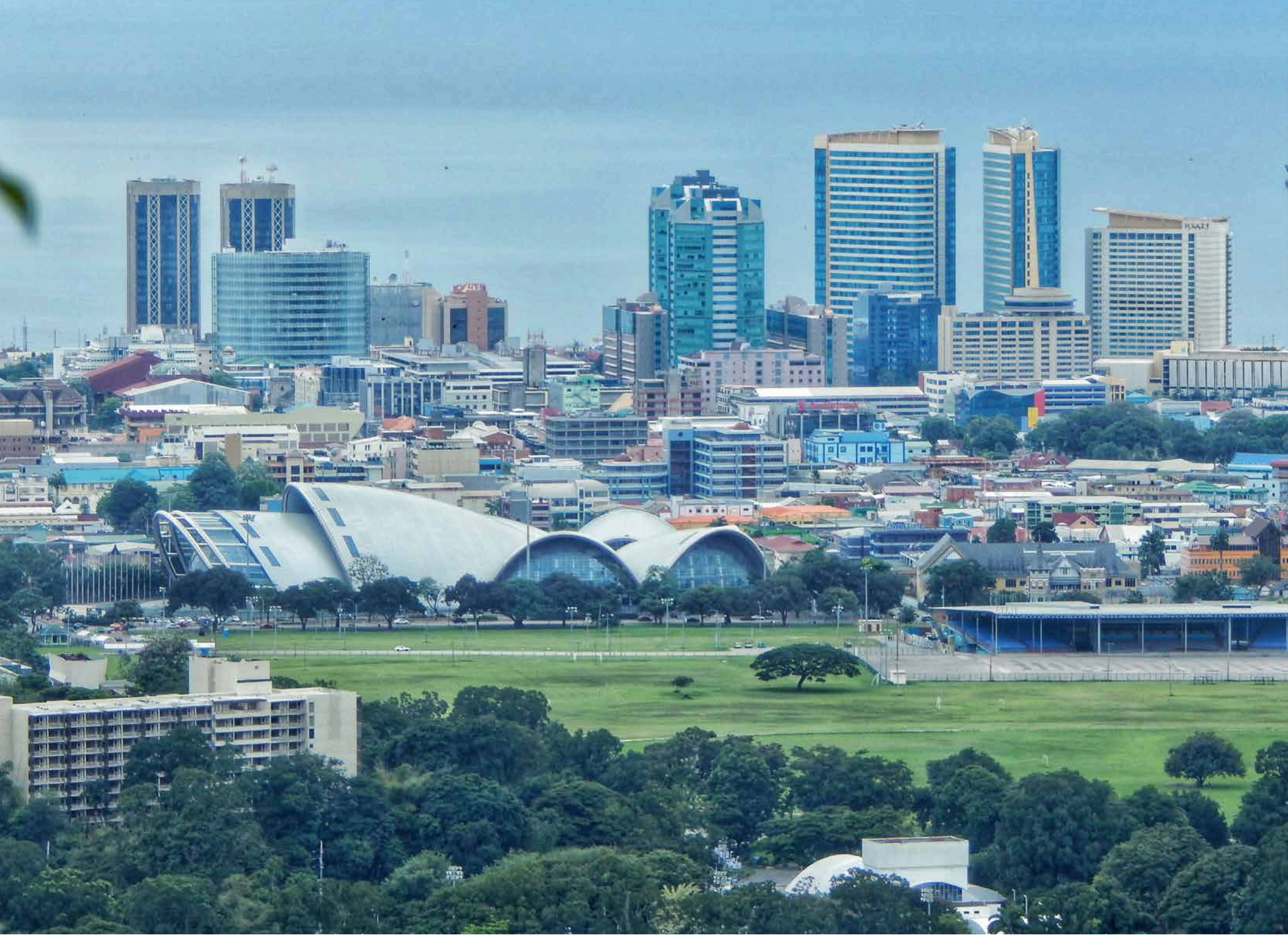


Photo Credit: Nandani Bridglal

▲ View of the Port of Spain cityscape, 2016

1.1 Geographic Profile

Trinidad and Tobago is a country of two islands located at the southernmost end of the Caribbean archipelago. Situated between 10° and 11.5° North Latitude and 60° to 62° West Longitude, it shares maritime borders with Venezuela, Grenada and Barbados. The country's total area is 5,128 km² of which Trinidad accounts for 4,828 km² and Tobago for 300 km².

Their geology indicates that the two islands were once part of the South American mainland. Remnants of this connection survive in the string of small islands off the north western peninsula of Trinidad and in its flora and fauna which are similar to that of Venezuela.

A defining feature of Trinidad is the mountainous Northern Range which runs along the island's northern coastline and rises 940 metres to its highest peak, El Cerro Del Aripo. Beyond the foothills of the Northern Range are the undulating plains of Central Trinidad and a series of rolling hills in the south.

Geologically, Tobago is a continuation of Trinidad's Northern Range with its dominant feature being the Main Ridge, a 29-kilometre spine which runs from southwest to northeast across the island before sloping down to the island's sandy beaches. Its highest point is Pigeon Peak which rises to 550 metres in the air. The Main Ridge Forest Reserve has been legally protected since 1776 and is described as the first act of the modern environmental movement.

The islands have a tropical rainforest ecosystem similar to that of Guyana and Venezuela on the South American mainland.

Both have many natural aquifers and rivers, some of which flow into mangrove coastlines. Natural events have given both islands stunning formations that attract international attraction. Trinidad's La Brea Pitch Lake is the world's largest natural and most significant deposit of asphalt. Estimated at 10 million

FIGURE 1.1 Map of Trinidad and Tobago
Source: Geoatlas, worldometer.info

tons, the Pitch Lake was created during the Pilocene movement as oil ascended from the intersection of two faults deep below the centre of the lake. Tobago's coral reefs, the most famous of which is Buccoo Reef with its abundance of colourful marine life, is the result of the confluence of the Guyana and the North Equatorial currents combined with occasional infusions of nutrient-rich water from the Orinoco River during the rainy season.

Land Use

Approximately 44 percent of Trinidad and Tobago is forested while 10 percent is under agriculture. The remaining 45 percent is occupied by housing, commerce, industry and recreation, among other things.

The islands' unique tropical ecosystems nurture a rich biodiversity around which a thriving eco-tourism sector has developed and supports coastal and other rural communities. As the world's second largest nesting site for leatherback turtles, Trinidad draws turtle-watchers from all over the world to Grand Riviere, Matura and other beaches along its north east coast.

Other eco-tourism activities include mangrove tours in the Caroni and Nariva Swamps; scuba diving at Buccoo Reef, Speyside and other areas in Tobago; bird-watching, wildlife-spotting and sight-seeing tours in Trinidad's Northern Range and Tobago's Main Ridge Forest Reserve. Together, these two forested areas support the largest number of rare plant species globally. The Northern Range is also home to rare species of birds at the Asa Wright Nature Centre, internationally recognised as a birdwatcher's paradise.

While these activities promote biodiversity conservation, the pollution of coastal waters remains a problem, particularly in parts of the Gulf of Paria.[1]

Trinidad and Tobago's ecosystem is interlinked with the livelihood of its people. Forests, inland freshwater systems of streams and rivers, and coastal and marine systems, contribute directly and indirectly to their well-being through the provision of food and other products and by creating a healthy, harmonious and aesthetically enjoyable environment.

A wide range of ecological services are provided by the country's forests which:

- regulate water regimes by intercepting rainfall and controlling its flow through the hydrological system;
- maintain soil quality while providing organic materials through leaf and branch fall;

1 Institute of Marine Affairs, *State of the Marine Environment Report—Trinidad and Tobago* (2016).

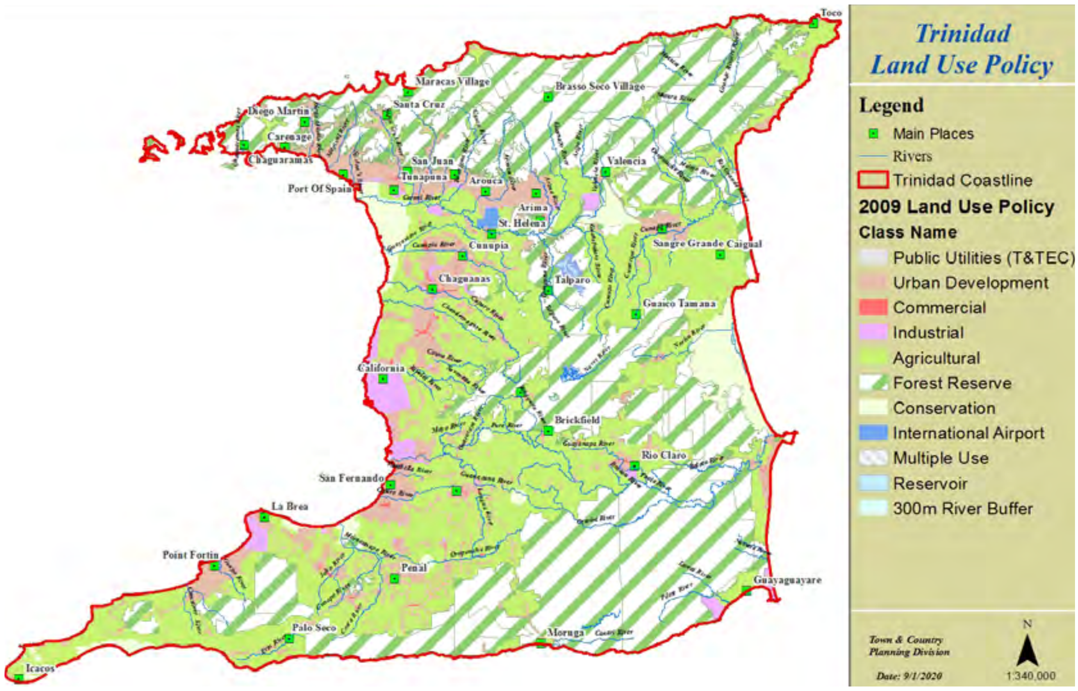


FIGURE 1.2 Trinidad Land Use Policy, 2009 | *Source: Town and Country Planning Division*

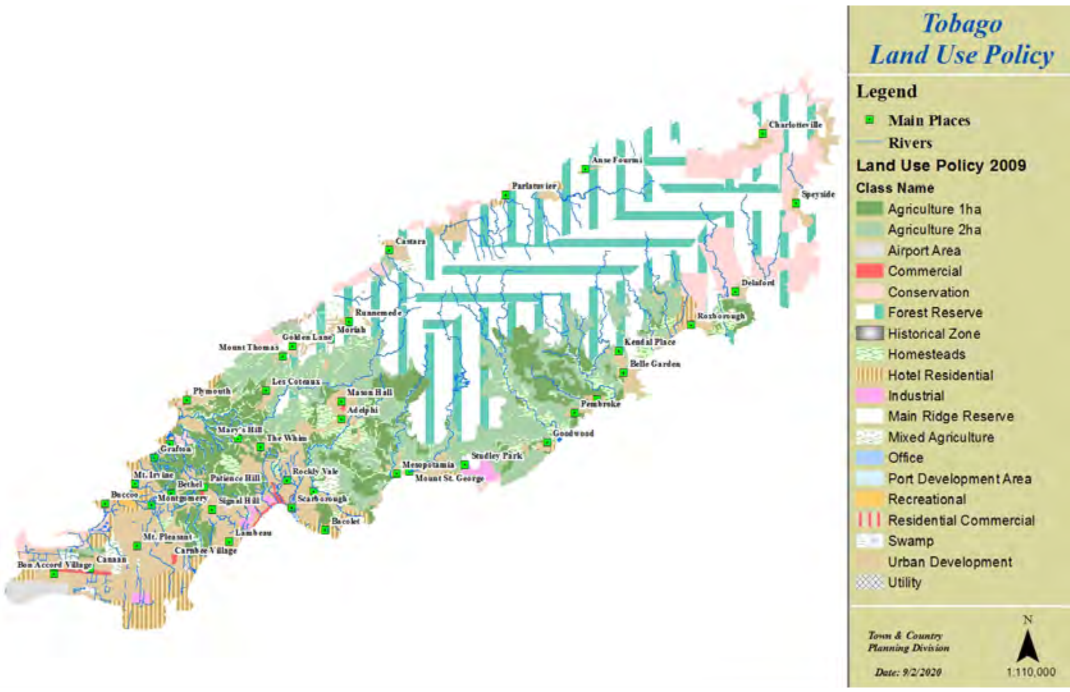


FIGURE 1.3 Tobago Land Use Policy, 2009 | *Source: Town and Country Planning Division*

▲ Tobago's Parlatuvier Bay viewed from above

- limit erosion and protect soil from the direct impact of rainfall;
- modulate climate; and
- serve as key components of biodiversity, both in themselves and as a habitat for other species.

The estimated monetary value (2010) of a number of ecosystem services at the scale of a square hectare of forest per year in Trinidad and Tobago is provided in **TABLE 1.1**.[2]

In Trinidad, 60–80 percent of the surface water comes from the forests of the Northern Range and is used for human consumption and economic activities, particularly in the food, beverage and tobacco industries.

In the country's jurisdictional space which covers surface area, archipelagic waters, territorial sea and exclusive economic zone, the sea is 15 times greater than the land surface area.[3] This area not only accommodates Trinidad's valuable oil and gas sector, which is the largest contributor to GDP, but also includes ecosystems which support other main contributors to GDP such as the commercial fishing industry and the tourism industry of Tobago, in particular. These

TABLE 1.1 Estimated value of ecosystem services from forests in Trinidad, 2010 | *Source: Environmental Management Authority, 2012* ▼

Ecosystem Service	ES value (USD per hectare per year)
Climate regulation	1,088
Erosion control	346
Flood Prevention	5
Water Purification	359
Sustainable timber	397
Total	2,195

2 Environmental Management Authority, *2012 Annual Report* (2012).
3 Institute of Marine Affairs, *State of the Marine Environment Report—Trinidad and Tobago* (2016).

Photo Credit: Tobago House of Assembly

▲ One the largest brain corals in the Western Hemisphere located off Little Tobago, 2018 ecosystems also provide indirect services such as shoreline protection, sediment control and water purification.

Mangroves in Trinidad are adversely impacted by human activities since most are located in the western part of the island where more than 70 percent of the population lives. Similarly, the largest mangrove areas in Tobago are in the southwest which is also the most populated and developed part of the island.[4]

The projections indicate that these important ecosystems will be adversely impacted by climate change. Loss and damage of the mangroves will decrease their effectiveness in shoreline protection while negatively impacting the quality of the marine water.

Coral reefs are an important breeding ground and habitat for a wide variety of commercially exploited seafood species. They provide subsistence and commercial fishing resources and are especially important for lobster and a number of other species. However, coral cover around Tobago has been declining since 1985[5] as a result of unregulated coastal development, polluted run-off and changing watershed and land use.[6] Climate change is also contributing to the loss of hard corals, particularly due to bleaching events.[7] Hard corals in Buccoo, Culloden and Speyside were severely bleached in 1998, 2005 and 2010.

Marine fisheries are an important socio-economic activity for many coastal communities, both as a source of income and for subsistence. In 2006, annual direct estimates were reported to be between 640,000–912,000 USD per year (4.1–5.8 million TTD), based on revenue earned from the sale and processing of harvested fish resources.[8] In addition, annual indirect economic benefits from the repair of equipment associated with fishing activities such as nets, fish pots and boats were estimated at between 118,000 and 235,000 USD (between 755,200 and 1.5 million TTD). Given the challenges of data collection in Tobago the actual income is believed to be even higher.[9] Recreational fishery also exists but little is known about this activity due to the dearth of data.[10]

1.2 Climate Profile

Trinidad and Tobago's climate is largely influenced by its island characteristics, proximity to the equator, prevailing northeast trade winds, the surrounding ocean and the mountain chains that modify the weather systems as they traverse the country. All of these factors contribute to a mixture of tropical climate types with two distinct climatic seasons referred to as the dry and wet seasons. Localised differences in these seasons across the two islands are primarily due to land-size, orography, elevation and orientation.

The country's two distinct climatic seasons can be characterised as follows[11]:

- *Dry season*, with characteristics of a *Tropical Maritime* climate, occurs from January to May and is cooler with warm days and cool nights with mostly localised rainfall of relatively low amounts in the form of showers which are influenced by the islands' proximity to the sea and daytime convection.
- *Wet season*, with characteristics of a *Modified Moist Equatorial* climate, occurs from June to December and is warmer with more hot, humid days and nights, relatively low wind speeds and increased rainfall, which often causes flooding. Rainfall during this period is highly variable in space and time and is characterised by a bimodal pattern due to equatorial and tropical weather systems such as the Intertropical

4 Ibid.
5 Ibid.
6 Ibid.
7 Ibid.
8 World Resources Institute, *Coastal Capital: Economic Valuation of Coral Reefs in Tobago and St. Lucia* (2008). www.wri.org/publication/coastal-capital-economic-valuation-coral-reefs-tobago-and-st-lucia.
9 Ibid.
10 Institute of Marine Affairs, *State of the Marine Environment Report—Trinidad and Tobago* (2016).
11 Trinidad and Tobago Meteorological Service. www.metoffice.gov.tt.

Convergence Zone (ITCZ), tropical waves and tropical cyclones among others. Subsumed within the wet season is the North Atlantic Hurricane season, during which the country is occasionally threatened or impacted by tropical cyclones.

Trinidad and Tobago's climate has a high variability from one year to the next. Both seasons are also variable and prone to extremes of droughts, dry spells, hot days, hot spells, bushfires, intense rainfall and floods. These extremes can significantly impact communities, infrastructure, the economy and the natural environment. This annual and seasonal climate variability is influenced by changes in large-scale atmospheric circulations such as the El Niño–Southern Oscillation (ENSO), the Atlantic Intertropical Convergence Zone, the Madden Julian Oscillation, the North Atlantic Oscillation (NAO), and the North Atlantic High Pressure System, among others, which can lead to extreme weather and climate events.

Temperature Distribution

Across both islands, temperatures are generally constant with relatively small annual and seasonal variations. Trinidad and Tobago has an average temperature of about 27.4 °C, with an average maximum temperature of 31.7 °C and an average minimum temperature of 22.5 °C. On average, the month of September is the warmest month of the year with an average maximum temperature of 32.6 °C, followed by April with an average of 32.5 °C. The heat season, March to October, during which maximum temperatures often exceed 33 °C, has great influence on the country's cooling needs, which impact energy use. For example, Piarco, where the country's reference climate station is located, experiences on average annually 547 cooling degree-days (when daily mean temperature is greater than 26° C).[12]

Trinidad and Tobago's climate is experiencing ongoing and consistent warming trends, as shown in **FIGURE 1.4**. The average annual temperature has warmed by about 2.1 °C over the period 1946 to 2019, at a rate of 0.28 °C per decade. This is approximately two and a half times the global average. The year 2019 was about 1.1 °C above the long-term 1961–1990 levels and since 1993, annual temperatures have averaged 0.5 °C to 2.1 °C higher than the 1961–1990 average. Slightly stronger trends are observed during the wet season than the dry season. Notably, seven of the last ten years ranked among the twelve warmest years. In Trinidad and Tobago, record warm years have usually corresponded with moderate to strong El Niño events. Consequently, 2010 is the warmest year on record followed by 2016 and 2015, all of which were El Niño years.

The decade of 2010 to 2019 was warmer than any previous decade and has been 1.4 °C warmer than

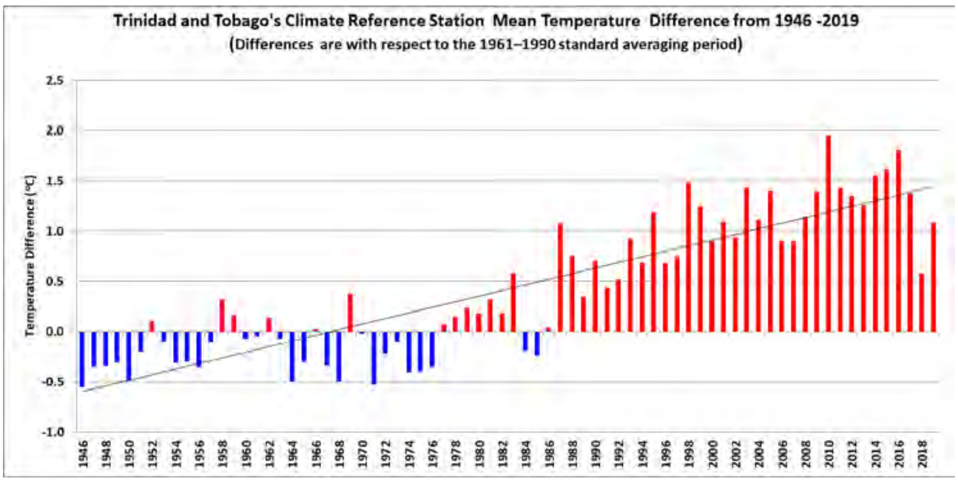


FIGURE 1.4 Trinidad and Tobago climate reference station surface temperature anomalies, 1946–2019. Anomalies are with respect to the 1961–1990 standard averaging period | *Source: Trinidad and Tobago Meteorological Service, 2020*

12 Trinidad and Tobago Meteorological Service. www.metoffice.gov.tt.

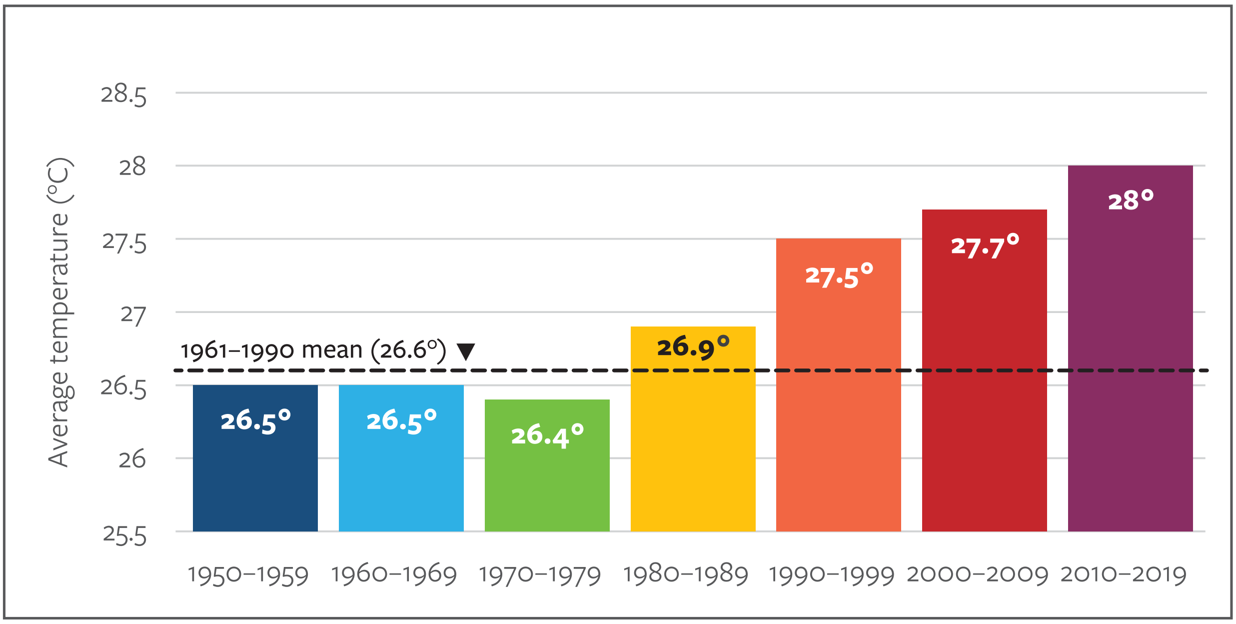


FIGURE 1.5 Decadal Surface Temperature Changes 1950–2019 (70 years)
Data source: Trinidad and Tobago Meteorological Service, 2019

the 1961–1990 average (**FIGURE 1.5**). An increase in very hot days (maximum temperature > 33.9 °C) and warm nights (minimum temperature > 24.9 °C) has also been observed.

Precipitation Distribution

Due to the small variation in temperatures, Trinidad and Tobago's climate is best described by its rainfall pattern. Annual rainfall differs considerably, both spatially and temporally across the two islands. The northeastern and eastern areas are usually the wettest year-round, while the western and southwestern areas are the driest. Some areas in the northeast average as much as 2,000 to 3,000 millimetres (mm) of rainfall a year in contrast to parts of the much drier western region which record as little as 1,300 mm a year (**FIGURE 1.6**). The wet season accounts for 75–80 percent of the annual rainfall. Averaged over the country, the total rainfall in the dry season is 412 mm while the wet season is 1,586 mm, giving an annual total of 1,998 mm.

Due to the high variability, rainfall trends across the country are less obvious and more difficult to assess than temperature trends. However, within recent years Trinidad and Tobago has become drier. Since 1946, total annual rainfall at the country's climate reference station at Piarco has decreased slightly, but the decrease has been more pronounced over the last 38 years from 1982–2019.

The June–July–August (JJA) season is typically the wettest period for the country and produces the highest rainfall maxima in the bimodal rainfall pattern. However, shifts in seasonal rainfall have been observed. Since 1946, JJA rainfall has decreased with JJA of the last decade (2010–2019) experiencing 11 percent less rainfall than that of the JJA for the period

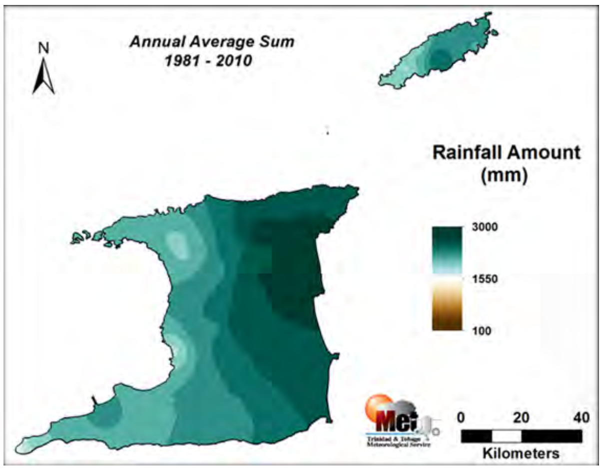


FIGURE 1.6 Trinidad and Tobago's average annual rainfall 30-year climatology (1981–2010) | *Source: Trinidad and Tobago Meteorological Service* ▲

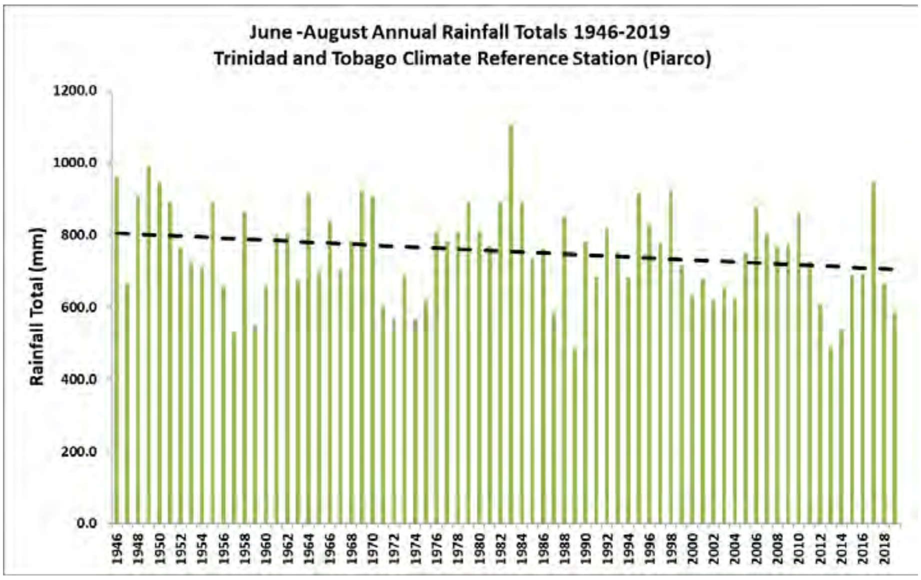


FIGURE 1.7 Seasonal rainfall totals for June to August (JJA), 1946–2019, at Trinidad and Tobago Climate Reference Station (Piarco) | *Source: Trinidad and Tobago Meteorological Service, 2019*

1961–1990 period (**FIGURE 1.7**). This contrasts with the monthly rainfall totals for October at Piarco which have increased since 1946 (**FIGURE 1.8**) and is statistically significant.[13]

Heavy rainfall over a day or less can cause localised flooding and damage to infrastructure, while moderate to heavy multi-day rainfall events can produce widespread flooding over large portions of the country. Observed trends in extreme rainfall have high spatial variability across the country but consistent changes have been found in some of the extreme rainfall indices at the country's climate reference station at Piarco.

The annual 3-day maximum rainfall totals at the climate reference station at Piarco show a significant increasing trend over the period 1960–2018 (**FIGURE 1.9**). Similarly, the figures show that the top one percent of heaviest rainfall events at the station have contributed more rainfall to the annual totals over the same period.

Based on available station data, there appear to be spatially detectable trends in Annual 1-day and Annual 3-day maximum rainfall events across the country for the period 1981–2016 although the direction of the trends is not consistent spatially. Some stations

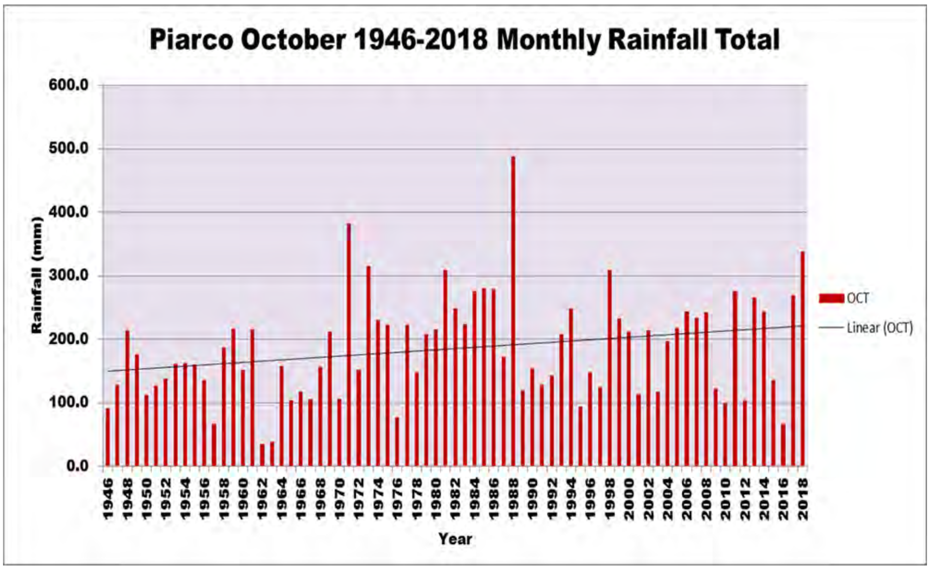


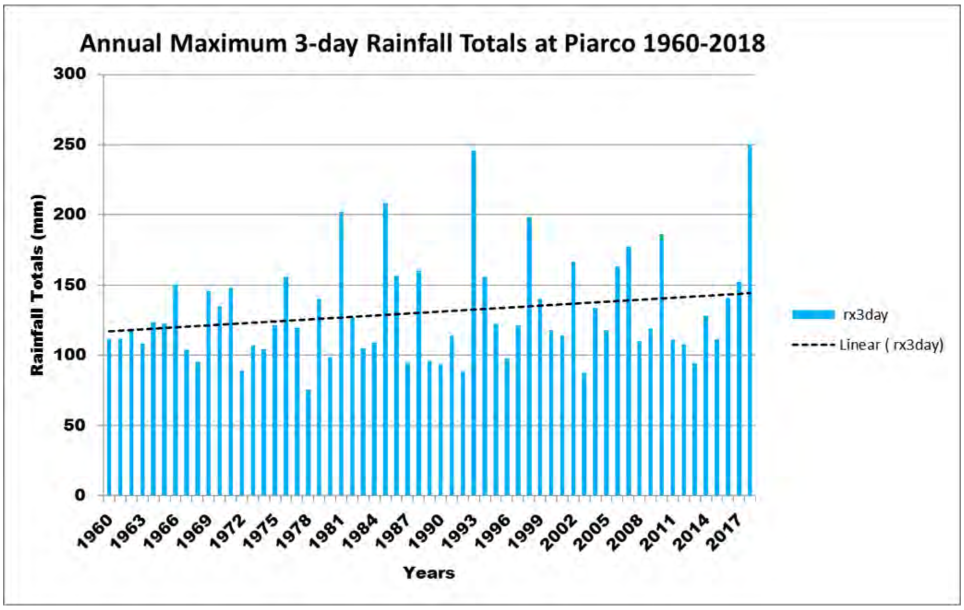
FIGURE 1.8 Monthly rainfall totals for October at Piarco, Trinidad for the period October 1946–2018 | *Source: Trinidad and Tobago Meteorological Service, 2019*

13 Trinidad and Tobago Meteorological Service. www.metoffice.gov.tt.

Photo Credit: Ministry of Planning and Development

▲ Nelson Island Heritage Site, Down de Islands, off the coast of Trinidad, 2018

FIGURE 1.9 Annual maximum 3-day rainfall totals at Piarco, Trinidad for the period 1960–2018 | *Source: Trinidad and Tobago Meteorological Service, 2019*



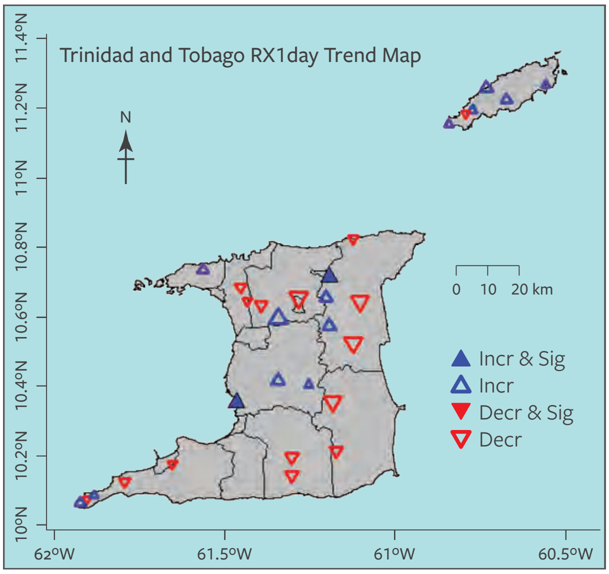


FIGURE 1.10 ▲ **Annual maximum 1-day rainfall totals at Piarco, Trinidad for the period 1960–2018.** Triangles are scaled according to the magnitude of the trend. Solid blue triangles correspond to an increasing trend that is significant at the 5 percent level and unfilled blue triangles correspond to an increasing trend that is not significant. Solid red triangles correspond to a decreasing trend that is significant at the 5 percent level and unfilled red triangles correspond to a decreasing trend that is not significant. *Source: Trinidad and Tobago Meteorological Service*

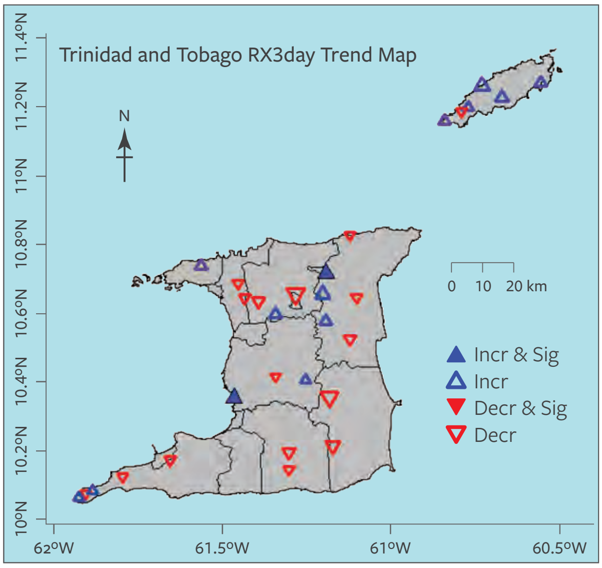


FIGURE 1.11 ▲ **Annual maximum 3-day rainfall totals at Piarco, Trinidad for the period 1960–2018.** Triangles are scaled according to the magnitude of the trend. Solid blue triangles correspond to an increasing trend that is significant at the 5 percent level and unfilled blue triangles correspond to an increasing trend that is not significant. Solid red triangles correspond to a decreasing trend that is significant at the 5 percent level and unfilled red triangles correspond to a decreasing trend that is not significant. *Source: Trinidad and Tobago Meteorological Service*

(about 50 percent) show trends towards higher totals in both indices while other stations show trends towards lower totals. However, the number of stations with significant trends is limited to only two (**FIGURE 1.10** and **FIGURE 1.11**).

1.3 Population Profile

Trinidad and Tobago has an estimated population of 1,363,985[14], which places it at 159 on the world's population ranking. The 2019 population density is 272 people per square kilometre. About 96 percent of the population lives in Trinidad and is concentrated on the western half of the island, while the remaining four percent lives in Tobago, mostly on the southern half of the island. Most of Trinidad's population, 52.4 percent, is urban with an estimated 544,000 persons living in the capital city of Port of Spain and adjacent areas.[15]

Population censuses are conducted in Trinidad and Tobago every 10 years by the Central Statistical Office (CSO). The 2019 Census quantified the estimated population at 1.36 million with a gender breakdown of 50.2 percent (681,946) male and 49.8 percent (677,247) female as shown in **FIGURE 1.12**. The birth rate stood at 11.77 per 1,000 women and the death rate at 8.26 per 1,000 persons. The crude natural growth rate is estimated at 4.09 with a very minimal population change of 0.4 percent.

Population

Over the past decade, there has been an increasing number of immigrants moving to Trinidad and Tobago. **FIGURE 1.13** shows places of settlement by migrants.

According to the Human Development Index (HDI), Trinidad and Tobago's score is 0.799, setting the country in the high human development category with a rank of 63 out of 189 countries. Over the last two

14 Government of the Republic of Trinidad and Tobago, *Review of the Economy 2019* (2019).
15 Trinidad and Tobago's Central Statistical Office. https://cso.gov.tt.

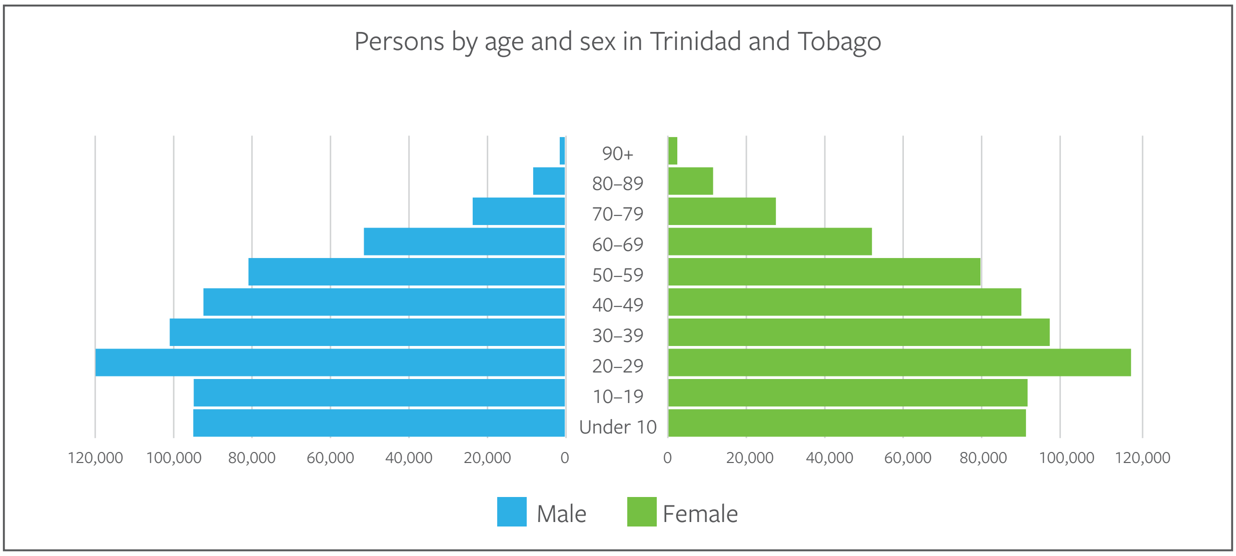


FIGURE 1.12 Break-down of the male/female population distribution taken from the 2011 Census
Data source: http://cso.gov.tt/census/2011-census-data/

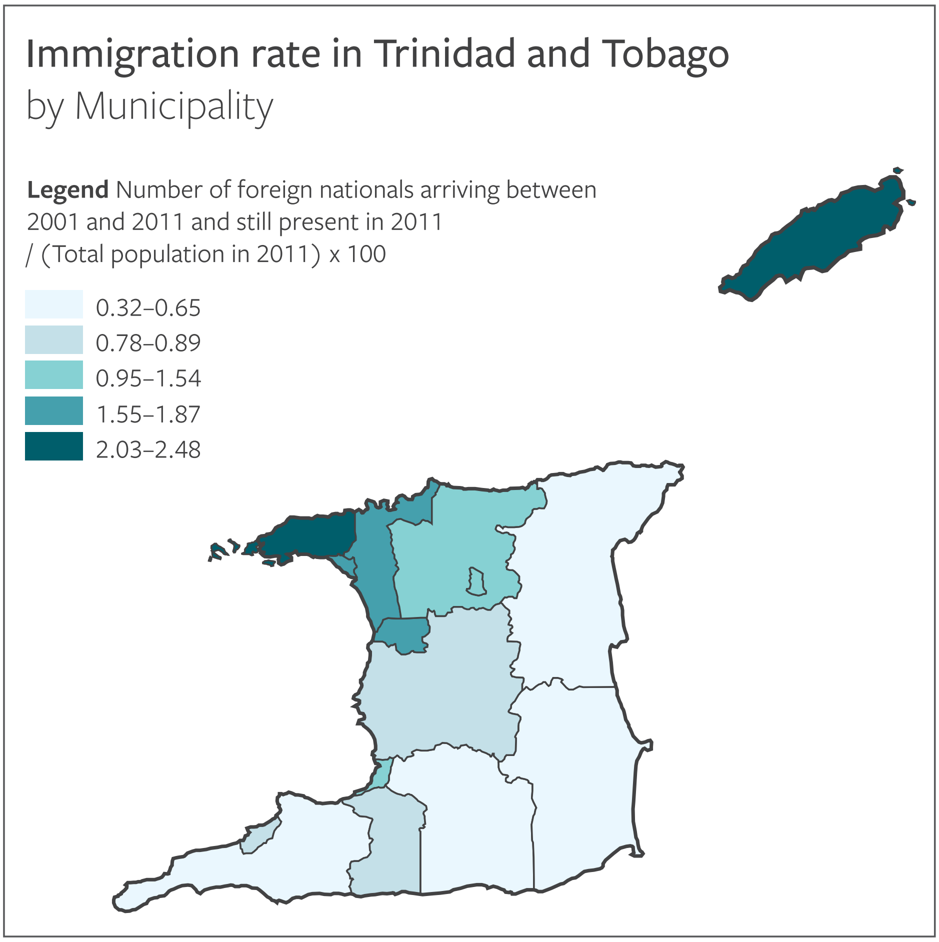


FIGURE 1.13 Map of Trinidad and Tobago showing migration settlement densities
Data source: http://cso.gov.tt/census/2011-census-data/

TABLE 1.2 Population, Labour Force and Employment (Mid-year) | *Source: Review of the Economy, 2019*

	2013* P	2014* P	2015*P	2016*P	2017*P	2018*P	2019*P
Total Population	**1,340,557**	**1,345,343**	**1,349,667**	**1,353,895**	**1,356,633**	**1,359,193**	**1,363,985**
% change	0.4	0.4	0.3	0.3	0.2	0.2	0.4
Total Male	**672,596**	**674,997**	**677,166**	**679,288**	**680,661**	**681,946**	**684,350**
% change	0.4	0.4	0.3	0.3	0.2	0.2	0.4
Total Female	**667,961**	**670,346**	**672,501**	**674,607**	**675,972**	**677,247**	**679,635**
% change	0.4	0.4	0.3	0.3	0.2	0.2	0.4
Dependency Ratio[1] (%)	42	42	42	42	42	42	42
Non Institutional Pop. 15 yrs and over	1,059,600	1,063,400	1,065,100	1,068,500	1,071,300	1,073,300†	-
Labour Force**	650,200	658,600	645,300	638,300	633,900	630,200†	-
Persons Employed	626,300	636,900	623,300	613,100	603,400	606,100†	-
Persons Unemployed	23,900	21,800	22,000	25,300	30,500	24,100†	-
Participation Rate[2] (%)	61.4	61.9	60.6	59.7	59.2	58.7†	-
Unemployment Rate (%)	3.7	3.3	3.4	4	4.8	3.8†	-
Births per 1,000 persons	13.98	13.7	14	12.83	12.82	12.67	11.77
Deaths per 1,000 persons	7.74	7.91	8.58	8.23	8.59	8.58	8.26
Crude Natural Growth Rate per 1000	6.24	5.79	5.42	4.6	4.23	4.09	3.51

Source: Central Statistical Office

1 The dependency ratio is the ratio of dependents (i.e. persons under 15 years of age or 65 years and over) to the total working age population (15 to 64 years).

2 The participation rate is the portion of the non-institutional population, aged 15 years and over, that is part of (participates in) the labour force.

* Figures based on 2011 census.

** Figures based on CSSP estimates.

† For the period January to June 2018.

p Provisional

decades, there has been progress in the country's HDI indicators, with life expectancy at birth currently being 73.4 years; mean years of schooling and expected years of schooling of 11.0 and 13.0 years respectively; and the increment on Gross National Income (GNI) per capita having increased by 183.3 percent to US$28,497.[16]

TABLE 1.2 and **TABLE 1.3** reveal the population, labour force and employment for the period 2013–2019.

1.4 Economic Profile

Due to the COVID-19 pandemic, global growth in 2020 is estimated to have contracted by 3.5 percent, with an expected recovery of 5.5 percent in 2021 with the assumption of vaccine-powered strengthening of economic activity and continued policy support from large economies. Forecasts for growth in Latin America and the Caribbean point to a 4.1 percent recovery in 2021, following the deep contraction of 7.4 percent in 2020.[17]

Economic statistics in Trinidad and Tobago are published by the Central Statistical Office (CSO), complemented by data provided by the Ministry of Finance. The CSO is the official source of national statistics and has continued to revise its methodology for calculating GDP based on the 2012 constant prices model. The adjustments are shown in **TABLE 1.4**, provided by the CSO.

16 United Nations Development Programme, *Human Development Report 2019, Inequalities in Human Development in the 21st Century, Trinidad and Tobago* (2019).

17 International Monetary Fund, *World Economic Outlook Update, January 2021* (2021).

TABLE 1.3 Mid-year Estimates of Population by Age | *Source: Review of the Economy, 2019*

	2012p	2013p	2014p	2015p	2016p	2017p	2018p	2019p
Total Population[1]	1,335,194	1,340,557	1,345,343	1,349,667	1,353,895	1,356,633	1,359,193	1,363,985
Non-Institutional Population[2]								
All Ages								
Under 15	274,892	275,996	276,982	277,872	278,742	279,306	279,833	280,820
15–19	98,911	99,308	99,662	99,983	100,296	100,499	100,688	101,043
20–24	114,857	115,319	115,730	116,102	116,466	116,701	116,922	117,334
25–29	124,185	124,684	125,129	125,531	125,925	126,179	126,417	126,863
30–34	106,150	106,577	106,957	107,301	107,637	107,855	108,058	108,439
35–39	93,039	93,413	93,746	94,047	94,342	94,533	94,711	95,045
40–44	86,629	86,976	87,287	87,568	87,842	88,020	88,186	88,497
45–49	96,633	97,021	97,368	97,681	97,987	98,185	98,370	98,717
50–54	87,655	88,007	88,321	88,605	88,883	89,062	89,231	89,545
55–59	73,611	73,906	74,170	74,408	74,642	74,793	74,934	75,198
60–64	58,964	59,201	59,412	59,603	59,790	59,911	60,024	60,235
65 and over	119,668	120,149	120,578	120,965	121,344	121,590	121,819	122,248

Source: Central Statistical Office. Figures for 2012–2019 are based on 2011 census. p = provisional.
1 Refers to all persons whose usual residence is Trinidad and Tobago, inclusive of: Household or Non-institutionalised population usually resident in the country and who were present on Census Night; Household or Non-institutionalised population usually resident in the country who were abroad for less than 6 months on Census Night; Population in institutions and Workers camps, Street Dwellers; and Trinidad and Tobago students studying abroad.
2 Comprises households found in private dwellings.

The economy of the country is based mainly on its industrial activities. The oil and gas sector account for the largest portion of GDP, contributing about 40 percent of GDP. Trinidad and Tobago is the most industrialised economy in the English-speaking Caribbean and ranks among the highest GDP per capita in Latin America and the Caribbean with a GDP of approximately 23.25 billion USD and a per capita GDP of 17,012.6 USD in 2019.[18]

TABLE 1.4 Revision of GDP by the Central Statistical Office (CSO) | *Source: Review of the Economy, 2019, p. 33*

	2013	2014	2015	2016	2017	2018
Original GDP, Current Prices (TT$ Mn)	174,660.6	176,109.0	160,210.0	145,026.7	150,847.0	158,504.5
Revised GDP, Current Prices (TT$ Mn)	175,679.9	176,992.7	159,836.1	148,617.2	152,368.1	161,200.2
Original GDP Growth Rate (%)	5.4	0.8	−9.0	−9.5	4.0	5.1
Revised GDP Growth Rate (%)	6.1	0.7	−9.7	−7	2.5	5.8
Original GDP, Constant Prices (TT$ Mn)	169,010.2	167,371.3	170,347.0	159,258.7	156,301.6	159,223.6
Revised GDP, Constant Prices (TT$ Mn)	169,339.6	167,794.3	170,853.5	160,095.8	156,394.2	156,010.7
Original GDP Growth Rate (%)	2.0	−1.0	1.8	−6.5	−1.9	1.9
Revised GDP Growth Rate (%)	2.2	−0.9	1.8	−6.3	−2.3	−0.2

18 Data sourced from the Central Statistical Office and converted to USD by the Central Bank of Trinidad and Tobago.

TABLE 1.5 Imports and exports in TTD for period 2011–2020 | *Source: Ministry of Trade and Industry and Central Statistical Office* ▼

Year	Imports (TTD)	Exports (TTD)
2011	60,723,317,991	95,633,877,722
2012	74,563,286,350	82,711,135,376
2013	81,021,477,713	120,226,778,093
2014	72,024,591,281	93,057,839,644
2015	58,883,269,421	68,542,183,455
2016	53,697,650,711	50,906,732,120
2017	46,776,390,065	59,256,064,408
2018	52,203,238,048	71,297,242,705
2019 (provisional)	42,730,974,360	48,575,730,272
2020 (Jan–Nov)	32,835,798,543	37,168,226,793

Other contributors to the country's economy include the food and beverage industry, manufacturing, cement production and downstream energy industries such as Liquefied Natural Gas (LNG), ammonia, methanol and steel.. Although accounting for a small portion of the economy, agriculture also has a place.

Imports and exports also reflect the changes to the economy as seen in **TABLE 1.5**, which shows the total imports and exports for the period 2011–2020. The figures for 2020 cover the 11-month period from January–November.

Gross Domestic Product[19]

In 2020, nominal GDP is forecasted to fall to 147,757.2 million TTD, down from 2019's nominal GDP at Purchaser Prices of 156,756.0 million TTD. Having commenced the production of quarterly GDP in 2019, the CSO reported that real GDP during the first half of 2020 contracted by 5.9 percent. Real GDP in the first quarter of 2020 declined by 1.9 percent. However, as more restrictive measures were put in place to minimise the spread of coronavirus at the end of March 2020, real economic activity fell by 10.0 percent in the second quarter of the year. Over the first three quarters of 2020, labour productivity across all industries registered a (year-on-year) increase of 3.9 percent. Meanwhile, latest available data point to an increase in the unemployment rate to 4.2 percent during the first half of 2019, up from the country's 2018 average unemployment rate of 3.9 percent.

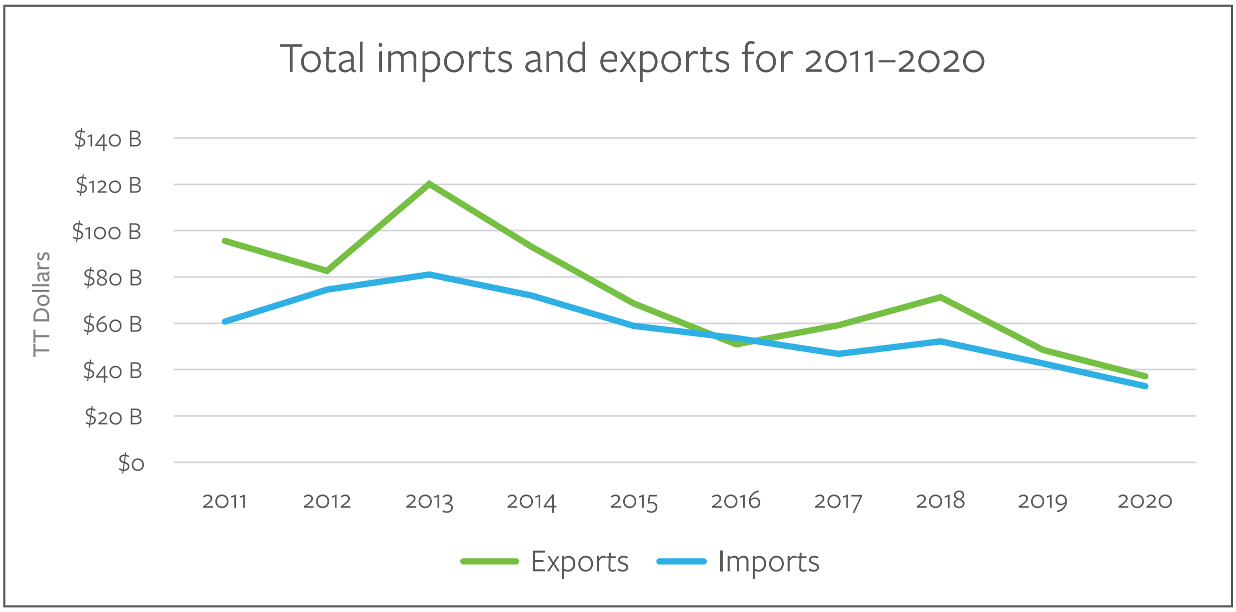


FIGURE 1.14 Total imports and exports for 2011–2020 | *Data source: Central Statistical Office*

19 Excerpts from Government of the Republic Trinidad and Tobago, *Review of the Economy 2020* (2020).

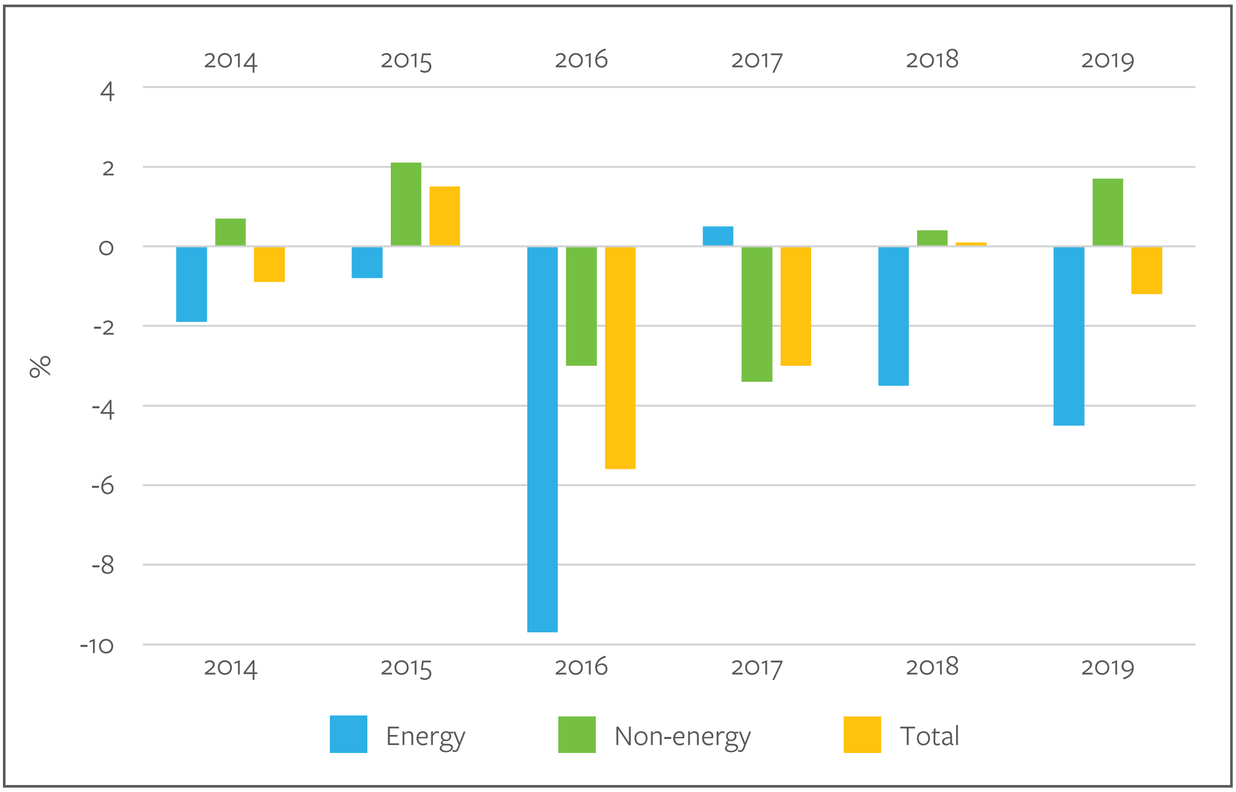


FIGURE 1.15 Real GDP growth rates for the period 2014–2019 | *Data source: Central Statistical Office*

In 2020, like most other countries, the COVID-19 pandemic resulted in Trinidad and Tobago's economy being deeply impacted by the sharp decrease in major energy commodity prices and the precipitous fall in global demand, which significantly reduced export opportunities for manufactured goods and energy products. Moreover, tourism was gravely impacted as Trinidad and Tobago closed its borders.

Notwithstanding the effects of the pandemic, Manufacturing and Mining and Quarrying had the greatest impact on the out-turn for real GDP during the first two quarters of calendar 2020. The Manufacturing sector contracted by 1.5 percent and 5.8 percent in the first and second quarters of 2020, respectively. Mining and Quarrying contracted by 5.1 percent in the first quarter of 2020, followed by a deeper contraction of 8.9 percent in the second quarter. The sector's performance was mainly driven by overall decreases in real economic output in the following sub-industries during the first half of the year: Crude Oil Exploration and Extraction; Condensate Extraction; Natural Gas Exploration and Extraction; and Petroleum Support Services.

Also contributing to the negative economic performance over the January to June 2020 period was a 2.6 percent fall in real output in Trade and Repairs in the first quarter, which further deteriorated by 23.7 percent in the following quarter.

The closure of international borders, including the borders of Trinidad and Tobago in the first quarter of 2020, coupled with restrictions to inter- and intra-island travel, devastated the domestic tourism sector. The Transport and Storage sector recorded a 6.6 percent fall in real economic activity in the first quarter and contracted by 35.9 percent in the second quarter—the single largest contraction of any such sector for the year. Similarly, Accommodation and Food Services contracted by 4.2 percent over the first quarter and by a further 20.3 percent over the second quarter. This reflected a reduction in restaurant and accommodation services due to the restrictions placed on the opening and operations of restaurants, hotels and guest houses during the period.

Real output in Electricity and Gas also fell by 2.9 percent and 9.8 percent in the first and second

TABLE 1.6 Selected macro-economic indicators, Trinidad and Tobago 2011–2020
Extracted from Economic Bulletin March 2016 Volume XVIII Vol. 1, Central Bank of Trinidad and Tobago and Economic Bulletin January 2021 Volume XXIII Vol. 1, Central Bank of Trinidad and Tobago

Indicator	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020[p]
Real GDP Growth (%)	–0.3	1.3	2.2	–0.9	1.5	–5.6	–3	0.1	–1.2	n.a.
Energy Sector	–3.9	–2.8	1.6	–1.9	–0.8	–9.7	0.5	–3.5	-4.5	n.a.
Non-energy sector	3.2	2.3	3.1	0.7	2.1	–3	–3.4	0.4	1.7	n.a.
Inflation (%, end of period)	5.3	7.2	5.6	8.5	1.5	3.1	1.3	1.1	0.4	0.8
Unemployment (% of labour force)	4.9	5	3.7	3.3	3.4	4	4.8	3.9	4.2[1]	n.a.
Central government fiscal balance (% GDP)	–0.7	–1.3	–2.9	–2.5	–1.7	–5.3	–9	–3.6	–2.6[r]	–11.2[re]
External current account balance (% GDP)	7	14.9	20.3	15	8.2	–3.5	6.3	6.8	4.6	2.3^
Public sector debt (% GDP)	31.2	39.4	38.2	40.2	47.1	58.3	61.8	60.4	65.5	80.9
Net Official Reserves (US$M) (net of HSF)	9,822.7	9,370.7	10,175.9	11,497.1	9,933.0	9,465.8	8,369.8	7,575.0	6,929.0	6,953.8

1 For the first half of 2019
^ For the period January to September 2020
p Provisional
r Revised
re Revised Estimates
n.a. Not Available

quarters of 2020, respectively. This reflected an overall reduction in the distribution of natural gas during the period due to the temporary cessation of operations at some petrochemical plants as a result of COVID-19 restrictions and the global slump in economic activity.

Construction activity, however, grew by 7.1 percent in the first quarter of 2020, due to major ongoing capital projects. Subsequently, real output in the sector fell by 7.0 percent in the second quarter on account of a temporary halt in construction activity due to the COVID-19 pandemic.

Notwithstanding this, Financial and Insurance Activities grew robustly in the first and second quarters, expanding by 5.1 percent and 6.0 percent, respectively. This was on account of increases in commercial banking activity, primarily in the areas of credit and deposits. Non-Bank Financial Institutions also recorded growth during the first half of the year.

Trade

In recent years, Trinidad and Tobago, along with the rest of the CARICOM Region, has devoted considerable human and financial resources to negotiating trade agreements involving numerous countries and regions. The aim of these has been to remove barriers to trade to allow goods to move more freely among the parties concerned. Currently, Trinidad and Tobago is a party to nine multilateral, regional and bilateral trade agreements.

By and large, efforts to build its trade capacity were facilitated by buoyant revenues received from

TABLE 1.7 List of trade agreements | *Source: Ministry of Trade and Industry*

Name of Trade Agreement	Type/Date signed	Countries involved
CARIBCAN[1]	Bilateral: 28th November 1986	Commonwealth Caribbean and Canada
Agreement Between CARICOM and the Government of the Republic of Venezuela on Trade and Investment	Bilateral: 13th October 1992	CARICOM and Venezuela
Agreement on Trade, Economic and Technical Cooperation between CARICOM and the Government of the Republic of Colombia	Bilateral: July 24, 1994	CARICOM and Colombia
World Trade Organization[2]	Multilateral: 1st January 1995	CARICOM and WTO members
CARICOM–Dominican Republic Free Trade Agreement	Bilateral: 22nd August 1998	Caribbean and USA
United States–Caribbean Basin Trade Partnership Act (CBTPA)	Bilateral: 1st October 2020	Caribbean and USA
Caribbean Basin Economic Recovery Act (CBERA)	January 1984	Caribbean and USA
Trade and Economic Co-operation Agreement between CARICOM and the Government of the Republic of Cuba	Bilateral: 5th July 2000	CARICOM and Cuba
CARICOM–Costa Rica Free Trade Agreement	Bilateral: 9th March 2004	CARICOM and Costa Rica
CARIFORUM–EU Economic Partnership Agreement	Regional: 30th October 2008	CARIFORUM and EU
Partial Scope Trade Agreement between Trinidad and Tobago and Panama	Bilateral: 3rd October 2013	Trinidad and Tobago and Panama

1 Non-reciprocal trading arrangement.
2 On 1 January, 1995 the WTO replaced the General Agreement on Tariffs and Trade (GATT) as the organization overseeing the multilateral trading system. Trinidad and Tobago had been a member of GATT since 23 October 1962

its lucrative energy sector. In 2013/2014, the country's exports of oil, natural gas and petrochemicals contributed 58 percent to government revenue. However, in September 2014, Trinidad and Tobago experienced an exogenous shock to its economy when oil prices fell dramatically. Due to the ongoing volatility of energy prices in the international markets, Mid-Year Revised projections for fiscal 2015 were predicated on an average oil price of 45 USD per barrel of crude compared to the earlier 80 USD per barrel projection in the 2015 budget statement.

Trade Agreements

During Fiscal 2019, Trinidad and Tobago signed on to, and ratified, both new and existing agreements. Some of the key agreements are identified below. This is in keeping with its mandate to pursue an agenda of negotiating new and existing free trade agreements to support development of the country's export-competitive structure.

» CARIFORUM-UK Economic Partnership Agreement: Trinidad and Tobago, as part of the Caribbean Forum of African, Caribbean and Pacific

States (CARIFORUM) negotiated and signed an Economic Partnership Agreement (EPA) with the United Kingdom (UK). The Agreement was signed by His Excellency Orville London, Trinidad and Tobago's High Commissioner to the United Kingdom, on April 1, 2019. The CARIFORUM-UK EPA is a roll-over agreement of the CARIFORUM-European Union (EU) EPA and aims to preserve the Region's preferential trading relationship with the UK in the event of the UK's departure from the European Union.

» WTO Agreement on Trade Facilitation: Trinidad and Tobago, through its National Trade Facilitation Committee (NTFC) has been working towards implementing the World Trade Organization (WTO) Agreement on Trade Facilitation (TFA). The benefits of implementing the TFA include greater transparency in import and export procedures and the reduction of bureaucratic processes and procedures at the nation's ports, thereby contributing to greater efficiency and improved export competitiveness.

The national implementation of the TFA is also being pursued under the Inter-American Development Bank-funded programme for Strengthening of the Single Electronic Window for Trade and Business Facilitation under the Ministry of Trade and Industry (MTI). In particular, the following projects assist with meeting Trinidad and Tobago's commitments under the TFA:

- Consultancy for Business Process Re-engineering to assist with achieving common border procedures and uniform documentation requirements
- Development of a trade information portal to assist with meeting transparency obligations
- Implementation of an electronic funds transfer framework
- An integrated risk management for customs control
- Legislation to give effect to the TFA in Trinidad and Tobago

» TT-Panama Partial Scope Trade Agreement (PSTA): In Fiscal 2018, the Cabinet approved a five-year National Implementation Plan for the Agreement (October 2018–September 2022) which sets out, among other things, to establish Agreement Coordinators to serve as contact points for communication; set up the Joint Administration Commission to oversee all matters covered by the Agreement; implement tariff reductions; and conduct stakeholder awareness sessions on the opportunities and requirements under the Agreement. In Fiscal 2019, both Trinidad and Tobago and Panama identified their Agreement Coordinators and are working to convene the First Meeting of the Joint Administration Commission under the Agreement.

1.5 Energy

Trinidad and Tobago is highly dependent on its fossil fuels for electricity generation. Its natural gas reserves are estimated at 664 billion cubic metres from which 99 percent of the country's electricity is generated. The industrial sector heavily utilises natural gas as a feedstock and for heat and, in the transportation sector, for fuel as Compressed Natural Gas (CNG) and Liquified Natural Gas (LNG). As a result of the abundance of these resources, there is minimal uptake of renewable energy sources throughout the country.

At present, the Trinidad and Tobago Electricity Commission (T&TEC) remains the sole entity responsible for the transmission, distribution and maintenance of electricity throughout the country which has an electrification rate of 99.8 percent.

T&TEC was vertically integrated until 1994 when its electricity generation assets were divested into Powergen with T&TEC as the majority shareholder. Today, electricity generation is divided among T&TEC and other Independent Power Producers (IPPs) as shown in **TABLE 1.8**. A 33kV cable supplies electricity from Trinidad to Tobago, although Tobago has enough generation capacity to cover its load demand.

T&TEC serves approximately 492,000 customers, broadly divided into residential, commercial and industrial classes. The total customer base has seen consistent growth of approximately 1.5 percent annually for the past three years based on T&TEC's actual

TABLE 1.8 Overview of Power Producers | *Based on information from Trinidad and Tobago Electricity Commission (T&TEC) and validation from Ministry of Public Utilities (MPU)*

Owner	**Location**	**Installed Capacity (MW)**
T&TEC	Cove Eco-Industrial and Business Park, Lowlands, Tobago	84
Powergen	Pt. Lisas	824 (862)
	Penal	210 (236)
Trinity Power Ltd.	Pt. Lisas	225
Trinidad Generation Unlimited (TGU)	La Brea	720
TOTAL		**2101 (2137)**

figures.[20] According to *T&TEC's Annual Performance Indicator Report for the Year 2017* as published by the Regulated Industries Commission (RIC), the per capita energy usage (6,516) is consonant with comparable GDP per capita countries and attributable to its high level of industrialisation and very low electricity rates. However, 2018 and 2019 saw consecutive declines in energy consumption. **TABLE 1.9** gives a breakdown of how the energy purchased by T&TEC is utilised.

The industrial sector is responsible for just over 50 percent of the country's electricity consumption, followed by the domestic sector with 31 percent. A further look into the industrial sector reveals that most of the load is utilised by a small number of large industrial entities. Further, the bulk of the industrial load may be carried by a few very large industries. It should be noted that the increase in new electricity customers has not resulted in a commensurate increase in kWh consumption.

Despite an increase of 6,116 new customers in 2019, electricity consumption fell by approximately 400 million kWh. Most of the decline, 89.2 percent, occurred in the residential sector where electricity consumption declined by 357 million kWh despite the fact that the majority of new customers, 5,784, were residential. Following upon the decrease of 211 million kWh in 2018, this decline indicated a downward trend in residential energy consumption. The reduction is attributable to a significant number of residential customers being in receipt of a 25 percent rebate on electricity bills below 300 TTD. Between 2018 and 2019 the number of these customers increased by 2,000. Electricity consumption among commercial and industrial customers also decreased by 30 million kWh due to the closure of Arcelor Mittal's steel plant in Point Lisas. The downward trend in electricity consumption is expected to continue as a result of energy conservation measures coupled with more

TABLE 1.9 Electrical Energy Usage
Based on information from MPU ▼

Energy use	**Number of Customers**	**Approximate % of Load**
Residential	433,627	30.9
Commercial	54,349	10.3
Industrial	4028	50.6
Street Lighting, pole use and unmetered	102	1.9
Losses	-	6.3
TOTAL	**492,106**	**100**

20 Trinidad and Tobago Electricity Commission, *Monthly Corporate Performance Report, December 31, 2019* (2019).

Photo Credit: Trinidad and Tobago Electricity Commission (T&TEC)

▲ Implementation of Grid tied Solar installation at T&TEC, Mt Hope, Trinidad. 10PV panels were installed, 2012

efficient energy practices.[21] **TABLE 1.10** outlines the electrical power sold yearly for the period 2016–2019.

The delaying factor in implementing renewable energy generation, which is central to GHG mitigation, has been the preferential cost of natural gas for electricity production. Trinidad and Tobago's domestic electricity rates, for example, are 5–10 times less than those of other CARICOM countries.[22] However, it is a barrier that can be overcome as the country's depleting natural gas reserves drive the implementation of renewable energy generation. Further, as the price of solar energy levelises with the country's electricity tariffs, renewable-sourced power generation will become much closer to reality.

TABLE 1.10 Electrical power sold for 2016–2019
Source: Ministry of Public Utilities, 2019 ▼

Year	kWh sold	Year	kWh sold
2016	8,669,111,737	**2018**	8,463,412,741
2017	8,564,536,980	**2019**	8,401,569,265

In 2017 the RIC began consultations for a rate re-evaluation for T&TEC. However, since then, there has been no definitive move to implement actual increases. Historically, the imposition of increases in utility rates is linked with the risk of negative political fall-out for the government overseeing such an increase. However the similarly politicised issue of fuel subsidies in the transportation sector has been gradually reduced and removed. Low electricity rates

21 Based on information from T&TEC, with validation from the Ministry of Public Utilities
22 Regulated Industries Commission, *T&TEC Annual Performance Indicator Report* (2018).

TABLE 1.11 Renewable Energy Past Initiatives in Trinidad and Tobago
Source: Framework for Development of a Renewable Energy Policy for Trinidad and Tobago

Year	Project	Location	Agencies	Comments
1994/1995	Experimental 10kW Wind turbine	Bacolet, Tobago	T&TEC	Revealed some favourable results but project was short-lived.
2004	Demonstration Solar PV	Chickland, Freeport, Cumaca Village, Valencia and Paria, Blanchisseuse	T&TEC	Off-grid PV systems shown to be quite competitive for small loads and performed satisfactorily
2006–2008	Pilot Solar Water Heating Project	10 host-homes at various locations in Trinidad and Tobago	MEEI, BPTT, THA & TDC with the UNDP as Project Manager	Represented the first real attempt to deepen inter-agency cooperation in facilitating a local RE project
Ongoing	Research activity particularly solar & wave	N/A	UWI & UTT	

not only harm the adoption of renewable energy (RE) technologies but also keep the utility in a perpetual state of debt, adversely affecting its operations and inhibiting grid modernisation. Despite this, there has been a general recognition by the Government of the Republic of Trinidad and Tobago (GoRTT) and the utility that RE integration is inevitable. Plans for sizeable pilot RE installations have been developed through the Ministry of Energy and Energy Industries in collaboration with Ministry of Public Utilities and other relevant stakeholders.

Renewable Energy

In its National Development Strategy (2016) the Government committed to the addition of 10 percent of renewable energy to the national power supply by 2021. The creation of an enabling environment to facilitate the inclusion of renewable energy is being developed with the implementation of several projects already underway.

Some of the past achievements as it relates to the renewable energy sector are listed in **TABLE 1.11**.

The Government has instituted several incentive-based initiatives to achieve greater energy efficiency through the use of renewable energy, as summarised in **TABLE 1.12**.

In July 2012, the GoRTT entered into a policy-based loan agreement with the Inter-American Development Bank (IDB) with respect to the development of a Sustainable Energy Framework. The framework consisted of three main components:

1. Preparing the Sustainable Energy Programme by identifying a regulatory framework to promote the use of Renewable Energy (RE), Energy Efficiency (EE) and carbon reduction

TABLE 1.12 Government's Incentives for Renewable Energy | *Source: Ministry of Finance*

Solar	Wind	Energy Efficiency (EE)
25% Tax Credit on Solar Water Heaters (SWH)	0% VAT on Wind Turbines	150% allowance for the design and installation of energy-saving systems by an Energy Service Company (ESCO)
150% Wear & Tear Allowance for SWH: SWH plant, machinery and equipment, and Solar PV Systems	150% Wear & Tear Allowance for Wind Turbines and supporting equipment	ESCO can write off value of assets in two years: a) 75% depreciation on plant, machinery and equipment acquisition b) 25% Wear & Tear Allowance in following year.
Conditional Duty Exemptions for SWH Manufacturers		
0% VAT on SWH & Solar PV Systems		

2. Provision of technical assistance to the GORTT in the area of EE
3. Development of a comprehensive action plan for implementing recommended interventions; exploration of alternatives for renewable energy funding with a special focus on Tobago; and specific studies to point the way forward for future investment in green energy in the country

This activity was completed in 2014 and has guided the direction of future RE and EE studies and programmes.

In May 2013, the then Ministry of Energy and Energy Affairs (MEEA) collaborated with the United States Department of Energy (USDOE) on the establishment of a Regional Renewable Energy Research Center. The major focus was placed on capacity-building, policy, and regulation. A Memorandum of Understanding (MoU) between the MEEA and USDOE to effect this development was signed by the parties. In July 2015, the Caribbean Centre for Renewable Energy and Energy Efficiency was established in Barbados as the implementation hub for sustainable energy activities and projects within the Caribbean region.

It was envisioned that the Centre would work closely with the ECOWAS Centre for Renewable Energy and Energy Efficiency (ECREEE) and the Pacific Centre for Renewable Energy and Energy Efficiency (PCREEE) on common sustainable energy issues and solutions for Small Island Development States (SIDS). The Centres are part of a wider Global Network of Regional Sustainable Energy Centres which was created in collaboration with regional organisations and communities. After receiving the required number of ratifications, the legal agreement establishing the CCREEE went into force on May 19, 2018.

The United Nations Environment Programme (UNEP) has collaborated with the Ministry of Energy and Energy Affairs to undertake a Feed-In Tariff (FIT) study and develop a toolkit suited to the needs of Trinidad and Tobago. This toolkit is comprised of policy design options, a law drafters' guide, and recommendations on the financing of FITs and capacity-building. The initiative aims at building domestic capacity and providing technical assistance to the Ministry in developing a nationally appropriate FIT framework (policy and regulatory), as part of the national priorities on renewable energy. A Feed-In Tariff Policy is currently being developed through an Inter-Agency Committee.

In 2017, the Ministry of Energy and Energy Industries also received technical support from the European Union via its Technical Assistance Facility for the Sustainable Energy for All Initiative. A sustainable Roadmap and Implementation Plan 2021/2030 was prepared for Trinidad and Tobago.

Finally, in March 2018 the GoRTT sought to find companies willing to invest in Renewable Energy by placing a call for expressions of interests for both utility-scale renewable energy projects greater than 3 MW and Waste-to-Energy Projects. A request for proposals for a utility-scale project on a build, own, operate basis was issued in 2019. Proposals were received and evaluated by an Inter-Agency Committee. In 2020 the GoRTT announced that Lightsource BP and Shell had emerged as the successful bidder to build, own and operate solar plants to add 112.5 MW to the electricity grid. Negotiations are underway to finalise the project agreements before the start of construction. Further, an indicative target of 30% RE by 2030 was announced in the *Public Sector Investment Programme 2021* document (Ministry of Planning and Development [MPD], 2020b). The GoRTT is also pursuing the installation of Electric Vehicle (EV) Solar Chargers at the Queen's Park Savannah (QPS) which are part of a larger project which includes the construction of a Carport with Solar PV at the Grand Stand of the QPS.

1.6 Transportation

Transportation in Trinidad and Tobago is organised into three categories—Sea, Land and Air.

Sea

Transportation via sea occurs through many ports across the islands of Trinidad and Tobago. The 'Sea Bridge' is the sea-based route between them for domestic, commercial and industrial supplies and services. This service is provided by four main vessels:

1. T&T Spirit, commissioned in 2007, accommodates 865 persons and 180 vehicles.
2. MV Cabo Star, acquired in 2017, serves as the main cargo and vehicle transport for domestic and commercial use and accommodates 130 persons and 300 vehicles.
3. MV Galleons Passage, commissioned in 2018, accommodates 400 persons and 60 cars.
4. The APT James, commissioned in January 2021, accommodates 926 passengers and 250 vehicles.

The sea bridge operates daily with some restrictions on cargo transport between the Port of Port of Spain in Trinidad and the Port of Scarborough in Tobago.

The port at Port of Spain is the country's largest port installation, serving the needs of passengers between the islands and domestic and international cargo transportation. Two passenger ferries operate daily from Port of Spain to Scarborough under the aegis of the Trinidad and Tobago Ferry Service. Additionally, a Water Taxi Service operates between Trinidad's two main cities of San Fernando and Port of Spain. The Port of Scarborough in Tobago serves as a terminal for cruise ships which are important for the island's tourism economy.

The country also has other important ports for oil transportation, such as the ports at Brighton, Chaguaramas, Pointe-a-Pierre and Point Fortin. The Port of Brighton is important for oil and asphalt loading. There are also oil terminals at Chaguaramas, Pointe-a-Pierre and Point Fortin. Port of Point Lisas is a deepwater port that principally accommodates the energy-based industries at the Point Lisas Industrial Estate. Port Point Lisas opens to the Gulf of Paria along the western coast of Central Trinidad, 32 km south of Port of Spain and 20 km east of Venezuela. It is referred to as the "Gateways to the Americas", catering for containerised cargo from around the world. It has six berths and its services include import/export of containers; breakbulk cargo; transshipment; and provision of stevedoring services. This port also handles large volumes of steel and project cargo, mainly for new plants on the adjacent estate, making it one of the top breakbulk ports in the Caribbean.[23]

The main public entity in charge of sea transport is the Maritime Services Division of the Ministry of Works and Transport. Its objectives are to ensure the safety and security of Trinidad and Tobago's ships worldwide and shipping in Trinidad and Tobago waters; to ensure the control and prevention of vessel source pollution in Trinidad and Tobago waters; and to facilitate the growth of the national maritime sector through the necessary regulatory, advisory, administrative and developmental frameworks.

Land

In general, the country's public road transport system is based on subsidy policies which fall short of the population's demand. Consequently, the road transport sector consists mainly of private vehicles with a car to people ratio of almost 1:1. Among the demand push factors responsible for the high volume of vehicles were the decommissioning of the rail system during the mid-1960s followed by the national windfall from high oil prices consequent to the oil embargo initiated by the Organization of Petroleum Exporting Countries (OPEC) in 1974.

To address the traffic congestion caused by the number of vehicles on the nation's highways the National Renewable Energy Committee has recommended the introduction of a more comprehensive and reliable mass transit system inclusive of a rapid rail network whose many benefits would include the reduction of GHG emissions.[24]

The increase in the demand for other communication routes has led to intensive development of a highway network that connects east and west as well as north and south communities in both islands. However, traffic congestion has become a persistent feature of the transportation system because the volume of vehicles outstrips road capacity. Other

23 Point Lisas Industrial Port Development Corporation, *PLIPDECO Annual Report 2012* (2012).
24 Ministry of Energy and Energy Affairs, *Downstream Gas Industry Annual Report 2012* (2012).

Photo Credit: Mr. Wilfred Watson for the Public Transport Service Corporation (PTSC)

▲ PTSC Bus at Stollmeyer's Castle, 2012

impediments are the poor state of secondary roads, low connectivity and access management.

The Highways Division of the Ministry of Works and Transport (MOWT) is responsible for major roads and highways. It provides physical infrastructure necessary for the safe and efficient movement of people, goods and services on land. The Division undertakes the planning, design, construction, preservation, maintenance and repairs of national bridges and road network, and is responsible for 2,156 kilometres of the 9,592 kilometres or 21 percent of roads throughout Trinidad. It also has responsibility for 1,200 bridges and 2,500 culverts in the road network under its purview.

Air

Trinidad and Tobago has two airports. The main airport is the Piarco International Airport which is located at Piarco in Trinidad, approximately 26 km

from the capital of Port of Spain. A secondary airport, the A.N.R. Robinson International Airport, is located at Crown Point in Tobago. The national airline is state-owned Caribbean Airlines Limited which replaced British West Indian Airways in 2007. Caribbean Airlines operates domestic, regional and international flights.

Public Transport Service Corporation (PTSC)

The PTSC is a Statutory Corporation charged with the responsibility of operating omnibus services throughout Trinidad and Tobago. In October 2010, the PTSC's operational core fleet consisted of 336 buses of 21 different bus types from 10 different manufacturers.

The Corporation has an unpublished schedule which requires 255 buses operating on 107 routes throughout Trinidad and Tobago. However, on a typical day, approximately 185 buses are available for service. This represents a demand shortfall of about 30 percent with resulting delays and long waiting times for peak period passengers. Moreover, the schedule assumes that on any given day 25 percent of the operational fleet will not be available for scheduled services. PTSC estimates its daily ridership at 75,000 passengers utilising 1,143 round trips per day.[25]

Additionally, the PTSC, acting on behalf of the Ministry of Education, contracts 363 maxi-taxis which provide charter services to students attending schools in rural areas. Some 32,000 students utilise this service per day.

The Corporation's fare box and ancillary income amount to 40 percent of its annual operating income of 238.7 million TTD (2009) with the remaining 60 percent coming from government loans of 140.8 million TTD. This yields an average subsidy per passenger of 5.00 TTD.[26]

Facilities for operators and patrons of taxis and maxi-taxis are usually non-existent since on-street stands offer no amenities. Thus, there is always competition, and sometimes conflict, for the limited road space between moving vehicles, pedestrians, and parked transit vehicles.

Shelter and basic toilet facilities are offered only at the City Gate public transport hub and the Route 1 stand, both at South Quay in Port of Spain.

The Government of Trinidad and Tobago is currently developing an e-mobility policy in line with its policy objective of sustainable transportation.

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25 All-Inclusive Project Development Services Limited and SoftCom Ltd, *"A Framework for Implementation of National Transport Projects," National Infrastructure Development Company, Port of Spain, Trinidad and Tobago* (2010).
26 Ibid.

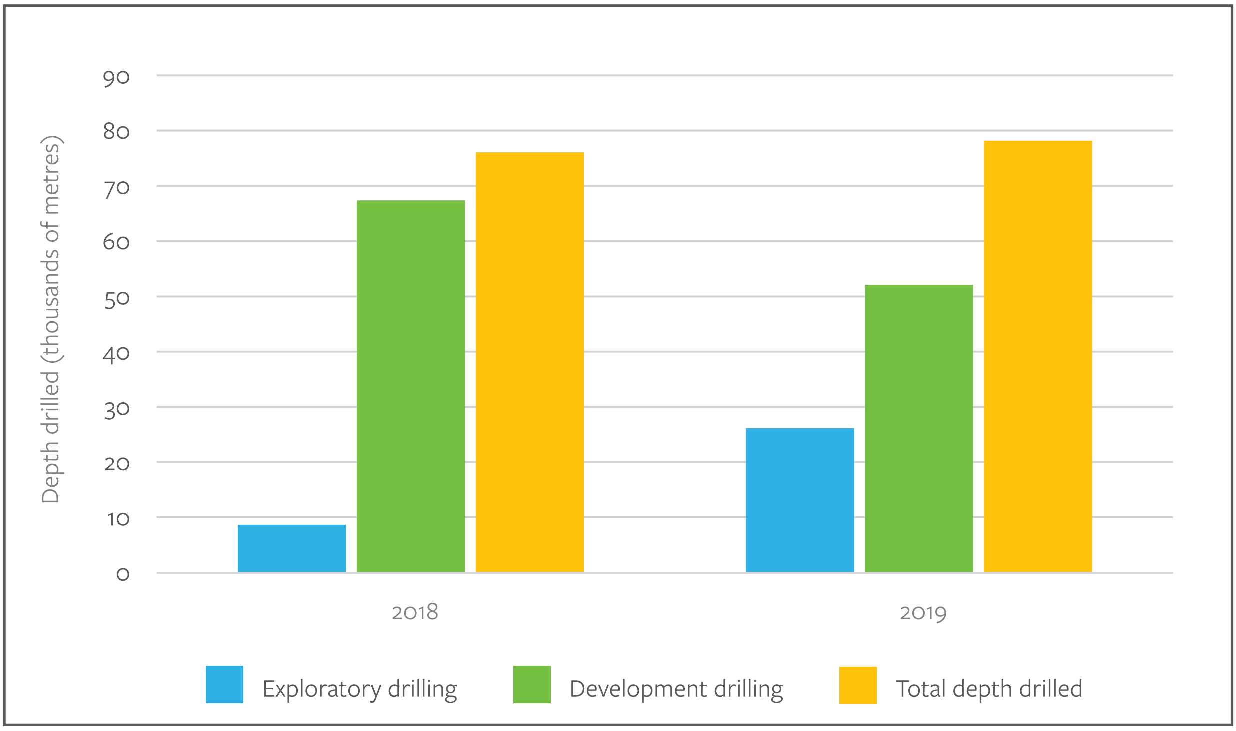


FIGURE 1.16 Development and Exploratory Drilling | *Data source: Review of the Economy, 2019*

1.7 Industry

With its economy driven mainly by industrial activities, Trinidad and Tobago is very different from the other countries of the Caribbean. Its major industries are Oil and Gas, Manufacturing, Food and Beverage, Agriculture and Tourism.

Oil and Gas

For over 100 years, Trinidad and Tobago has been involved in Oil and Gas production. The country's economy was built mainly around this sector which is globally recognised as one of the world's largest producers of natural gas following its monetisation in the 1990s.

Drilling activities aimed at bringing new oil wells on stream continue in an attempt to maintain a steady level of production. For the period October 2018–July 2019, a total of 35 wells were drilled by various petroleum companies in Trinidad and Tobago. The companies De Novo, EOG, BHP Billiton and Lease Operators Limited conducted Development and Exploratory Well Drilling on both land and deepwater. **FIGURE 1.16** shows comparative drilling data for the period October 2017–July 2018 and October 2018–July 2019.

Further exploration and extraction continue with BPTT developing its holdover fields of natural gas. One example of a successful exploration is in BPTT's Angelin Field which is expected to yield more gas than originally estimated. Other companies such as BHP Billiton, Shell, EOG and Perenco are striving for success in their fields.

In 2018, state-owned oil company Petrotrin was shut down following a restructuring exercise that resulted in the creation of Trinidad Petroleum Company Limited and four subsidiaries:

1. Heritage Petroleum Company Limited (Heritage) which assumed the exploration and production operations of Petrotrin and into which Petrotrin's operating assets were transferred.
2. Paria Fuel Trading Company (Paria) which was established to ensure the uninterrupted importation, storage and distribution of refined fuels to domestic and regional markets.
3. Guaracara Refining Company Limited which holds the refinery's assets and is responsible for their security and maintenance.
4. Legacy Petrotrin which holds all Petrotrin's non-core assets, such as land, clubs and bungalows.

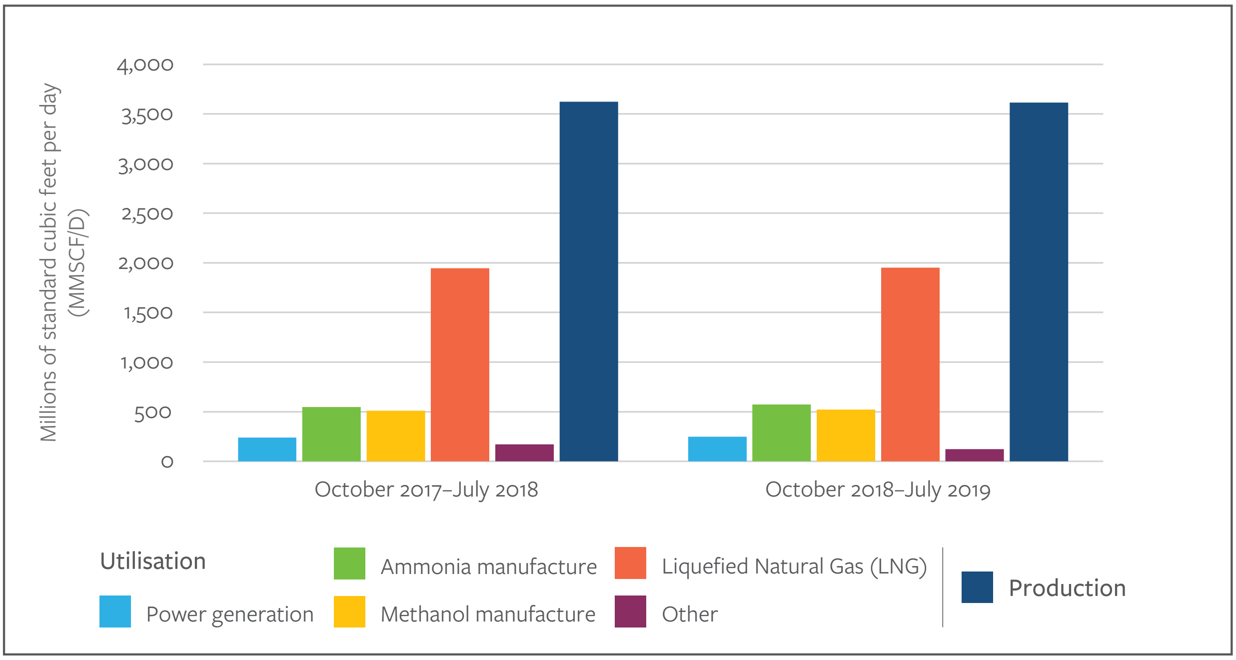


FIGURE 1.17 Natural Gas Production and Utilisation | *Data source: Review of the Economy, 2019*

Oil and gas prices are always heavily scrutinised by the Government since its expenditure and planning are based on their price projections. **TABLE 1.13** reflects prices over the period October 2013–July 2019.[27]

A decline in natural gas production was observed throughout 2018–2019 despite new fields being commissioned into production. This marginal decline was due to the decline in production within mature fields. **FIGURE 1.17** represents the change in natural gas production for the period 2017–2019.

Natural gas is mainly used by Atlantic LNG which accounts for about 54 percent of total output. Ammonia manufacturing follows with about 16 percent while methanol manufacturers utilise 14.5 percent of the natural gas supply. Electrical power generation utilises 6.9 percent.

Natural Gas Liquids (NGLs) are produced by Phoenix Park Gas Processors Limited (PPGPL) and are comprised of propane, butane and natural gasoline. A steady decline in production can be observed in **FIGURE 1.18** for the period October 2014–July 2019 which is attributed to lower production numbers upstream.

Manufacturing

The manufacturing sector is comprised of several sub-sectors ranging from downstream petrochemical products, food and beverage, clothing and textiles, light industry and cement production. Their total contribution to GDP is about 16 percent of total industrial output.

TABLE 1.13 Oil and Gas Prices for Period October 2013–July 2019 | *Source: Review of the Economy, 2019*

	Oct ’13/ Sep ’14	Oct ’14/ Sep ’15	Oct ’15/ Sep ’16	Oct ’16/ Sep ’17	Oct ’17/ Sep ’18	Oct ’17/ Jul ’18	Oct ’18/ Jul ’19
Crude Oil (Spot Price US$/Barrel) ▼							
West Texas Intermediate	99.30	56.49	41.35	49.33	64.01	62.98	57.84
European Brent	107.23	60.56	42.14	51.16	69.52	68.28	66.33
Natural Gas (US$/Thousand Cubic Feet) ▼							
Henry Hub	4.41	3.05	2.29	3.02	2.94	2.93	3.02

27 Government of the Republic of Trinidad and Tobago, *Review of the Economy* (2019).

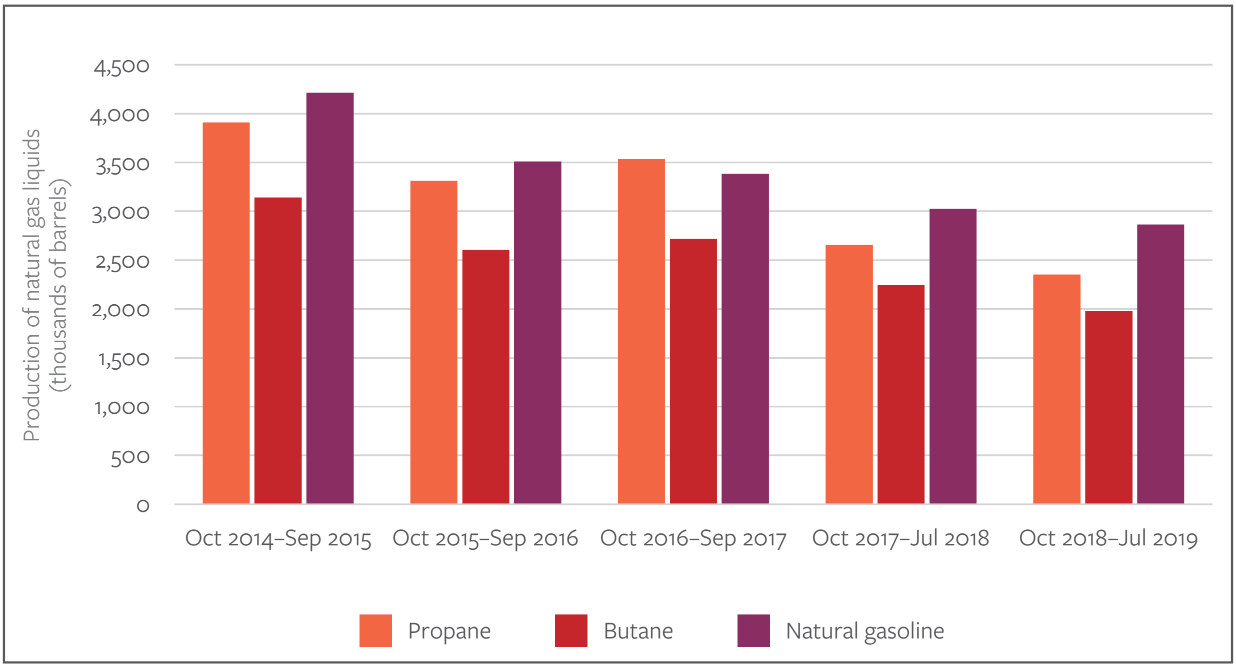


FIGURE 1.18 Production of NGLs (Propane, Butane and Natural Gasoline) | *Data source: Review of the Economy, 2019*

Tourism

Although of less economic value than the oil and gas and downstream petrochemical sectors, tourism is significant, particularly to the economy of Tobago. **TABLE 1.14** presents visitor arrivals for the period 2015–2019.[28]

Further Developments

Launched in September 2019, the Ministry of Trade and Industry's Trinidad and Tobago Trade Policy (2019–2023) provides a national roadmap for reducing dependency on traditional export markets through diversification of manufacturers' productivity, with greater focus on Research and Development in product development.

TABLE 1.14 Air Arrivals, Cruise Vessels and Passenger Arrivals | *Source: Review of the Economy, 2019*

TYPE	2015	2016	2017	2018	Jan–May 2018	Jan–May 2019
TOTAL VISITOR ARRIVALS	**519,330**	**491,232**	**464,744**	**501,088**	**260,633**	**232,639**
Trinidad	432,338	418,368	408,018	413,416	190,103	192,615
Tobago	86,992	72,864	56,726	87,672	70,530	40,024
International Air Arrivals (No. of persons)	**439,749**	**408,782**	**394,650**	**375,485**	**164,029**	**166,179**
Trinidad	417,314	389,404	375,202	356,044	154,151	154,527
Tobago	22,435	19,378	19,448	19,441	9,878	11,652
Cruise Passengers (No. of persons)	**79,581**	**82,450**	**70,094**	**125,603**	**96,604**	**66,460**
Trinidad	15,024	28,964	32,816	57,372	35,952	38,088
Tobago	64,557	53,486	37,278	68,231	60,652	28,372
Cruise Ships (No. of ships)	**70**	**62**	**60**	**75**	**55**	**36**
Trinidad	18	21	22	27	16	16
Tobago	52	41	38	48	39	20

28 Government of the Republic of Trinidad and Tobago, *Review of the Economy 2019* (2019).

The Trade Policy outlines initiatives to: (i) increase the value and volume of non-energy exports of goods and services; (ii) enhance the facilitative and enabling environment for trade, business and investment; (iii) grow the production and export of high value-added goods and services; and (iv) increase the country's share of CARICOM trade, inclusive of trade in services. Key developments during fiscal 2019 which positively impacted the manufacturing sector included the provision of grant funding and financial support; participation at a WTO Trade Policy Review; finalisation of a Trade Agreement; the hosting of specialised trade missions; and construction of a manufacturing facility.

The Grant Fund Facility is an initiative designed to assist small and medium-sized enterprises (SMEs) in eight designated sectors (manufacturing, agriculture and agro-processing, financial services, maritime services, creative industries, software design and applications, fish and fish processing, and aviation services) with the acquisition of machinery and equipment.

The Grant Fund Facility finances 50 percent of the cost of acquisition, up to a maximum of 250,000 TTD (37,313 USD) per beneficiary. During fiscal 2019, eight companies received grants totalling approximately 1.57 million TTD (234,328 USD) in various sub-sectors including printing and publishing; cocoa processing inclusive of the manufacture of chocolate; food and agro-processing; and manufacture of packaging material, among other things. To complement this initiative, the Research and Development Facility (RDF) provides financial support to promote research, development and innovation by local manufacturers. Twenty-six applications were received during Fiscal 2019, of which three were approved with total disbursements of 1.14 million TTD (170,149 USD).

1.8 Waste

Solid and Other Waste

With population growth, increased urbanisation, industrial expansion and increased consumerism, waste generated per capita is expected to increase. The *Trinidad Solid Waste Management Programme: Waste Characterisation & Centroid Study Final Report, September 2010* estimated that the landfills managed by the Trinidad and Tobago Solid Waste Management Company Limited (SWMCOL) at Beetham, Guanapo and Forres Park receive approximately 700,000 tonnes of waste per year which represent 95 percent of the waste generated annually in the country.

SWMCOL is responsible for developing and managing these three waste disposal sites in Trinidad while the Tobago House of Assembly (THA) is responsible for the island's only waste disposal site at Studley

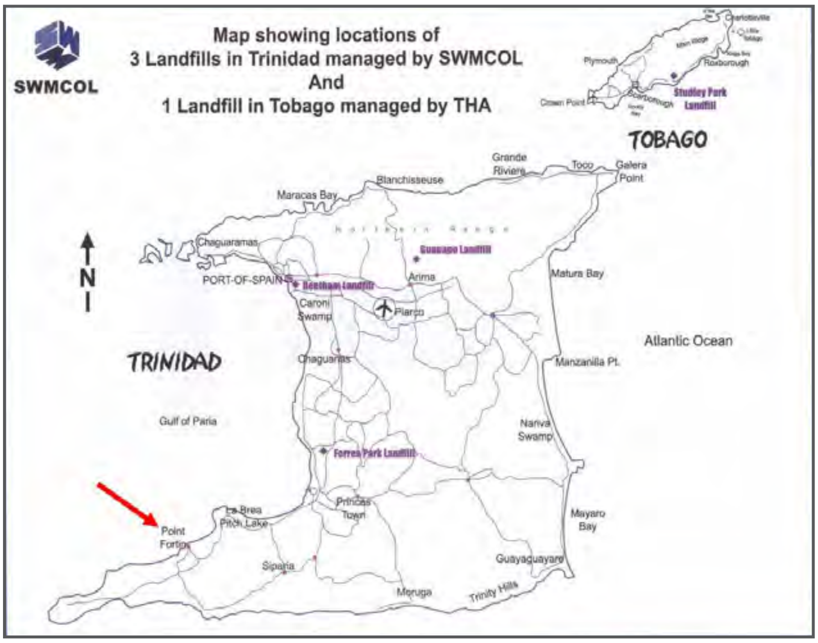


FIGURE 1.19 Locations of Landfill Sites in Trinidad and Tobago
Source: SWMCOL, 2019

Photo Credit: Vikki Arjoon

▲ Sandy Point Beach Sunset, Tobago, 2021

Park. In Trinidad, the Guapo disposal site was managed by the Point Fortin Borough Corporation until 2012 when a private firm, Earth Company Limited, took over its operations.

FIGURE 1.19 shows the locations of the disposal sites in Trinidad and Tobago.

In Trinidad and Tobago, Solid Waste Management (SWM) is handled by various institutions. These institutions perform many different tasks and currently operate unregulated. The institutions are involved in various aspects of the SWM and operate with their own priorities and agendas. Following are the main SWM agencies with their associated responsibilities.

» **Ministry of Public Utilities through SWMCOL:** Overall responsibility for SWM in Trinidad while SWMCOL manages the Beetham, Guanapo and Forres Park waste disposal sites in Trinidad. It is also overseeing finalisation of the Beverage Containers Deposit Refund Policy.

» **Ministry of Rural Development and Local Government through the Municipal/Regional Corporations:** Responsible for municipal waste collection and transportation in Trinidad and the associated monitoring of solid waste contractors. Point Fortin Borough Corporation is a special case as it also manages the Guapo disposal site.

» **Tobago House of Assembly:** Management of municipal waste collection in Tobago and the Studley Park disposal site in Tobago.

» **Ministry of Planning and Development:** Management of the Multilateral Environmental Agreements (MEAs) to which Trinidad and Tobago is a signatory. Many of these relate to waste such as the Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and Disposal, and the Stockholm Convention on Persistent Organic Pollutants.

» **Ministry of Health:** Monitoring of waste management at health establishments such as public hospitals, health centres and licensed private hospitals. It also responds to public health complaints and concerns. The Regional Health Authorities which fall under the Ministry of Health are responsible for the management of waste from all major hospitals and health centres in their respective regions.

» **Environmental Management Authority (EMA):** Responsible for developing and implementing legislation for the management of wastes as described in Sections 55 to 58 of the Environmental Management Act, Chap. 35:05. Rules may be prescribed in accordance with Section 26 of the Environmental Management Act. The EMA also coordinates the National Recyclable Solid Waste Collection.

» **Ministry of Trade and Industry:** Receives and evaluates applications for scrap metal licence under the Old Metal and Marine Stores Act (scrap metal collection) and the Export Negative List (export of scrap metal). The EMA also regulates scrap metal dealers through the Certificate of Environmental Clearance (CEC) process.

» **Ministry of Energy and Energy Industries (MEEI):** Receives applications from the oil and gas sector for the importation of industrial chemicals in oil and gas exploration.

TABLE 1.15 provides estimates of the combined quantity of solid waste disposed annually at the SWMCOL Managed Landfills in Beetham, Guanapo and Forres Park.

A waste composition assessment was conducted in 2010 at all three sites in Trinidad. The results of this survey for Trinidad are shown in **FIGURE 1.20**.[29]

TABLE 1.15 Quantity of Solid Waste Disposed 2006–2017 | *Source: SWMCOL* ▼

Year	Quantity (tonnes)	Year	Quantity (tonnes)
2006	560,887	2012	505,926
2007	594,641	2013	558,617
2008	633,871	2014	682,526
2009	629,414	2015	862,107
2010	548,393	2016	767,536
2011	500,489	2017	505,926

29 CBCL Limited, *Trinidad Solid Waste Management Program Waste Characterization and Centroid Study* (Ministry of Local Government, 2010).

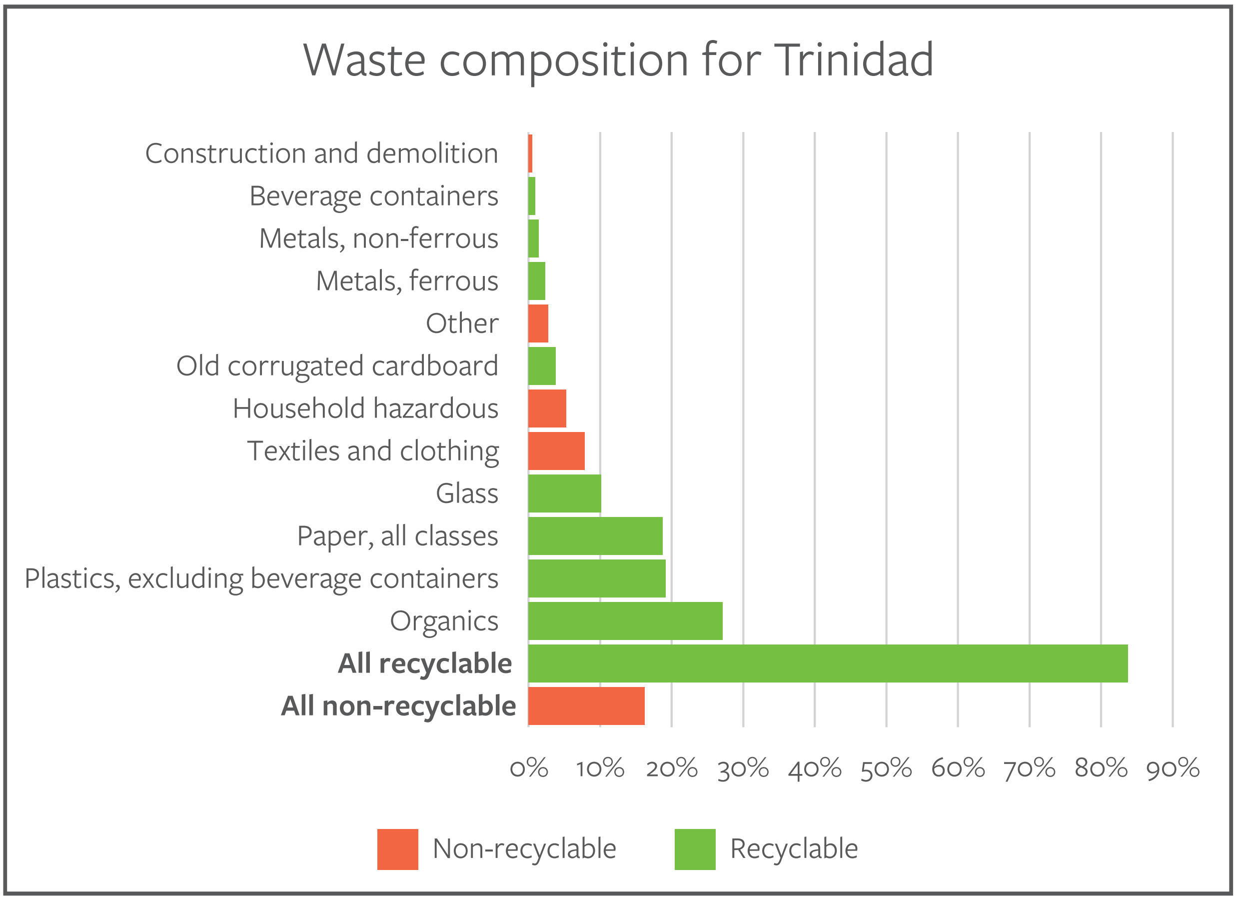


FIGURE 1.20 Waste composition for Trinidad | *Data source: CBCL Centroid Study, 2010*

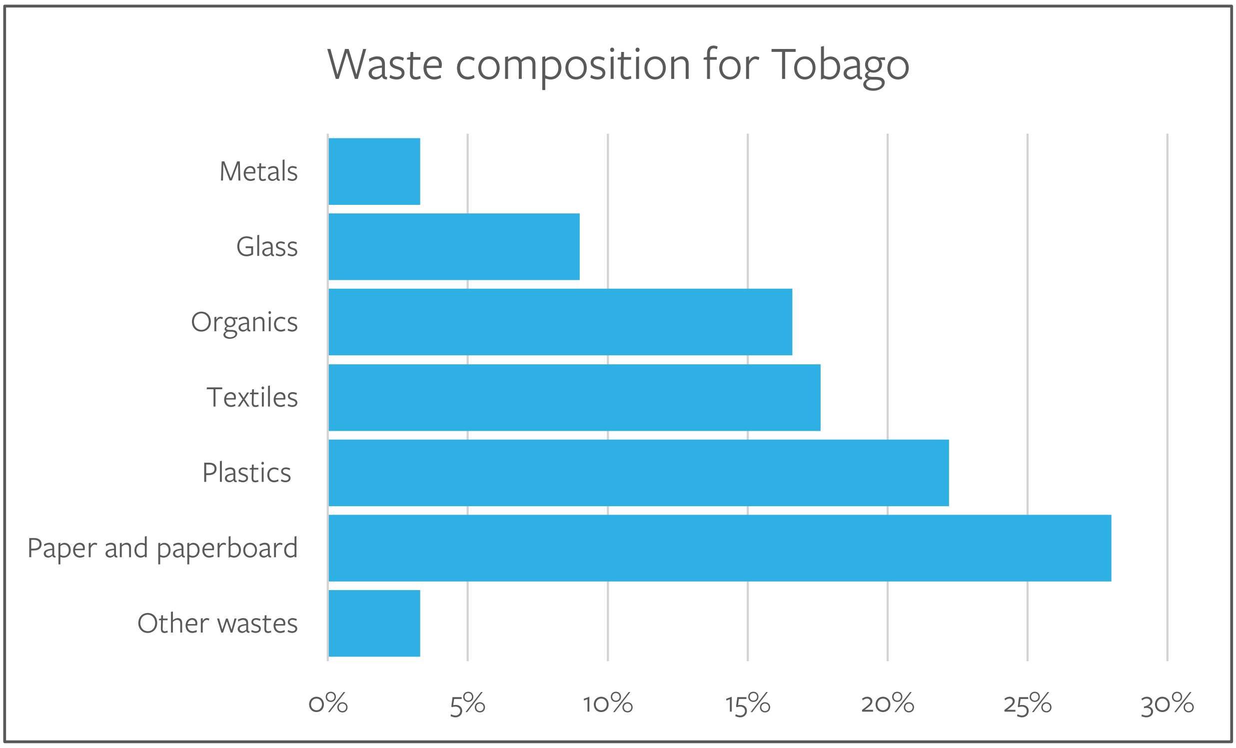


FIGURE 1.21 Waste composition for Tobago | *Data source: Simmons and Associates, 2013*

TABLE 1.16 Black Water Disposal 2012–2017
Source: SWMCOL ▼

Year	Black water disposed (gallons)	Year	Black water disposed (gallons)
2012	6,110,985	**2015**	5,453,390
2013	6,567,190	**2016**	5,266,865
2014	7,416,760	**2017**	7,817,990

Data collection for this report took place between April and May 2010.

FIGURE 1.21 shows overall waste composition in Tobago from the residential as well as the Industrial, Commercial, and Institutional sectors (ICI). It was derived from a series of studies, the first of which was a baseline study conducted between 13–19 September 2010. The second study was conducted from 15–21 March 2012 to capture the anticipated spike in garbage generation prior to the Easter period. The third study, conducted from 12–19 December 2012, attempted to capture information representative of waste generated during the Christmas holiday cleaning season.

The landfills also accept black water—faecal waste—for disposal. **TABLE 1.16** outlines an estimated quantity of black water disposed in the Beetham landfill for the period 2012–2017.

Recycling in Trinidad and Tobago

Each disposal site has organised ad hoc waste recycling activities which target paper, cardboard, glass, batteries, copper wire and scrap metals. Limited provisions are also made on site for sorting and recycling certain waste, such as the collection/sorting of glass bottles at the Beetham Landfill. High volume recycling of glass, paper, newspapers, batteries, electronic waste (e-waste) and scrap metals are also done by some private and public entities.

SWMCOL has implemented various programmes for the recycling of post-consumer glass, plastic, tetra-packs and aluminium beverage containers in the Public, Private and Institutional sectors. The company's PET wash plant provides further processing of plastic to flakes and is pursuing further downstream processing options.

A Beverage Containers Deposit Refund Policy is currently being considered by the Cabinet which, if successfully implemented, will ensure that this waste stream is diverted from landfills and recycled.

Wastewater

The Water and Sewerage Authority (WASA) is the main regulatory authority for water and wastewater in Trinidad and Tobago. It is a vertically integrated state-owned Statutory Authority which was established by an Act of Parliament in 1965 with the responsibility to manage the country's water supply and services.

WASA has the mandate to deliver water supply in a safe, reliable and efficient manner. The asset base of WASA's water production consists of 41 surface water treatment plants, 55 groundwater treatment facilities, 37 rural intakes and spring sources, 229 wells, 70 service reservoirs, and 9 raw water impounding reservoirs. WASA also owns/manages 111 pumping stations and an estimated 5,800 km of pipeline ranging from 20 mm to 1,350 mm in diameter. In 2015, an estimated 59 percent of the water managed by WASA came from surface water sources while 23 percent came from groundwater sources with the remaining 18 percent from desalinated water plants.[30]

Increased water demand prompted WASA to purchase water from two desalination companies, the Desalination Company of Trinidad and Tobago Ltd (Desalcott) and Seven Seas Water, a US-owned company. Desalcott is located at the Point Lisas Industrial Estate where its primary clients operate. In 2012, WASA re-negotiated its contract with Desalcott to secure an additional 40 million imperial gallons of water per day (MIGD) to supply Central and Southern Trinidad.

Seven Seas Water is located at Point Fortin and has been supplying water to WASA since 2013. In 2015 its output was increased to 6.7 MIGD in order to augment the water supply to the south western peninsula of Trinidad.

30 Regulated Industries Commission, *T&TEC Annual Performance Indicator Report* (2018).

Photo Credit: Kishan Ramcharan

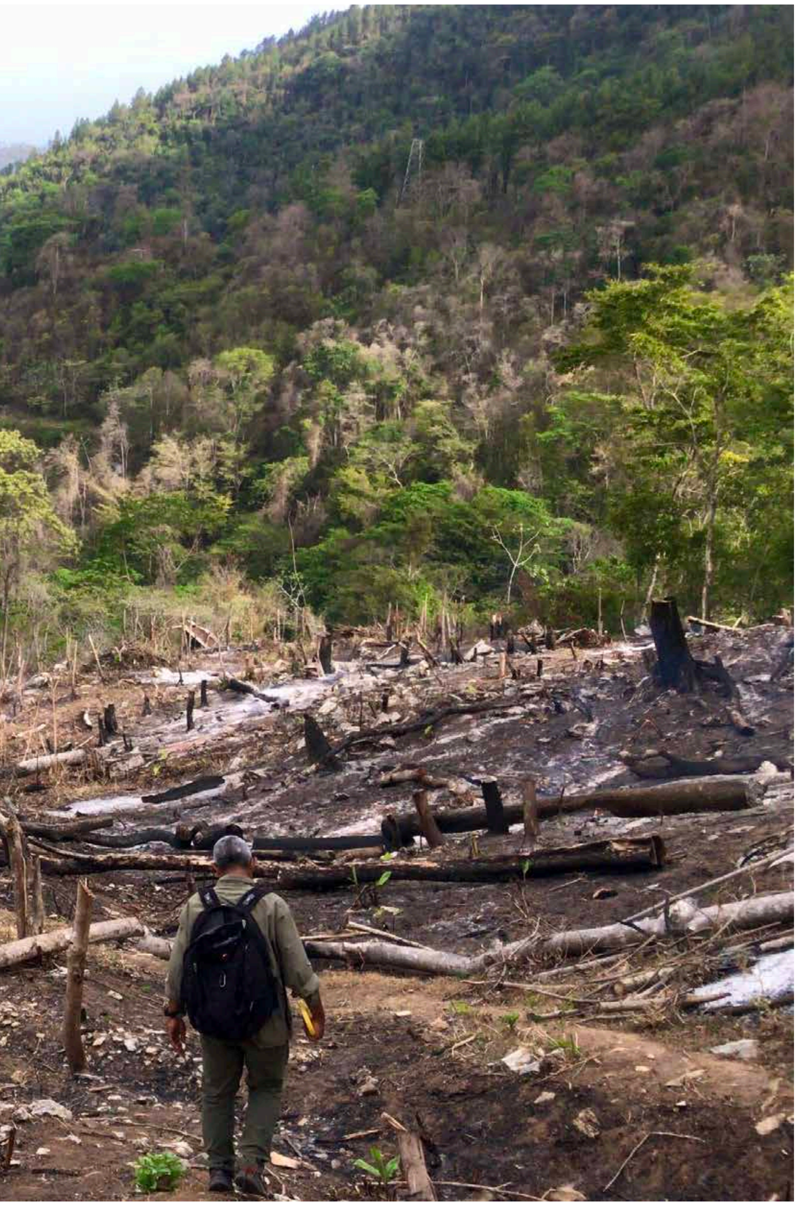
▲ Slash and burn land clearing, 2020

Another important function of WASA is the collection, transmission, treatment and disposal of wastewater. Its public sewerage systems in Port of Spain, San Fernando, Arima, Point Fortin and Scarborough handle approximately 30 percent of the country's wastewater needs. In addition to these decentralised sewage treatment plants, WASA operates 33 other plants and an estimated 1,522 hectometres of main sewers. By mandate, WASA also has the responsibility to adopt and refurbish more than 150 wastewater facilities from private developers and other government authorities.

WASA's customers are categorised as residential and commercial. In 2015, its water customer base was 411,777 while its wastewater customer base was 77,245. In recent years, the Malabar wastewater treatment was upgraded while the San Fernando wastewater plant is under renovation.

1.9 Agriculture, Forestry and other Land Use

Among the national sectors, Agriculture, Forestry and Other Land Use (AFOLU) is unique in incorporating activities that can lead to either GHG emissions/



sources or GHG sequestration/sinks. Mitigation options for this sector fall into three categories:

- Reduction/prevention of emissions to the atmosphere
- Sequestration—especially the enhancement of carbon uptake by terrestrial reservoirs
- Reduction of specifically CO_2 emissions by the replacement/substitution of fossil fuel and other energy-intensive products

The two main subcomponents of this sector within Trinidad and Tobago are Agriculture and Forestry which are expanded to include conversion to and from each other, and other land uses.

Overview of Agriculture and Forestry in Trinidad and Tobago

According to Trinidad and Tobago's *Review of the Economy 2018* (Ministry of Finance, 2018), the Agriculture and Forestry (and Fishing) sector continues to be a small contributor to economic growth, generating 0.9 percent of National GDP, with a growth rate of 9.6 percent. However, this sector provides employment for approximately four percent of the labour force and is critical to the rural socio-economy.

Robust growth within the Agriculture, Fishing and Forestry Sector produced a noticeable increase of 19 percent by first quarter 2019. **TABLE 1.17** depicts the production of selected crops and livestock for the period 2014–2018.[31]

Forestry

The state manages over 192,000 hectares of forests which are distributed across 36 forest reserves, 11 game sanctuaries and state lands. As of June 2019, 1,500 Ha of teak and pine plantations provided raw materials for 122 sawmillers and 130 furniture shops. Also, 113 contracts were awarded for harvesting 50,000 Hoppus Feet of teak; 171,000 Hoppus Feet of Pine; and 13,000 Hoppus Feet of mixed species. The national Reforestation and Watershed Rehabilitation Programme (NRWRP) replanted a total of 112,100 plants on 203 Ha of land during the period October 2018–August 2019.

Fisheries

A total of 102 non-artisanal, large-scale vessels were registered in Fiscal 2019 of which 88 were for Trinidad and 14 for Tobago, with an associated 418 fishers. Commercial small-scale fishing vessels are estimated at 2,525 with a breakdown of 1,939 for Trinidad and 586 for Tobago, and 5,050 associated fishers.

31 Government of the Republic of Trinidad and Tobago, *Review of the Economy 2019* (2019).

TABLE 1.17 Domestic Production of Agricultural Products | *Source: Review of the Economy, 2019*

Type	2014	2015	2016	2017	2018	2017 (Oct–Dec)	2018 (Oct–Dec)
Root crops ('000 kgs)	**10,276.9**	**9,744.2**	**12,687.1**	**9,357.4**	**9,453.1**	**2,132.0**	**2,053.7**
of which:							
Cassava	2,673.2	2,293.9	2,661.6	1,333.3	2,060.0	81.0	168.0
Dasheen	4,059.7	1,916.8	2,395.8	3,224.3	2,511.0	934.0	496.0
Eddoes	921.2	2,504.8	4,680.3	2,013.1	2,080.4	995.0	1,143.6
Ginger	561.7	539.4	801.6	857.1	366.8	0.0	1.0
Sweet Potato	1,986.2	2,473.6	2,132.1	1,908.1	2,425.3	122.0	245.1
Copra ('000 kgs)	**44.01**	**44.57**	**51.87**	**19.47**	**88.70**	**2.17**	**33.74**
Rice (paddy) ('000 kgs)	**2,912.0**	**1,900.0**	**1,822.9**	**1,619.9**	**584.8**	**764.0**	**228.0**
Vegetables ('000 kgs)	**15,505.3**	**20,731.8**	**20,857.8**	**24,595.0**	**24,094.4**	**6,980.0**	**3,919.4**
Tomato	1,415.6	2,698.0	2,223.3	2,645.1	1,678.2	438.0	126.0
Cabbage	343.6	593.7	433.7	434.9	755.5	7.0	173.0
Cucumber	1,184.6	1,173.3	1,101.5	803.9	741.1	206.0	130.0
Melongene	1,164.8	905.5	1,713.4	913.3	488.2	110.0	63.0
Bodi	979.9	1,261.8	1,612.7	1,965.6	587.3	218.0	120.0
Ochro	977.5	1,027.4	1,065.9	1,351.9	1,729.2	333.0	480.0
Lettuce	2,062.2	2,807.1	1,994.1	1,702.0	1,335.3	483.0	465.0
Pumpkin	2,130.0	3,279.0	3,031.7	1,884.2	4,532.9	402.0	534.0
Pak choi	663.0	1,904.6	921.9	1,464.4	846.0	112.0	74.0
Water Melon	474.4	746.6	536.9	547.8	402.8	19.0	35.0
Sweet Pepper	525.0	490.0	563.5	447.7	1,003.5	175.0	147.0
Celery	764.6	1,152.2	3,192.0	6,670.7	4,818.3	3,156.0	175.0
Cauliflower	107.1	198.9	187.6	158.7	131.6	1.0	24.0
Chive	2,016.5	1,782.0	1,384.0	2,473.9	2,448.1	873.0	944.4
Hot Pepper	314.1	398.3	503.8	718.0	2,203.7	216.0	250.0
Dasheen Bush	58.1	235	153.1	224.0	306.9	49.0	101.0
Sorrel	324.3	78.4	238.7	188.9	85.8	182.0	78.0
Fruits ('000 kgs)	**3,662.5**	**3,246.4**	**2,607.5**	**3,611.2**	**5,133.70**	**907.0**	**1,168.0**
of which:							
Pineapple	1,428.10	1,371.9	1,274.2	1,980.0	2,463.2	565.0	659.0
Pawpaw	1,799.2	1,355.1	941.9	1,269.6	1,312.2	277.0	370.0
Poultry ('000)							
Broilers (number sold)	34,136.3	32,160.8	31,708.0	33,267.0	31,889.0	9,660.0	7,797.0
Broilers (kgs)	58,826.7	56,099.7	60,696.0	63,906.0	65,039.0	18,068.0	17,483.0
Small ruminants ('000)							
Mutton (kgs)	74.2	77.3	60.0	70.0	48.9	25.4	17.2
Sheep (number sold)	5.1	6.1	5.6	10.6	3.2	2.1	1.0
Goat Meat (kgs)	34.7	53.7	46.4	71.8	55.6	21.0	15.5
Goat (number sold)	2.4	5.0	4.5	7.0	3.4	1.4	1.0
Dairy ('000)							
Milk (Litres)	3,941.8	3,730.6	2,323.7	2,428.4	3,456.3	530.2	688.2
Beef/Veal (kgs)	326.3	287.1	285.0	225.9	96.9	36.9	11.8
Pigs ('000)							
Pork (kgs)	2,619.3	1,778.1	1,910.4	2,178.1	2,378.7	807.7	781.0
Pigs (number sold)	61.0	50.2	47.7	42.7	46.6	16.3	19.3

In Fiscal 2018, production from longline fleet was estimated at 1.326 metric tonnes, representing a 10.3 percent increase from 1,202 metric tonnes in fiscal 2017.

Aquaculture currently has 42 registered commercial fish farmers, with approximately 50 percent operating at full capacity. The ornamental aquaculture component is vibrant with 60,906 fishes being exported and 45,820 fishes being imported.

Agriculture Subcomponent

The most up-to-date agriculture policies for Trinidad and Tobago are in an Action Plan dated 2012 to 2015 which does not acknowledge climate change as an issue requiring attention.[32] These policies are deemed outdated and there is no mention of plans or activities that could be considered as mitigating/adaptive precautions or responses to already changing climate conditions. In addition, there is a paucity of information indicating impacts of climate change upon specific agricultural commodities which would assist in assessing and developing mitigation suggestions. In the absence of this, the GoRTT provides financial relief to farmers who are affected by floods and other natural disasters.

A major barrier in developing robust mitigation proposals for the Agriculture subsector is the chronic lack of reliable data and information. This has led to many data gaps which must be filled before greenhouse gas emissions for this sector can be inventoried and assessed with any confidence. This problem has been cited by several sources, including being listed as a reason for the AFOLU's omission from the NDC. There is also little to no documentation or sharing on what, if any, climate adaptive, mitigative or resilient practices are carried out within this subsector. For example, despite the National Environment Policy's reference to the empowerment of agencies regarding the management of agricultural waste and fires, little could be found regarding details of plans or actions.

Yet, a literature search revealed that GHG emissions data on various aspects of Trinidad and Tobago's agricultural activities are available for the period 1998 to 2017 from the FAOSTAT database, although there is little information on how the data were generated. The challenge is compounded by the associated caveat that "Aggregate may include official, semi-official, estimated or calculated data" for almost every data category. Also, a recent Food and Agriculture Organization (FAO) document[33] also makes reference to two emissions assessments of the agricultural sector for 1990 and 2005 from which the largest emissions were attributed to enteric fermentation in domestic livestock (CH_4) and the burning of agricultural residues (CO_x). A comparison of both assessments revealed higher levels of emissions during 1990 compared to 2005 for both CH_4 (3.69 Gg vs 3.21 Gg) and CO_x (19.01 Gg vs 5.48 Gg). Here, the major decline in the burning of agricultural residue is associated with the discontinuation of sugar production in 2003. This document also refers to estimates of net emissions in Agriculture in 2016 at 295 Gg.

Poor performance within various components of the Agriculture sector in 2017, such as decreases in the production of root crops and some vegetables, has been attributed to unacknowledged factors linked to climate conditions such as tropical storm Bret (2017), other unfavourable weather conditions, ensuing floods and the incidence of pests and diseases.

There are, however, other problem areas which can potentially create opportunities for developing mitigative (and adaptive) solutions. These include, but are not limited to the already identified gaps/shortfalls: (i) out-dated technology and low levels of mechanisation; (ii) a lack of greenhouse and other similar means of enhancing control of exposure to changing climate conditions; (iii) high cost of fertilisers; (iv) non-prevalence of agricultural insurance; (v) overuse and misuse of chemical fertilisers and pesticides; and (vi) absence of official safety standards and facilities for testing residual pesticide/chemical levels.

Given its responsibility for climate change issues, the Ministry of Planning and Development is implementing a project as part of the Green Climate Fund Readiness

32 Ministry of Food Production, Land and Marine Affairs, *The National Food Production Action Plan 2021–2015.*

33 Green Climate Fund with the Food and Agriculture Organization of the United Nations for Republic of Trinidad and Tobago, *Readiness Proposal* (2019).

Portfolio titled "Improving the monitoring system for climate change impacts on the agriculture sector in Trinidad and Tobago". This is being done in collaboration with the Food and Agriculture Organization (FAO) and the Ministry of Agriculture, Land and Fisheries. The project aims to develop a framework for collecting and analysing agricultural and associated activity data, including food import dependency, hydrological, and meteorological data to allow for visualisation and assessment of greenhouse gas emissions in addition to reporting gender sensitive climate impacts on agriculture and food systems, and to strengthen the capacity of key stakeholders to use the collected data to improve resilience to climate change.

Forestry Subcomponent

Overall, forest cover across Trinidad and Tobago is approximately 44 percent collectively,[34] with an estimated 20 percent of this area being under private ownership. These values may have variances because of discrepancies in assessment methods and even basic definitions of what constitutes forested land.

Forest cover is reported to be increasing due to the reclamation of cocoa and coffee plantations which had been abandoned between the 1960s and early 1980s, and ongoing attempts to reforest denuded and semi-denuded areas through such initiatives as the 'Northern Range Restoration Project' which was launched by the GoRTT in the 1970s. Pockets of reforestation have also been carried out by NGOs and private entities such as the National Gas Company.

However, despite these increases, a forest loss rate of 0.8 percent per year from 1990 to 2000 has been reported.[35] Additionally, T&T's National Wetlands Policy[36] reported a disappearance of more than 50 percent of original wetlands across the country. The above-mentioned increases in forest cover are believed to be counterbalanced by annual occurrences of deforestation from multiple sources such as, but not limited to increasing physical development (e.g. roads, pipelines and public infrastructure); agriculture; settlement; quarrying; squatting, and especially forest fires which have been identified as the main cause of deforestation.

Further, as more and more state forests are set aside for conservation purposes, privately-owned forests have become the dominant source of native timber, while the Forestry Division remains the larger provider of timber from teak and Caribbean Pine monocultures. With private forests constituting approximately one-fifth of forested land across T&T and over 1,200 'forest farmers' actively planting commercial timber species on their holdings, it is critical that the development of forest mitigation policies include these private stakeholders.

Mainstreaming of climate change responses into the AFOLU sectoral plans and policies has not yet occurred. A review of the literature revealed no example of detailed, proactive plans or actions from the GoRTT which specifically seek climate mitigation as an objective. Several national policies relevant to forest management such as the National Forest Policy,[37] the National Environmental Policy,[38] the National Protected Areas Policy,[39] and the National Policy and Programmes for Wetlands Conservation in Trinidad and Tobago[40] may mention climate change and the related need to

34 Government of the Republic of Trinidad and Tobago, *National Forest Policy* (2011), 35(3), 720–726. https://agriculture.gov.tt/wp-content/uploads/2021/03/National-Forest-Policy-2011.pdf

35 Food and Agriculture Organization of the United Nations, *Forests and climate change in the Caribbean* (2014), 39. http://www.fao.org/documents/card/en/c/c34802da-3b5c-4c32-998b-1ee2ad750ade/

36 National Wetlands Committee, Forestry Division and Ministry of Public Utilities and the Environment, *National Wetland Policies—Trinidad and Tobago: National Policy and Programmes on Wetland Conservation for Trinidad and Tobago* (2001).

37 Government of the Republic of Trinidad and Tobago, *National Forest Policy* (2011).

38 Government of the Republic of Trinidad and Tobago, *National Environmental Policy* (2006). https://www.protectedareastt.org.tt/index.php/resources/publications/policy-documents/228-national-environmental-policy

39 Government of the Republic of Trinidad and Tobago, *National Protected Areas Policy* (2011).

40 National Wetlands Committee, Forestry Division and Ministry of Public Utilities and the Environment, *National Wetland Policies—Trinidad and Tobago: National Policy and Programmes on Wetland Conservation for Trinidad and Tobago* (2001).

TABLE 1.18 Agriculture Sector Contributions for the Period 1991–2011
Source: Central Bank of Trinidad and Tobago, Annual Economic Survey, 2011

Year	GDP (Market Prices, TT$M)	GDP at Current Market Prices by Sector of Origin (TT$M)	Annual Change of Agri. GDP (Current Market Prices, %)	Sectoral Composition of GDP at Current Market Prices	Agriculture Labour Force (Persons)	Agriculture Share of Labour Force (%)
1991	22,558.6	762.2	3.4	3.4	51,100	11.7
1992	23,117.6	8701.6	5.2	3.5	49,100	10.8
1993	24,490.5	815.6	1.7	3.3	45,675	10.8
1994	29,311.7	651.4	–30.1	2.2	52,590	11.7
1995	31,697.0	733.1	12.5	2.3	47,800	10.1
1996	34,448.1	668.7	–8.8	1.9	42,275	9.0
1997	36,552.4	864.7	29.3	2.4	46,900	9.3
1998	38,197.1	828.3	–4.2	2.2	41,200	8.1
1999	41,044.9	891.3	7.6	2.2	46,800	9.1
2000	513,370.6	697.2	–16.0	1.4	36,400	7.2
2001	55,007.3	707.6	1.5	1.3	40,100	7.8
2002	55,365.6	787.2	11.2	1.3	36,100	6.9
2003	66,168.3	674.6	–14.3	1.2	31,400	5.9
2004	83,652.5	637.0	–5.6	0.8	26,000	4.6
2005	100,682.0	487.3	–23.5	0.5	25,000	4.4
2006	115,951.2	657.3	34.9	0.6	25,700	4.4
2007	136,952.5	509.0	–22.6	0.4	22,400	3.8
2008	175,287.2	640.7	25.9	0.4	25,300	4.3
2009	124,358.8	739.3	15.4	0.6	23,300	3.9
2010	132,960.6	869.3	17.6	0.7	21,000	3.6
2011	143,880.7	926.5	6.6	0.6	20,500	3.5

develop sustainable management policies towards adaptation. However, there is no further elaboration of plans or activities on how this could be achieved. The National Climate Change Policy[41] did go one step further with its reference to forests as carbon sinks and the need to preserve and enhance these sinks.

Despite this paucity of detailed mitigation plans, there have been actions under programmes within the National Forestry Division which are contributing towards mitigation and adaptation of climate impacts. These include the Re-afforestation Programme, Agroforestry Programme, Fire Prevention Unit, and the Wetlands Management Project. Additionally, there are examples of mitigation activities being undertaken by a few private entities such as the prevention of deforestation by the Asa Wright Nature Centre and the reforestation of some areas previously cleared for the installation of a gas pipeline by the National Gas Company. The latter went on to calculate and project the resulting carbon that could be sequestered from the reforestation of these areas.

Finally, while the National Environmental Policy mentions a commitment to critical issues related to the mitigation of soil and land degradation, the literature review reveals no details of specific plans, actions or policies related to soil conservation and management. It is, however, noteworthy that an assessment of land degradation between 2000 and 2015 has been reported in the document *National Report: Land Degradation Neutrality Target Setting Programme* (MPD, 2020a). This can be used as the first step towards the development of relevant mitigation strategies.

TABLE 1.18 shows the Agricultural Sector Contributions to the economy for the period 1991–2011. The following are noted:

41 Government of the Republic of Trinidad and Tobago, *National Climate Change Policy* (2011).

TABLE 1.19 Total forested area (Ha) by forest class for the period 1970–2010
Source: Food and Agriculture Organization of the United Nations, Forestry Department, Global Forest Resources Assessment Country Report for Trinidad and Tobago, 2010

National Classes	1970	1994	1990	2000	2005	2010
Evergreen Seasonal Forest	98,180	88,718	90,295	86,352	84,381	82,410
Semi-Evergreen Seasonal	13,928	12,586	12,810	12,251	11,971	11,691
Deciduous Seasonal Forests	3,617	3,268	3,326	3,181	3,108	3,035
Dry Evergreen Forests	495	447	455	435	425	415
Seasonal Montane Forests	926	837	852	815	796	778
Montane Forests	21,619	19,535	19,882	19,014	18,580	18,146
Swamp Forests	16,789	15,171	15,441	14,767	14,429	14,092
Secondary Forests	22,650	20,467	20,831	19,921	19,466	19,012
Teak and Pine Plantations	16,308	15,000	15,000	15,000	15,000	15,000
Other Plantations	5,306	5,306	5,306	5,306	5,306	5,306
Bamboo	528	528	528	528	528	528
Water	1,613	1,613	1,613	1,613	1,613	1,613
Other Areas Within Forests	53,729	72,212	69,349	76,505	80,086	83,662
Private Lands	201,312	201,312	201,312	201,312	201,312	201,312
Total Forest Owned by State	255,688	255,688	255,688	255,688	255,688	255,688
Private Forest	56,000	56,000	56,000	56,000	56,000	56,000
Total Land Area (Ha)	**513,000**	**513,000**	**513,000**	**513,000**	**513,000**	**513,000**

- The Agricultural Share of GDP at Current Market Prices in 1991 had a value of 3.4 percent and drastically declined to a value of 0.6 percent in 2011.
- During the period of 1991–2011 the Agricultural Share of Labour Force decreased from 11.7 % to 3.5 %.

Forest

Since 2010, there has been a marked increase in research to improve the accuracy of data collection regarding the areas under forest cover in Trinidad and Tobago. In 2005, the Food and Agriculture Organization (FAO) reported that the estimates for forest cover included only data on state forests and not private forests (FAO, 2010).

According to the GoRTT (2013), total forested area in T&T declined from 256,346 Ha in 1970 to 226,413 Ha in 2010—a decrease of approximately 12 percent. Between 2010 and 2015, there was a reported increase in forested area on both islands of approximately 234,000 Ha. The increase in forest cover in T&T over the 2010–2015 period is attributed in part to the regeneration of secondary forest on abandoned sugar cane lands, abandoned cocoa and coffee plantations, and the increase in the cultivation of timber.[42] According to the Forestry Division (2016), it is estimated that forests now cover approximately 45.7 percent of the total land area in T&T. Of this, primary forests account for 26.6 percent. Of the total forested area, 55.94 percent belongs to the state and 44.06 percent are private lands.[43] Based on figures presented in T&T's 2014 MDG report,[44] total forest cover in T&T in 2012 was reported to be approximately 48 percent.[45]

42 Government of the Republic of Trinidad and Tobago, *Trinidad and Tobago's 5th National Report of Trinidad and Tobago to the United Nations Convention on Biological Diversity* (2016)
43 Ibid.
44 Government of the Republic of Trinidad and Tobago, *Trinidad and Tobago Millennium Development Goals Report* (2014).
45 Government of the Republic of Trinidad and Tobago, *Trinidad and Tobago's 5th National Report of Trinidad and Tobago to the United Nations Convention on Biological Diversity* (2016).

Forest Types

The predominant forest in Trinidad and Tobago is seasonal evergreen which accounts for 82,410 hectares or 36.4 percent of the total. According to the 5th National Report to the Convention on Biological Diversity[46] 55.2 percent of the total forested area of Trinidad and Tobago is seasonal evergreen.[47] The two main species of canopy trees in the lowland areas are the *Carapa guianensis* (Crappo) and *Eschweilera subglandulosa* (Guatecare). Tropical evergreen sub-montane and montane forests occur in the Northern Range of Trinidad. There are about 14,092 hectares of fragmented swamp forests and mangrove relics around the coast. **TABLE 1.19** and **TABLE 1.20** show the total forested area (Ha) by forest class and the total forests (including total secondary forests) for the period 1970–2010, respectively.

According to the FAO Report (2010) all lands lost from forests are categorised as 'Other areas within forests'. The subset of data (**TABLE 1.19**) highlights the rate of loss of forested areas over the period 1970–2010. Also, according to the FAO Report (2005) the estimated annual deforestation rate between 1990 and 2000 in Trinidad and Tobago was 2,000 hectares or 0.8 percent of the forest area.

Major factors influencing the loss of forests in Trinidad and Tobago are improper land use from agricultural practices on hillsides, housing developments on mountains, non-legal settlement (squatting), commercial or illegal felling of trees, forest fires and natural disasters such as hurricanes.[48]

TABLE 1.20 Total Secondary Forests for the Period 1970–2010 | *Source: Food and Agriculture Organization of the United Nations, Forestry Department, Global Forest Resources Assessment Country Report for Trinidad and Tobago, 2010* ▼

Year	Total Forested Area (Ha)	Total Secondary Forest (Ha)	Secondary Forests as a % of Total Forested Area
1970	256,346	22,650	8.84
1990	240,726	20,467	8.50
1994	237,863	20,831	8.76
2000	233,570	19,921	8.53
2005	229,989	19,466	8.46
2010	226,413	19,012	8.40

Planted Forests

The total area of planted forest was estimated at 20,306 hectares in 2010. Of this, 15,000 hectares were under *Pinus caribaea* (Caribbean Pine) and *Tectona grandis* (teak) which was introduced from Myanmar in 1913. The remaining 5,306 hectares were cultivated with other commercial forest species. Planted forests constitute about 8.97 percent of Trinidad and Tobago's total forested area.

Forest Fires

Forest fires are a perennial problem of the annual dry season when bush fires destroy hundreds of hectares of forest as a result of land-clearing for agriculture and general negligence. **TABLE 1.21** provides statistics on forest fires in Trinidad from 1987–2018.

Sustainable Forest Management (SFM) Policy Framework

The Republic of Trinidad and Tobago has long had a systematic approach to SFM. Examples of this are its application of block management and shelterwood systems for over 60 years. However, it lacks a system of Criteria and Indicators (C&I) suited to its needs which is an important part of any SFM policy framework. The GoRTT is moving to modernise its approach to SFM with the recent adoption of the National Forest Policy which seeks to redress some of the shortcomings through streamlined institutional arrangements and updated regulatory frameworks.

46 Ibid.

47 Food and Agriculture Organization of the United Nations, *Global Forest Resources Assessment 2010: Country Report: Trinidad And Tobago* (2010).

48 Government of the Republic of Trinidad and Tobago, *Second National Communication of the Republic of Trinidad and Tobago Under the United Nations Framework Convention on Climate Change* (2013).

TABLE 1.21 Forest Fires in Trinidad from 1987–2018
Source: Forestry Division ▼

Year	Number of Fires	Area Burnt (Ha)	Average Area Burnt (Ha)
1987	502	21,420.00	42.67
1988	583	5,495.00	9.43
1989	146	970.00	6.64
1990	234	1,100.00	4.70
1991	229	680.00	2.97
1992	431	2,710.00	6.29
1993	228	1,570.00	6.89
1994	256	2,600.00	10.16
1995	516	7,745.00	15.01
1996	178	2,664.00	14.97
1997	156	446.00	2.86
1998	764	10,289.00	13.47
1999	167	988.00	5.92
2000	91	927.00	10.19
2001	464	5,309.00	11.44
2002	62	273.00	4.40
2003	347	4,723.00	13.61
2004	136	1,493.00	10.98
2005	270	1,696.00	6.28
2006	210	1,245.80	5.93
2007	452	3,566.50	7.89
2008	226	1,534.10	6.79
2009	133	544.10	4.09
2010	754	12,477.80	16.55
2011	42	101.00	2.40
2012	58	205.20	3.54
2013	533	2,786.50	5.23
2014	310	2,342.68	7.56
2015	497	3,367.67	6.78
2016	467	4,195.70	8.98
2017	498	4,734.13	9.51
2018	218	1,829.64	8.40
2019	288	2,003.8	6.96
TOTAL	**10,446**	**114,032.6**	**10.92**

Relevant Environmental Management Policies and Programmes

Trinidad and Tobago has a number of environmental management programmes. These are:

National Environment Policy (2018)

The NEP provides the overarching framework for environmental management. Subsequent national and sectoral policies with bearing on environmental or natural resource management; detailed procedures on environmental management; and concrete actions towards environmental sustainability in Trinidad and Tobago will therefore be grounded in the principles and broader approaches embodied in this NEP. The achievement of policy actions will be driven by the action of each citizen across the public, private, governmental, and non-governmental sectors.

The NEP includes:

- Environmental priorities for Trinidad and Tobago. There are six priority areas delineated:
    1. Protecting Environmental & Human Health through Pollution Control
    2. Sustainably Managing Natural Assets
    3. Improving the Local Environment
    4. Evolving a Greener Economy
    5. Fostering an Environmentally Responsible Society
    6. Addressing Climate Change & Environmental and Natural Hazards
- Implementation and mainstreaming framework to achieve policy actions
- Monitoring and evaluation of the NEP and action plan

National Integrated Water Resources Management Policy (2017)

Its goals include, among others, the integration of water resources management to contribute to sustainable development and the protection of environmental quality and ecological systems. Some of the key activities proposed under the Watershed Management Policy are:


Photo Credit: Kishan Ramcharan

▲ Forest fire at Caribbean Pine plantation, Trinidad, 2019

- the prevention of the conversion of forest reserve to other uses;
- protection of critical watershed areas including source protection, restoration, conservation, flood buffers, slope stabilisation, intake protection, sedimentation reduction;
- establishment of zoned uses for critical watersheds;
- promotion of ecologically and technologically appropriate agro-forestry, soil conservation, reforestation;
- development of approaches to control negative practices such as quarrying and deforestation; and
- development of a programme to address non-point pollution from storm water, agricultural runoff and septic tanks.

National Wildlife Policy (2013)

The National Wildlife Policy was formally approved by Cabinet in December 2013. It provides guidance on the sustainable management of undomesticated animals and plants, whether introduced, resident or migratory, their parts or derivatives, and their habitats.

Wildlife management in Trinidad and Tobago has several legally designated protected areas/categories. One such category is the Wildlife or Game Sanctuaries as designated under the Conservation of Wildlife Act (Chap. 67:01). These sanctuaries are intended to protect wild animal species by restricting hunting and collection of animals within and from such sanctuaries (Ministry of Legal Affairs, 2009). The Act prescribes for the facilitation of the development and adoption of appropriate wildlife habitat and species management to produce a stable ecosystem and populations. Strategies include:

- conservation of natural habitats;
- recovery to a safe status of all wildlife species threatened with extinction; and
- management of habitats and migratory wildlife species for their intrinsic scientific and recreational value.

National Protected Areas Policy (2011)

The purpose of this policy is to establish an appropriate framework for the selection, legal designation and management of a national system of protected areas. The three objectives pursued in designating and managing protected areas are:

- to conserve the country's natural heritage, genetic, species and ecosystem diversity, evolutionary and ecosystem processes and biogeochemical processes;
- to conserve the country's cultural and historical heritage; and
- to optimise the contribution of protected areas to sustainable livelihood and human well-being, including opportunities for education and recreation.[49]

National Forest Policy (2011)[50]

The purpose of the National Forest Policy is to guide the sustainable management of the forest resources of Trinidad and Tobago, including the use of these resources and the impacts and consequences of these resources.

The policy objectives include:

- optimising the contribution of forest resources to livelihoods;
- enhancing native genetic, species and ecosystem diversity; and
- maintaining and enhancing the natural productivity of forest ecosystems (watershed functions, catchment area functions, etc) to provide important ecosystem services.[51]

National Climate Change Policy 2011

The National Climate Change Policy was laid in Parliament in 2011 and seeks to address, inter alia, the impacts of climate change including sectoral vulnerability and mitigation potential in major emitting sectors; current and proposed legislation related to mitigation and the identification of gaps in the legislation; and finally a Strategy and Action Plan.

The objectives of the National Climate Change Policy include:

- Reducing or avoiding greenhouse gas emissions from all emitting sectors;
- Enhancing carbon sinks;
- Protection of the natural environment and human health;
- Conserving and building resilience of human and natural systems to adapt to the adverse impacts of climate change including through capacity building, the application of cleaner and energy efficient technologies and relevant research and development;
- Enhanced agricultural production and food security;
- Educating the wider public on the potential impacts of climate change and the recommended adaptation strategies;
- Conserving and guaranteeing a sustainable supply of potable water.

The National Climate Change Policy (2011) made provisions for revision after five years therefore, the intent is to have a revised Policy by mid-2022. The revision which will take into consideration the new commitments of Trinidad and Tobago to the Paris Agreement of the UNFCCC inclusive of the commitments made in the NDC, the results of national risk and vulnerability assessments as well as the latest science from the Intergovernmental Panel on Climate Change (IPCC) and other recognised bodies.

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49 Government of the Republic of Trinidad and Tobago, *National Protected Areas Policy* (2011).
50 Government of the Republic of Trinidad and Tobago, *National Forest Policy* (2011). http://www.biodiversity.gov.tt/home/legislative-framework/policies/national-forest-policy-2011.html.
51 Ibid.

Photo Credit: Tobago House of Assembly

▲ Desilting of the Goldsborough River, Tobago, 2021

National Tourism Policy of Trinidad and Tobago (2010)

This policy acknowledges global warming impacts on climate change and its potential for negatively affecting the tourism industry. The effects of climate change can be manifested in the form of beach erosion, coral bleaching, water and food shortages, ecosystem collapse, sea level rise and extreme weather events.

The National Tourism Policy Goals are sustainably based, people-centered, innovation and investment-driven, and supported by the private sector.[52]

National Policy and Programmes on Wetland Conservation for Trinidad and Tobago (2002)

Trinidad and Tobago acceded to the Ramsar Convention on Wetlands in April 1993. This international Convention which currently has 130 Contracting Parties at present is an inter-governmental treaty aimed at conserving wetlands of international importance. Trinidad and Tobago's accession to the Convention on Wetlands signalled to the world its commitment to promoting the wise use of its wetlands.

In January 1995, Trinidad and Tobago established a National Wetland Committee with representatives of relevant Government ministries and non-governmental organisations. The result of the committee's work was the National Wetland Policy for Trinidad and Tobago for guiding the integration of wetland conservation and wise use into national planning. The policy was approved by Cabinet on 11 July 2001.

52 Ministry of Tourism, *National Tourism Policy of Trinidad and Tobago* (2010).

Photo Credit: Kishan Ramcharan

▲ Teak Plantation, Bunsee Trace, Penal, Trinidad, 2019

The policy also requires that the government protect, manage and restore wetlands in order to sustain and enhance their ecological and socio-economic values for future generations.

Some of the major objectives related to the protected wetland areas include:

- the encouragement of public protection of outstanding examples of wetlands in private ownership;
- persuading the management of all privately-owned wetlands to promote the protection of their functions;
- promoting the use of publicly-protected wetlands as examples for education and awareness; and
- integrating the management of wetlands with watershed and catchment area management.[53]

Three sites have so far been declared Ramsar Sites: the Buccoo Reef/Bon Accord Lagoon in Tobago and, in Trinidad, the Caroni Swamp and the Nariva Swamp Managed Resource Protected Area which was also declared an Environmentally Sensitive Area in 2006. Together they have a combined acreage of 15,919 hectares (Ramsar Sites, 2012).

National legislation—both draft and in force—relevant to climate change issues include the following:

- Air Pollution Rules 2014
- Water Pollution Rules (2019)
- Draft Waste Rules 2018 and the Waste Management (Registration and Permitting) Rules 2018
- Certificate of Environmental Clearance Rules (2001)
- Environmentally Sensitive Areas Rules (2001)
- Environmentally Sensitive Species Rules (2001)

53 Government of the Republic of Trinidad and Tobago, *National Policy and Programmes on Wetland Conservation for Trinidad and Tobago* (2002).

Photo Credit: Kishan Ramcharan

▲ Caribbean Pine plantation, St Michaels Hillside, Tacarigua, Trinidad, 2019

1.10 Development priorities and objectives

The National Development Strategy (NDS) more familiarly known as Vision 2030 aims to address the development issues and challenges being faced by Trinidad and Tobago such as crime, an ageing population, the impacts of climate change, loss of biodiversity, pollution, degradation of ecosystems, flooding, poor service delivery, and a greater need for transparency and accountability. The NDS aims to address these developmental challenges in establishing the foundation for catapulting the country onto a path of sustained economic and social progress. The NDS articulates the broad policy framework for development, the national vision to 2030 and national development priorities, and the main strategic initiatives for achieving them. The NDS outlines the following five key themes for development which are in strong alignment with the Sustainable Development Goals (SDGs) of the United Nations:

1. Putting people first: Nurturing our greatest asset
   - Goal 1. Grounding the society in principles of social justice
   - Goal 2. Improving Social Services Delivery to better serve the needs of vulnerable groups
   - Goal 3. Providing citizens with access to adequate and affordable housing
   - Goal 4. Building a national healthcare system that is sustainable, modern and delivers higher standards of healthcare
   - Goal 5. Empowering the population to lead healthy lifestyles
   - Goal 6. Protecting and supporting families
   - Goal 7. Creating a modern, relevant national education and training system

2. Delivering good governance and service excellence
   - Goal 1. Grounding the society in the principles of social justice.
   - Goal 2. Transforming the Public Service through modern, effective and efficient management systems
   - Goal 3. Delivering customer-focused public service
   - Goal 4. Modernising the country's legal, regulatory and law enforcement systems

3. Improving quality infrastructure and transportation
   - Goal 1. Building a safe and operationally efficient transport system
   - Goal 2. Improving the management of the public utility system with better access for all
   - Goal 3. Creating an inter-connected, well maintained transport infrastructure
   - Goal 4. Implementing a modern and well-maintained ICT system

4. **Building globally competitive businesses**
   Goal 1. Maintaining macroeconomic stability
   Goal 2. Developing a business environment that is conducive to entrepreneurship
   Goal 3. Making Trinidad and Tobago a more attractive destination for investment and trade
   Goal 4. Manufacturing high-value products and services with which the private sector can compete in export markets

5. **Placing the environment at the centre of social and economic development**
   Goal 1. Strengthening of environmental governance and management systems
   Goal 2. Reducing the national carbon footprint
   Goal 3. Assessing the national vulnerability to climate change
   Goal 4. Implementing comprehensive waste and pollution management systems
   Goal 5. Improving natural resource management

The NDS provides the overarching framework for policy and strategy development in Trinidad and Tobago. All sectoral policies and supporting legislation are expected to be congruent with it.

A number of national policies and strategies have been updated or are under revision or development in order to achieve the above goals. These include, inter alia, the following:

1. National Environmental Policy (2018)
2. National Climate Change Policy (2011, being revised)
3. Carbon Reduction Strategy (2015)
4. Nationally Determined Contribution and its Implementation Plan
5. Just Transition Policy (under development)
6. National Tourism Policy (draft)
7. Trinidad and Tobago Trade Policy (2019)
8. National Consumer Policy for Trinidad and Tobago (2018)
9. Integrated Coastal Zone Management Policy (draft)
10. National Guidelines for Trinidad and Tobago's Air Conditioning and Refrigeration Sector (2018)
11. National Biodiversity Strategy and Action Plan for Trinidad and Tobago (2017)
12. National Performance Framework (2017–2020)
13. Trinidad and Tobago's National ICT Plan ICT Blueprint (2018–2022)
14. National Policy on Gender and Development—A Green Paper (2018)

Progress towards the Sustainable Development Goals

In 2020, at the United Nations High Level Political Forum, Trinidad and Tobago presented its first Voluntary National Review on Sustainable Development (Ministry of Planning and Development, 2020c). This report gives an account of the country's progress towards sustainable development through accounting for the SDGs as enshrined in Vision 2030. The VNR's SDG Progress Snapshot is provided in **FIGURE 1.22**.

Challenges

1. **Dependence on oil and natural gas and oil–gas price cycle:** The economy remains highly dependent on oil and natural gas. Thus, while Trinidad and Tobago benefits from rising oil and natural gas prices, it is also severely affected when these prices collapse. The dependence on oil and natural gas has had the perverse effect of compromising growth and development of the non-energy economy which is heavily oriented toward imports of consumption and intermediate goods, with a few exceptions in food and beverage manufacture.
2. **Ageing population and migration:** Trinidad and Tobago has an ageing population whose median age is 32.6 years and with 13 percent of the total population being 60 years and over. Further, Trinidad and Tobago's popularity as a migrant destination is placing greater pressure on state resources.
3. **Food security and sustainability:** Trinidad and Tobago imports the bulk of its food and is

3 GOOD HEALTH AND WELL-BEING

Significant enhancements have been made to infrastructure to support the universal healthcare system, with parallel improvements in the number of physicians and nursing professionals. The Policy for Treating with Non-Nationals with respect to the Provision of Public Healthcare Services outlines the services made available to migrants.

4 QUALITY EDUCATION

The free and compulsory primary and secondary education systems have been modernised, through the introduction of a School Learning Management System and School-Based Management Standards to drive education outcomes.

5 GENDER EQUALITY

The National Policy on Gender and Development, being implemented by the Office of the Prime Minister (Gender and Child Affairs Unit), helps to eliminate barriers and promote gender equality. Major achievements include the Marriage Act, 2017 which abolished child marriages, and the establishment of a National Workplace Policy on Sexual Harassment.

8 DECENT WORK AND ECONOMIC GROWTH

The economy has steadily recovered following the crash in oil prices in 2014. The year-on-year change in Gross Domestic Product (GDP) moved from -6.3 per cent in 2016 to -0.2 per cent in 2018. The reduction of Government expenditure from TT$61.9 billion in 2014 to TT$50.5 billion in 2019 formed part of prudent fiscal management during a period of severely constrained fiscal environment. The Government of Trinidad and Tobago plays a significant role in promoting decent work through a number of strategic objectives. These include fostering decent working conditions, strengthening labour oversight bodies, modernisation of labour legislation and the further development of policies and initiatives toward the realisation of the Decent Work Agenda.

10 REDUCED INEQUALITIES

Support for the social sector and protection of the most vulnerable citizens is augmented through the National Social Mitigation Plan 2017-2022 and the development of a National Policy on Persons with Disabilities.

13 CLIMATE ACTION

Trinidad and Tobago's Nationally Determined Contribution (NDC) commitment aims to achieve a reduction in emissions from three sectors - electricity generation, industry and transportation - by 15% by 2030 from business as usual (BAU), and an unconditional reduction in public transportation emissions by 30%, compared to 2013, by 2030.

16 PEACE, JUSTICE AND STRONG INSTITUTIONS

Trinidad and Tobago constantly strives to devise and implement multi-dimensional solutions to strengthen capacities towards achieving long-lasting peace and safety in society. To provide greater protection, the Trinidad and Tobago Police Service established the Gender-Based Violence Unit while the Judiciary established the Children's Court System.

17 PARTNERSHIPS FOR THE GOALS

Civil society organisations lead the way on partnerships for the implementation of the SDGs, through initiatives such as the CSOs for Good Governance Project, SDG Catalyst Network and the SDG Knowledge Platform.

FIGURE 1.22 Trinidad and Tobago Sustainable Development Goals progress snapshot
Source: Trinidad and Tobago Voluntary National Review, p. 8

subject to the volatility of international commodity prices.

4. **Low productivity:** In many areas of national life, in both private and public sectors, productivity is demonstrably low. This affects the country's competitiveness, not only by increasing the cost of production but also by increasing the cost of doing business.
5. **Dependency and entitlement:** The response of public policy to the inadequate pace of private sector job creation and lack of diversification has been to institute "make work" programme to provide temporary employment. The number of such programmes has increased whilst the number of persons engaged in them has also increased. The unintended consequence of this is increased dependency and notions of entitlement.
6. **Weak institutions:** There are weaknesses in many public institutions such as the Police Service, Prisons Service, Immigration, Customs, and Land Management.
7. **Crime and criminality:** Trinidad and Tobago has been plagued by high rates of serious crimes,

especially murders, some of which are linked to domestic violence, gang activity and the drug trade. The policing response has been inadequate and the criminal justice system has also not adjusted to meet the challenge of rising crime due to resource and system inadequacies.

8. **Climate change and natural resources management:** As a Small Island Developing State, Trinidad and Tobago is particularly vulnerable to the impacts of climate change. This vulnerability is amplified by the inability to reap the benefits of economies of scale and its dependence on oil and natural gas. Various pollution issues affect the country, such as air, water and sea pollution.
9. **Rapid advances in technology:** With the exception of the energy sector, Trinidad and Tobago does not produce significant quantities of technologically advanced goods, services and exports. The country is hindered by low adoption rates of ICT services in the government and business sector and the absence of a proper legal and regulatory framework for ICT goods and services.
10. **Managing a diverse society:** Significant challenges remain in managing a society which is very diverse in terms of class, religion, culture and ethnicity. Political and social consequences often arise because of perceived bias and allegations of unfairness as everyone may not have the same access to opportunities or have their issues and challenges addressed.

1.11 Priorities related to mitigation of climate change

Trinidad and Tobago has begun the development of its long term strategy. Business-as-usual projections to 2050 have been developed for the major emitting sectors (power generation; transportation; industry; waste; and AFOLU (agriculture, forestry and other land use). Mitigation intervention options have also been identified with the long term aim of achieving carbon neutrality in the second half of the century.

Trinidad and Tobago submitted its Nationally Determined Contribution under the Paris Agreement in 2015 with the stated aim of achieving an overall reduction of 15 percent in cumulative emissions from the power generation, transport and industry sectors by 2030 from business-as-usual or 103 MtCO2e, conditional on international financing. It also committed to unconditionally reducing (through domestic financing) its public transportation cumulative emissions by 30 percent or 1.7 MtCO2e by 2030.

Power generation, transport and industry are the three main emitting sectors of the economy as evidenced from the most recent greenhouse gas inventory (see Chapter 2) and, as such, are the priority areas for mitigation. Although business-as-usual emissions projections have been developed for the other emitting sectors, data quality remains a challenge including the collection of relevant activity data to facilitate estimates of their emissions and, by extension, to formulate meaningful mitigation options. However, some interventions have already been identified, including waste recycling, reduced use of plastics and research into waste-to-energy which is already underway.

To facilitate the implementation of the National Climate Change Policy, as well as the tracking of the NDC, the required administrative, institutional, policy and legislative framework is being addressed through the following:

1. Incorporation of NDC objectives and low carbon development into the national development process framework
2. Cabinet appointment of a high-level Ministerial committee to provide high-level guidance to NDC implementation, supported by a technical advisory committee on NDC achievement and implementation
3. Development of an NDC Implementation Plan to guide the committees cited above
4. Development of a Financial Investment Plan to identify financial options for implementing the NDC and guide the aforementioned committees
5. Development, testing and operationalisation of a national mitigation monitoring, reporting, and verification (MRV) system supported by a

Knowledge Management System (KMS) as the main depository of data and information. The MRV/KMS systems are also being enhanced to incorporate the enhanced transparency framework of the Paris Agreement in order to ensure compliance with the Agreement. These systems will track NDC implementation, mitigation actions and their efficacy, as well as support received.

6. Incorporation of the MRV/KMS system into law in order to mandate the reporting of greenhouse gas emissions and the submission of mitigation, monitoring and evaluation plans by all emitting entities. To this end, training has been conducted to ensure the highest quality assurance of data supplied, and once satisfied, emissions data will be uploaded into a public registry to ensure transparency.
7. Training in data collection protocols and quality assurance procedures to improve data quality in the AFOLU and waste sectors
8. Development of an e-mobility policy by mid-2021 to address emissions in the transportation sector
9. Development of a Just Transition of the Workforce Policy around mid-2021 which has already had the benefit of wide stakeholder consultation, including on gender issues
10. A technology needs assessment for NDC, including a barrier analysis which is expected to be completed by mid-2021
11. Capacity-building of civil society organisation through education, awareness and training

The enhanced MRV/KMS system will also enable Trinidad and Tobago to track the implementation of its National Climate Change Policy in pursuit of a low carbon trajectory. In this regard, the policy is being updated to incorporate the provisions of the Paris Agreement. This is expected to be completed by mid-2021. The updating process is being conducted with the widest possible stakeholder involvement, particularly those identified in the preamble of the Paris Agreement. Stakeholder engagement is conducted primarily thorough the climate change focal point network, which is an interactive platform that hosts representatives from government ministries and agencies, non-governmental organisations, civil society organisations, the private sector, industries, fiduciary organisations, and trade unions.

Notwithstanding the above initiatives undertaken and the progress being made in reducing emissions by 31,509 tonnes in the transportation sector in line with the unconditional component of the NDC (see case study 1.1 on transportation fuel switching), challenges remain. These include economic diversification away from a fossil fuel-based economy, mainstreaming climate change into sectoral policies, and financing mitigation activities. Trinidad and Tobago already generates all of its power from natural gas, and efforts to further reduce emissions from this sector are being pursued, including through increased generating efficiency and an accelerated deployment of renewable energy.

To this end a utility-scale solar energy plant is being planned, with a generating capacity of 112.5 MW which would make it among the largest in the Caribbean. Additionally, solar energy is to be deployed at Piarco International Airport and through selected rural and urban installations which will serve as demonstration projects (see case studies 1.2 and 1.3).

As the country aims for a low carbon development trajectory while maintaining its vibrant industrial base, other initiatives are being pursued. These include the development of a hydrogen-based industry, given the country's industrial and manufacturing experience and research conducted by national universities on the potential for carbon capture (use) and storage with a view to identifying additional mitigation potential in the industrial sector.

Various other national policies also support mitigation through the conservation and preservation of natural ecosystem sinks, such as coastal mangroves and inland forests.

Quantifying these reservoirs should become more precise with the development and implementation of appropriate quality assurance and data collection procedures. The other challenges should be overcome, at least in part, through the implementation of an effective administrative, institutional, policy and legislative framework.

Photo Credit: Institute of Marine Affairs

▲ Alcan Bay—Freddy Bait Fisher, Trinidad, 2009

▼ Maracas Bay, Trinidad, 2019

Photo Credit: Kishan Ramcharan

Case Study 1.1 Fuel Switching in Transportation

While Compressed Natural Gas (CNG) is the cleanest fossil fuel for transportation it is recognised as a transitionary fuel as the country moves towards a sustainable transportation paradigm. To facilitate the transition, Trinidad and Tobago has embarked on a state-funded fuel switching programme at a cost of approximately 72 million USD to encourage the switch to CNG.

With the closure of the country's only oil refinery, CNG is now the only locally-produced fuel as well as the cleanest vehicular fuel available locally. Its price of approximately 15 cents US per lge also makes it particularly attractive to cost-conscious customers. The target market for CNG is high mileage users in the public transportation sector such as maxi-taxis and other mini buses, taxis and public buses. The public is also being encouraged to convert through a sponsored conversion strategy for switching vehicles from liquid fuels (gasoline, diesel) to CNG. To further incentivise the conversions, the government will launch a financing initiative through at least two financial institutions under which motorists will have access to small loans to make their vehicles CNG-ready. This will eliminate the need for sponsored conversions.

The number of conversions has been growing at a rapid rate.

In 2018, CNG litre sales grew by 48 percent over 2017 with accelerated growth. In 2019, sales more than doubled over 2018 with an increase of 106 percent. In 2020, despite the impact of Covid-19, CNG sales grew by a further 24 percent over 2019.

Such continuous growth has been achieved despite several implementation challenges including an inadequate network of CNG service stations and a lack of public awareness regarding the benefits of CNG, including its environmental and climate benefits.

Current implementation activities include:

1. the construction of 22 CNG stations with a target of serving approximately 18,055 vehicles powered by natural gas by the end of 2021 (sedan equivalents); and
2. conversion of existing liquid fossil fuel vehicles.

To date the following have been achieved:

1. the expansion of over 900 percent in Natural Gas Vehicles (NGV) between 2014 and December 2020 during which the number of vehicles grew from 1,522 vehicles to approximately 10,000
2. the equipping of 18 service stations to supply CNG, with a target of 22 stations by the end of 2021
3. reduction of approximately 31,509 tonnes of carbon dioxide has been achieved to date.

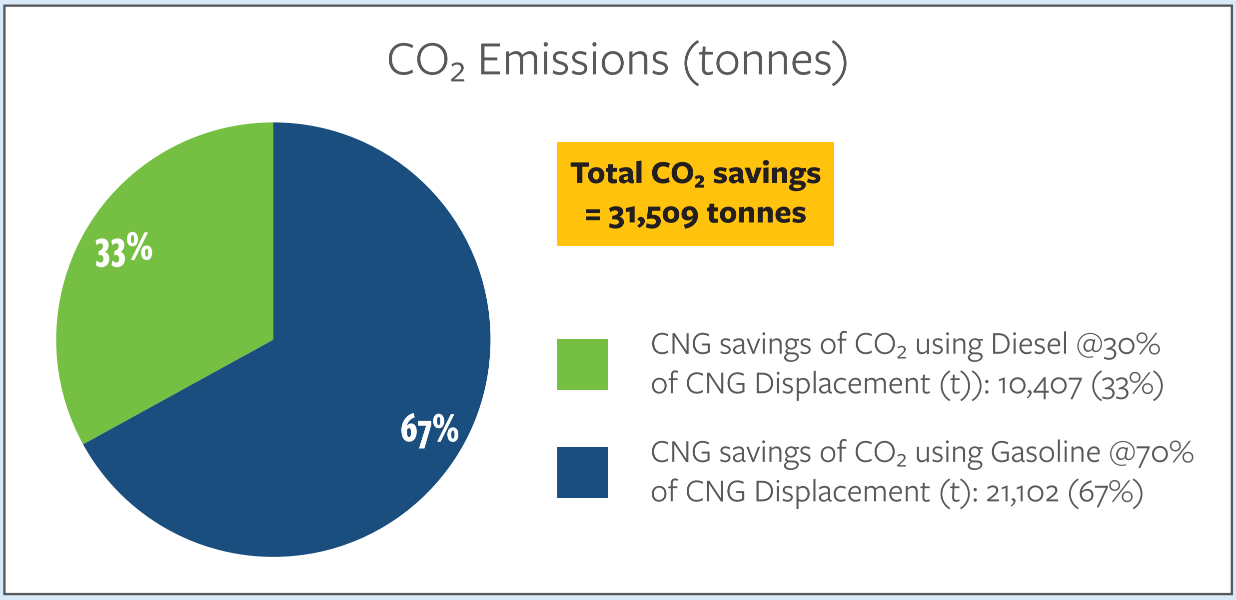


FIGURE 1.23 Total CO_2 savings from CNG usage

Case Study 1.2 Renewable Energy Through Solar Power—Pilot Project

Background

The Global Climate Change Alliance Plus (GCCA+) is a European Union (EU) flagship initiative that helps climate vulnerable countries address and increase resilience to climate change. The overall objective of the GCCA+ Project is to assist Trinidad and Tobago in the achievement of its commitments to the global community under the Paris Agreement, as laid out in its Nationally Determined Contribution (NDC). Specifically, the project is designed to increase the availability and use of energy from renewable sources and improve efficiency levels in the consumption of energy. Funded by the EU and implemented by the UNDP, this €2.4 million project was launched in November 2019 and is expected to be rolled out over the 42 months to April 2023.

The uptake of renewable energy in Trinidad and Tobago is challenged by:

» **Low and subsidised electricity rates:** This discourages the adoption of energy efficiency measures and creates a viability gap for generating renewable energy.

» **Inadequate policy and legislative framework:** These include gaps in current policies and regulations such as lack of appropriate incentives for generating renewable energy as well as for small-scale renewable energy producers connected to the grid etc.

» **Capacity gaps in technical expertise for solar energy generation and maintenance:** This is relative to the projected needs of scaled-up renewable energy generation.

» **Lack of awareness of the benefits of renewable energy:** A public that is better informed on the subject would be more motivated to seek out the economic, social and environmental advantages of renewable energy and energy efficiency.

» **Solar technology is new in the local context** and the business model for scale-up still needs to be fully established in T&T.

This project will address the barriers to the implementation of renewable energy through incremental interventions encapsulated in a strategy with four (4) main outputs:

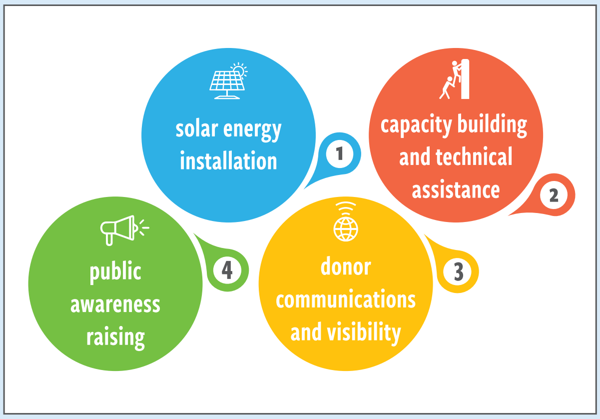


FIGURE 1.24 Project Outputs ▲

1. Installation of solar energy systems in public utilities and remote communities with the increased capacity to maintain solar power systems.
2. Support to the implementation of the new, RE/EE-conducive policy, legislative and regulatory framework.
3. Public awareness-raising on energy efficiency, correct pricing, and renewable energy.
4. Donor Communications and Visibility.

Twelve sites, representing a cross-section of non-governmental, community-based, and environmental conservation organisations were chosen based on specific criteria for small-scale, roof-mounted, solar photovoltaic (PV) installations. Apart from the carbon emissions avoided nationally, beneficiaries of this pilot installation will realise greater energy efficiency with reduced carbon emissions and will be supported by the upskilling of local technical assistance teams through capacity-building and specialised know-how to maintain the installations.

Raising public awareness is a critical aspect of the project and once installations are complete, they will become live reference points for others who may wish to adopt similar approaches to power generation and energy efficiency. Interactions at the community level and contributions to the national agenda to progress renewable energy are key deliverables that will signal the project's success and progress towards achieving T&T's NDC.

Case Study 1.3 Solar Park at Piarco International Airport

The Airports Authority of Trinidad and Tobago ("the Authority") is currently implementing a Solar Park at the Piarco International Airport (PIA), Trinidad and Tobago. This Solar Park, which is funded by the European Union, will produce renewable energy at a minimum of 1,443,830 kWh annually and potentially avoid 1,010 tonnes of CO_2 emissions annually. The project is supported by the European Union's Global Climate Change Alliance Plus (GCCA+) programme in Trinidad and Tobago.

Background

The Airports Authority's Strategic Plan has, as one of its main objectives, the upgrade of airport operations to the highest standards through enhanced systems and processes that ensure environmental compliance. The installation of a Solar Park is one project among several environmentally friendly initiatives and strategic approaches to mitigate the negative effects of climate change, and to reduce energy costs.

The appeal of the Solar Park was enhanced by the desire to contribute to Trinidad and Tobago's Nationally Determined Contribution (NDC). This project improves Trinidad and Tobago's resilience to climate change by introducing renewable energy as an energy source for electricity generation not only to the airport but to the country.

Context

The Solar Park, which will be located just north of the PIA, emanated from a feasibility study which was supported by the International Civil Aviation Organization (ICAO) and the EU. The study focused on capacity-building for CO_2 mitigation from international aviation and the use of renewable energy sources within the aviation sector in Trinidad and Tobago.

The Solar Park is expected to produce a minimum annual generation capacity of 1,443,830 kWh with the potential to avoid an annual emission of 1,010 metric tonnes of CO_2. The power produced from the site is expected to contribute to 7.1 percent of the Authority's current annual electrical consumption with capacity for future expansion, and facilitated through ground-mounted, hurricane (category 5) proof solar panels.

The Authority has been actively taking strides, supported by the EU, to commit to climate action initiatives in fulfilment of its corporate social responsibility to the environment and to future generations.

Project Objectives

The project objectives are:

5. the supply of solar-generated power to the Authority's estate power distribution system, effectively producing renewable energy at a minimum of 1,443,830 kWh annually;
6. the reduction of fossil fuel-based electrical consumption and its associated cost, resulting in a reduction in CO_2 emissions of at least 1,010 tonnes of CO_2 annually;
7. increased communication and visibility on reduction of carbon emissions through improved Corporate Social Responsibility programmes.

Key Messages

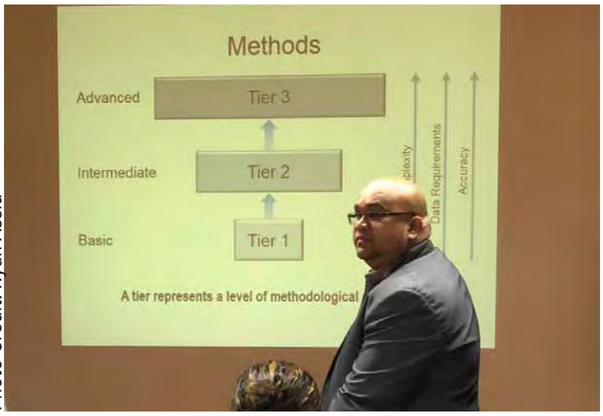
- The Solar Park will generate a clean, sustainable, green, renewable source of energy that is key to fighting climate change.
- The Solar Park project contributes towards the achievement of Trinidad and Tobago's NDC, and also to its goals to reduce the aviation carbon footprint as laid out by the ICAO.
- The EU supports Trinidad and Tobago in the implementation of a solar park as a climate action initiative.
- The Solar Park project at PIA is one of the major projects for renewable energy in Trinidad and Tobago.

2

THE NATIONAL GHG INVENTORY

(GREENHOUSE GAS EMISSIONS AND REMOVALS)

Photo Credit: Ryan Assiu



▲ Dr. Donnie Boodlal, GHG Consultant, delivering GHG Inventorying Training modules, September 25–28, 2018

Photo Credit: Ryan Assiu

▲ Cross section of participants in attendance at the GHG Inventorying Training Workshop, September 25–28, 2018

2.1 Introduction

This chapter provides an overview of Trinidad and Tobago's national Greenhouse Gas (GHG) emissions levels and the approaches used to estimate them. The information is reported in accordance with the accounting principles of Transparency, Accuracy, Consistency, Completeness and Comparability (TACCC) as stated in article 4.13 of the Paris Agreement.

This process identifies gaps for further action and capacity-building while the level of transparent reporting on the processes and experiences provides learning opportunities.

The United Nations Framework Convention on Climate Change (UNFCCC) Decision 2/CP.17 recommends that the Revised 1996 Intergovernmental Panel on Climate Change (IPCC) Guidelines be used for compiling GHG Inventories of non-Annex I Parties. However, for this inventory, Trinidad and Tobago utilised the IPCC 2006 Guidelines which improve on the 1996 IPCC Guidelines by providing more up-to-date default factors and detailed guidance for many inventory categories. Since the reporting on indirect GHGs, such as non-metallic volatile organic compounds, is not mandatory, these were not included due to data limitations.

The time series reported in this inventory is the period 2006–2018. This fulfills the mandate that the latest inventory year of the time series be no more than four years earlier than the current reporting year. In this case, the latest reporting year (2018) is within four years of the current reporting year 2021.

2.2 Overview of Current Inventory Management System

For the compilation of this inventory, no formalised national inventory management team was as yet established; however, the Ministry of Planning and Development acted as a coordinating entity to facilitate the required data collection and management since the country's MRV/KMS system was being developed and tested. The following are some of the key elements of the process:

- A GHG consultant was procured by the United Nations Development Programme (UNDP) and the Ministry of Planning and Development (MPD) to conduct the national GHG inventory for T&T from 2006–2018 using the IPCC 2006 Guidelines. The consultant's Terms of Reference (ToR) included the preparation of this chapter.
- The consultant reported to a Steering Committee which represented a wide cross-section of stakeholders from the UNDP, academia, Government and NGOs along with various sectoral experts. One of the Committee's responsibilities was to monitor tasks in line with the ToR to ensure that the deliverables were being achieved.
- The project had a designated project manager who facilitated all communications between the consultant and Steering Committee members. In addition, the Ministry of Planning and Development was responsible for coordinating and archiving data and documents related to the GHG inventory.

- The GHG consultant served as technical lead across all four sectors mentioned in the 2006 IPCC Guidelines (Energy, Industrial Processes & Product Use [IPPU], Waste, and Agriculture, Forestry & Other Land Use [AFOLU]).
- The consultant was responsible for quality control, key category analysis and uncertainty estimations.
- The results, assumptions and expert judgements were shared with sectoral experts and modified as required, based on feedback.
- GHG Inventory training sessions for capacity-building were conducted for key sectoral stakeholders and regulators. The training objective was to begin institutionalising the GHG Inventory process and procedural elements in preparation for the formalisation and full operation of the MRV/KMS system and, by extension, the next inventory cycle.
- The final draft inventory was subjected to an independent QA/QC analysis by a competent third party.

2.3 Inventory Overview: Scope and Methodology

This is Trinidad and Tobago's first BUR, with inventory estimates reported for the time series 2006–2018. This period continues from the last reported inventory year (2007) in the Second National Communication (SNC). Additional key points to be noted are:

- This chapter was done in conformity with the relevant UNFCCC reporting guidelines to the extent permitted by capacities and national circumstance.
- The inventory estimates were calculated in accordance with the 2006 IPCC Guidelines.
- Estimates were conducted on a gas-by-gas basis for CO_2, CH_4 and N_2O and reported as aggregated GHGs in CO_2 equivalents using the GWPs provided by the IPCC in its Fifth Assessment Report (AR5).
- To the extent capacities permit, emissions from international aviation and marine bunker fuels are also reported separately as a memo item in the inventory.
- For fuel combustion activities, sectoral and reference approaches are reported for all years (2006–2018).
- No recalculations or revisions were performed on the time series from base year to 2005 due to the unavailability of previous data sets and information.
- An uncertainty analysis was done using all default factors which found a level uncertainty of 9 percent and a trend uncertainty of 10 percent for the reported inventory.

Accordingly, the detailed results for Trinidad and Tobago, with all the sector models and comprehensive analyses, are available from the party on request. To accompany this chapter, a Technical Annex is provided with the summary tables.

2.4 Data Collection Methods

A series of meetings was held with the Steering Committee and the Project Management team to comprehensively identify the required activity data sets and relevant providers. The process of identifying requisite data was guided by the methodologies selected, using the decision trees provided in the 2006 IPCC guidelines. Once these data sets were identified the team selected suitable data providers, extracting from their knowledge of stakeholders previous inventory exercises and related projects and experiences. This list of data providers was further refined and updated after various stakeholder consultations and following recommendations from a GHG Inventory Quality Assurance Workshop which was organised by the UNFCCC and the Food and Agriculture Organization (FAO).

Primary data collection commenced incorporating a survey methodology and a request for specific activity data based on the sectoral guidance as outlined in the 2006 IPCC guidelines. Correspondence between the Permanent Secretary of the Ministry of Planning and Development (MPD) and data providers accompanied the requests to assist in easing the flow of the requested data.

During the primary data collection drive, formal written reminders and clarifications were sent

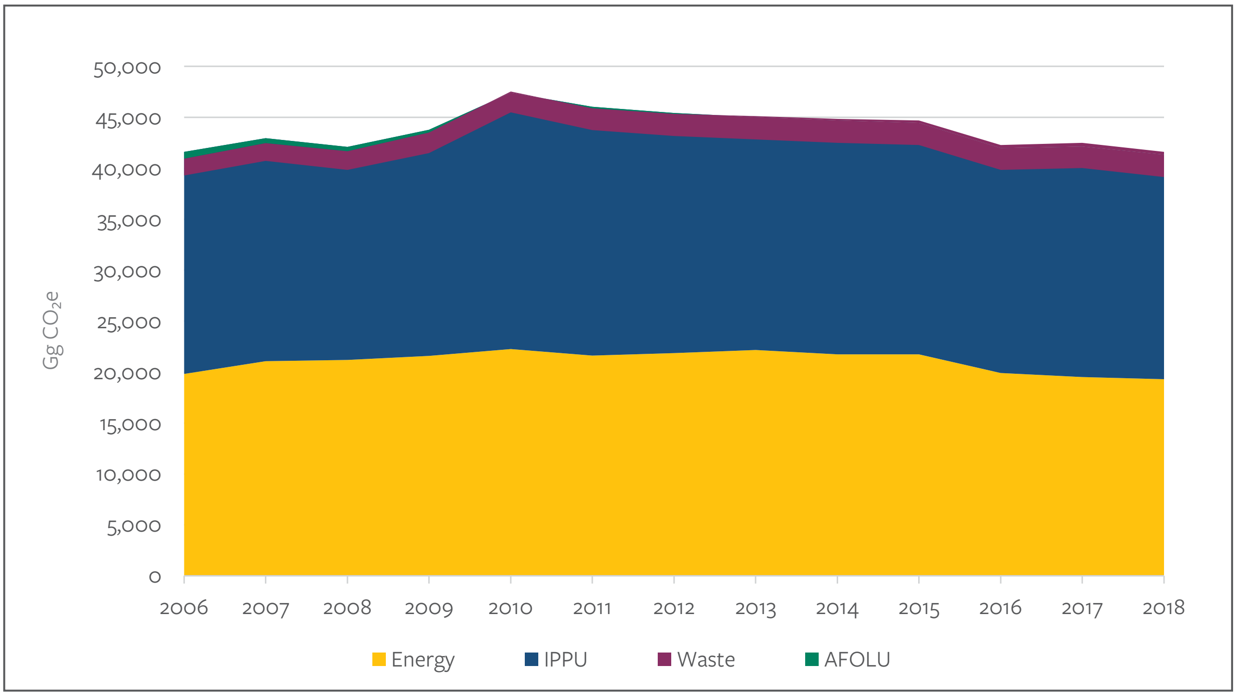


FIGURE 2.1 Total Gg CO_2e Emissions for T&T's Sectors (2006–2018)

out as necessary. All activity data sets are archived accordingly. Data were submitted directly to the MPD, which would be transferred and archived at the Environmental Management Authority (EMA) which is the custodian and manager of the country's KMS/MRV system. All archived data will be available for future GHG Inventory reporting cycles.

2.5 Quality Assurance and Quality Control Practices

Quality Assurance and Quality Control (QA/QC) are integral components of the IPCC 2006 guidelines since QA/QC practices contribute towards credible and reliable GHG inventories. Related to this, a robust quality assurance workshop was conducted by the UNFCCC and FAO during the period February 11–15, 2019, during which all the collected data and preliminary results (up to that date) were analysed. This current inventory benefitted tremendously from the rigorous exercise. As such, the findings and recommendations of this report include outcomes and recommendations from the UNFCCC and FAO teams.

In addition to the team's recommendation, the following QA/QC activities were devised and used by the consultant to further enhance the QA/QC of this inventory:

- cross-checking of activity input data for transcription errors
- cross-checking of unit conversion data to eliminate errors
- cross-checking emission factor and global warming potential (GWP) data with that listed in the 2006 IPCC guidelines and Fifth Assessment Report (AR5) for the purpose of consistency
- checks for unit consistency and labels in all sheets
- cross-checking other estimated parameters such as fuel density, etc., with those listed and documented
- checks for time series consistency for the reporting period (2006–2018)
- checks to confirm that assumptions were clearly documented
- checks to ensure consistency between data for different categories
- checking of each category and sub-category for completeness and/or omissions

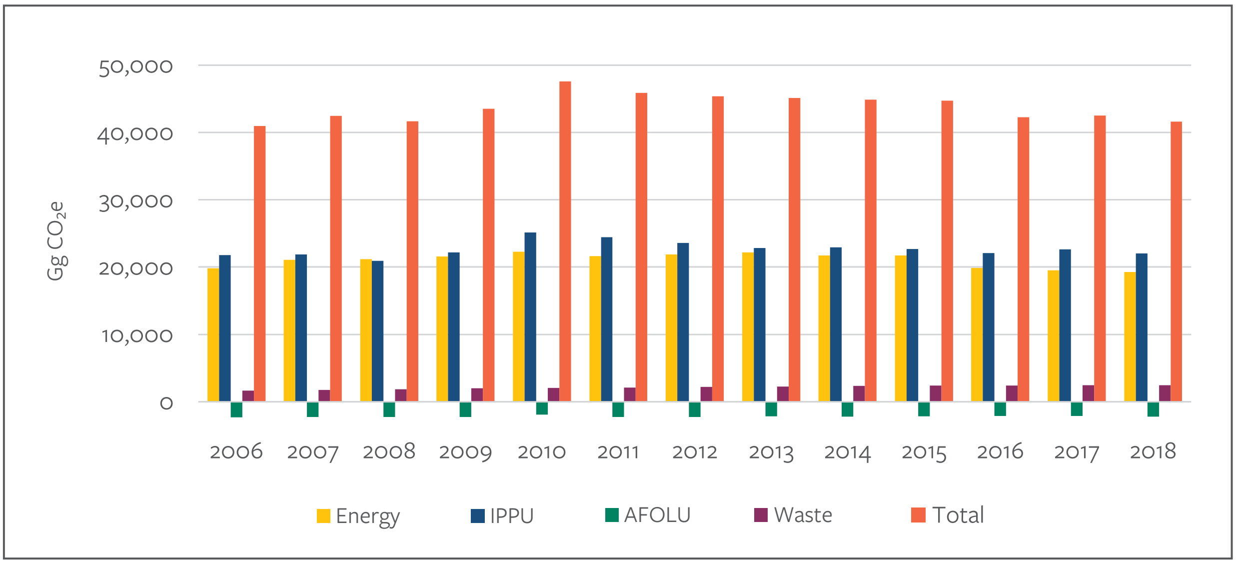


FIGURE 2.2 Total Gg CO_2e Emissions for T&T's Sectors (2006–2018) Showing Sources and Sinks

Further, the related Excel models were also used in a simultaneous exercise on emissions projections baseline setting, which provided an opportunity for independent analysis and comments before their incorporation into the inventory.

For this inventory cycle, no elaboration of internal QC checks from the data suppliers' side is presented. This is one area that has been marked for improvement in future reporting cycles and is later elaborated upon in the section on improvement plans. However, in many cases it was possible to verify submitted data with that from the national database using the MEEI bulletin reports, specifically for Energy and IPPU sub-categories. Notwithstanding this, some discrepancies persist that could not be resolved by the stakeholders. These are either outlined as relevant in the sectoral results sections or in the data gaps and improvement sections, presented at the end of this report.

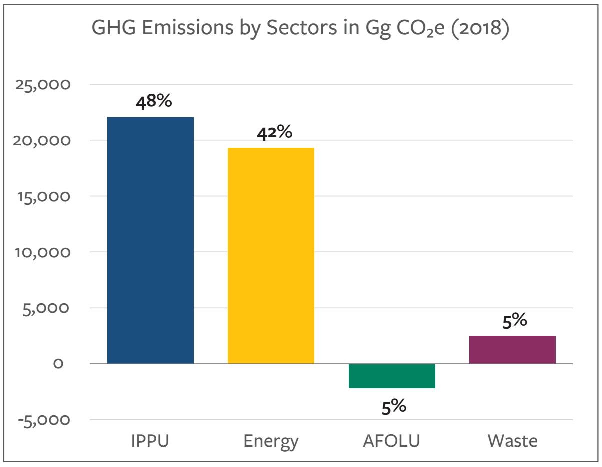


FIGURE 2.3 Total CO_2e Emissions for T&T (2018) ▲

2.6 Overview: Total General Results (Sectoral Analysis)

Trinidad and Tobago submitted its Second National Communication (SNC) in 2013 and its First National Communication (FNC) in 2001, both of which reported GHG inventories. However, the data sets used for these were not available for analysis in the production of this report. In addition, total overall summary tables were not embedded in the respective GHG inventory chapter of these previous submissions to allow their use in this report. Where sectoral values were reported in the FNC and SNC, they are appropriately referenced in this report.

For this reporting period, **FIGURE 2.1** and **FIGURE 2.2** illustrate the total GHG emissions for T&T (expressed in Gg CO_2e) over the inventory period (2006–2018) for the different sectors. In **FIGURE 2.1**, the sectoral results are summarised cumulatively and in **FIGURE 2.2** the same results are summarised via a bar chart. In **FIGURE 2.3**, the absolute emissions are presented to illustrate the relative size of each sector as it relates to GHG sources and sinks, the AFOLU sector being the only net sink for T&T.

TABLE 2.1 T&T's Emissions compared with Global Values (2018) ▼

Sector	T&T's Emissions	Global Values
IPPU	48%	6%
Energy	42%	73%
Waste	5%	3%
AFOLU	5%	18%
Total	**100**	**100**

These figures show that the total emissions in T&T increased over the period 2006–2010, followed by a general decrease from 2010 onwards. The decrease per annum from 2010 to 2018 is 867.4 Gg. This general trend and decrease are largely due to a decline in productivity of T&T's dominant IPPU and energy sectors as a result of lower natural gas supplies. Together, these two sectors contribute to approximately 90 percent of total emissions over the time series (see **FIGURE 2.3** for an example using 2018 data). This pattern is indicative of nations that are categorised as industrialised. This industrialised status is further exemplified when T&T's GHG emissions are compared with global values, as shown in **TABLE 2.1** where the carbon intensity of the combined IPPU and Energy sectors for T&T is more dominant compared to the AFOLU and waste sectors. This is mostly due to the large contribution of the IPPU sector in T&T.

The percentage change over the time series is presented in **TABLE 2.2**. As previously stated, although there was a general increase followed by a general decrease over 2006–2018, the resulting percentage change over the same period illustrated a 1.38 percent decrease in total emissions in 2018 when compared with 2006. Although the associated emissions in the waste sector increased by 49.49 percent, this overall percentage decrease occurred largely due to decreases in the Energy, IPPU and AFOLU sectors. The relatively significant growth of emissions in the waste sector was mainly due to its estimation using the First Order Decay (FOD) model which had not been used in previous estimations.

2.7 Overview: Total General Results (Gas Analysis)

FIGURE 2.4 illustrates the total GHG emissions for T&T (expressed in Gg CO_2e) over the inventory period for the different GHGs. From this figure, one can see that the related emissions in T&T over this period are largely dominated by CO_2 of approximately 85 percent, followed by CH_4 of approximately 12.5 percent and N_2O

TABLE 2.2 GHG Emissions in T&T in Gg CO_2e and Percentage Change over the Time Series

	2006	2007	2008	2009	2010	2011	2012
Sector	Gg CO_2-eq						
Energy	19817.22	21062.05	21194.72	21590.48	22265.95	21606.92	21860.55
IPPU	23020.14	23174.96	21721.89	22885.54	26145.28	25517.89	24646.09
AFOLU	–2304.13	–2237.62	–2276.62	–2278.84	–1917.98	–2272.17	–2262.06
Waste	1647.12	1737.00	1836.15	2007.91	2045.08	2111.80	2184.96
Total	**42180.34**	**43736.39**	**42476.15**	**44205.10**	**48538.34**	**46964.44**	**46429.55**

	2013	2014	2015	2016	2017	2018	% change (2006 & 2018)
Sector	Gg CO_2-eq						
Energy	22181.02	21736.61	21740.90	19896.85	19498.44	19285.16	–2.68
IPPU	23812.88	23788.01	23119.13	22077.59	22641.14	22043.79	–4.24
AFOLU	–2177.54	–2197.56	–2161.15	–2128.13	–2106.34	–2192.42	–4.85
Waste	2274.75	2351.99	2427.99	2430.52	2450.16	2462.32	49.49
Total	**46091.10**	**45679.04**	**45126.86**	**42276.82**	**42483.41**	**41598.85**	**–1.38**

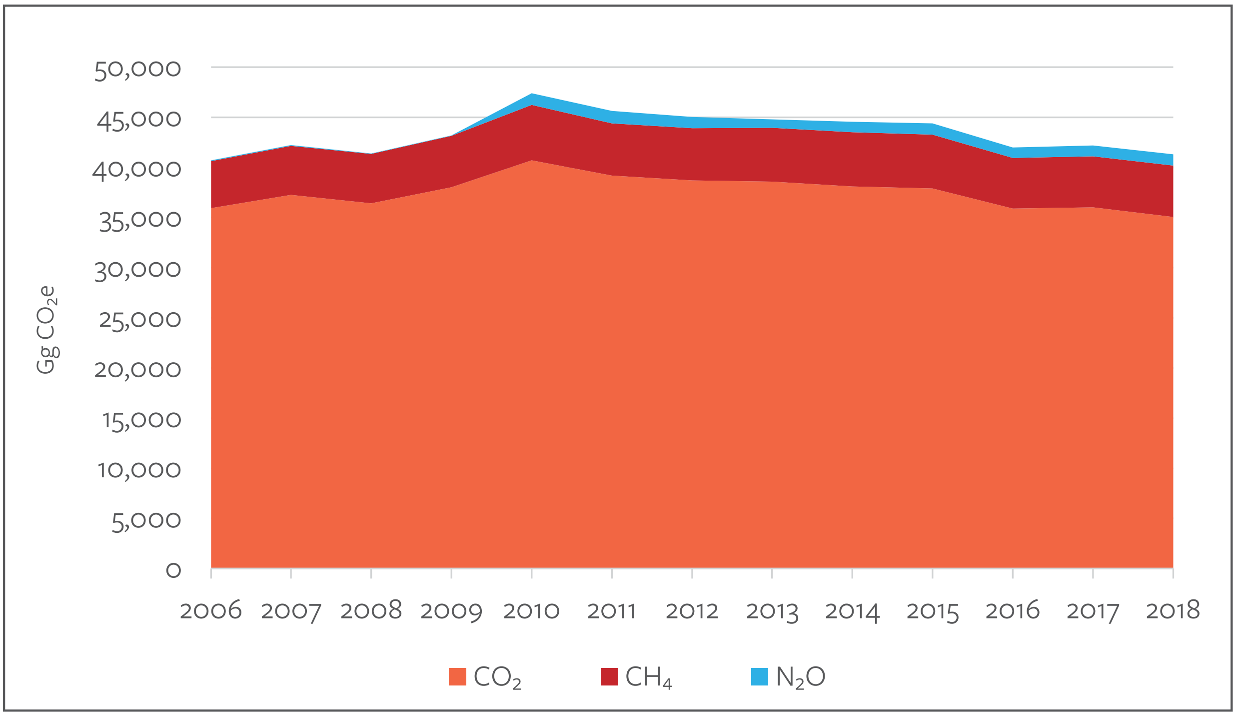


FIGURE 2.4 Gg CO_2e Emissions in T&T by Different Primary GHGs (2006–2018)

of approximately 2.5 percent. The "F" Gases were not included in these tables but are now being assessed and should be submitted as a supplementary report.

TABLE 2.3 illustrates how the percentage values changed for the reported GHGs over the time horizon, with the biggest percentage change occurring in N_2O, owing to the introduction of Nitric Acid Production in 2010.

Key Category Analysis (KCA)

As 2018 is the latest year in this time series, Approach 1 key category analysis (level) was completed for 2018

TABLE 2.3 GHG Gases in Gg CO_2e for T&T (2006–2018)

Sector	2006	2007	2008	2009	2010	2011	2012
				Gg CO_2-eq			
CO_2	37163.50	38480.32	37219.34	38702.01	41536.63	40276.28	39762.34
CH_4	4684.38	4907.99	4905.68	5141.15	5527.22	5193.18	5215.53
N_2O	332.46	348.07	351.13	361.93	1474.49	1494.98	1451.68
Total	**42180.34**	**43736.39**	**42476.15**	**44205.10**	**48538.34**	**46964.44**	**46429.55**

Sector	2013	2014	2015	2016	2017	2018	% change (2006 & 2018)
				Gg CO_2-eq			
CO_2	39506.84	38901.15	38290.87	35855.02	35945.37	35017.64	–5.77
CH_4	5392.51	5403.54	5346.29	5024.48	5099.80	5145.88	9.85
N_2O	1191.76	1374.35	1489.69	1397.33	1438.24	1435.33	331.73
Total	**46091.10**	**45679.04**	**45126.86**	**42276.82**	**42483.41**	**41598.85**	**–1.38**

TABLE 2.4 Approach 1 Level Key Category Analysis for T&T (2018)

A	B	C	D	E	F
IPCC Category	**Greenhouse gas**	**2018 Ex,t (Gg CO_2 Eq)**	**|Ex,t| (Gg CO_2 Eq)**	**Lx,t**	**Cumulative Total of Column E**
Ammonia Production	Carbon dioxide (CO_2)	16382.81152	16382.81152	0.350830094	0.350830094
Energy Industries—Gaseous Fuels	Carbon dioxide (CO_2)	12342.93811	12342.93811	0.264318132	0.615148226
Petrochemical and Carbon Black Production	Carbon dioxide (CO_2)	3404.605	3404.605	0.072907992	0.688056218
Forest land Remaining Forest land	Carbon dioxide (CO_2)	-2708.317277	2708.317277	0.057997323	0.746053541
Road Transportation	Carbon dioxide (CO_2)	2563.393972	2563.393972	0.054893859	0.8009474
Solid Waste Disposal	Methane (CH_4)	2199.213816	2199.213816	0.047095115	0.848042515
Natural Gas	Methane (CH_4)	2068.623745	2068.623745	0.044298591	0.892341105
Natural Gas	Carbon dioxide (CO_2)	1594.198628	1594.198628	0.034139003	0.926480109
Nitric Acid Production	Nitrous Oxide (N_2O)	1025.63745	1025.63745	0.021963537	0.948443645
Iron and Steel Production	Carbon dioxide (CO_2)	553.0938	553.0938	0.01184424	0.960287885
Petrochemical and Carbon Black Production	Methane (CH_4)	327.2486	327.2486	0.007007873	0.967295758
Cement production	Carbon dioxide (CO_2)	322.7229408	322.7229408	0.006910958	0.974206716
Wastewater Treatment and Discharge	Methane (CH_4)	268.4697296	268.4697296	0.005749151	0.979955867
Oil	Carbon dioxide (CO_2)	179.1350371	179.1350371	0.003836091	0.983791958
Non-Specified—Gaseous Fuels	Carbon dioxide (CO_2)	178.123455	178.123455	0.003814429	0.987606387
Energy Industries—Liquid Fuels	Carbon dioxide (CO_2)	128.462289	128.462289	0.002750959	0.990357346
Oil	Methane (CH_4)	91.81791835	91.81791835	0.001966237	0.992323583
Enteric Fermentation	Methane (CH_4)	80.693508	80.693508	0.001728013	0.994051596
Water-borne Navigation—Liquid Fuels	Carbon dioxide (CO_2)	70.54319081	70.54319081	0.001510649	0.995562244
Emissions from biomass burning	Methane (CH_4)	41.69359413	41.69359413	0.000892848	0.996455093
Urea application	Carbon dioxide (CO_2)	33.89906667	33.89906667	0.000725932	0.997181025
Road Transportation	Nitrous Oxide (N_2O)	33.35102101	33.35102101	0.000714196	0.997895221
Manure Management	Methane (CH_4)	24.7501436	24.7501436	0.000530013	0.998425234
Iron and Steel Production	Methane (CH_4)	22.123752	22.123752	0.00047377	0.998899004
Road Transportation	Methane (CH_4)	19.46903803	19.46903803	0.00041692	0.999315924
Emissions from biomass burning	Nitrous Oxide (N_2O)	11.62306248	11.62306248	0.000248902	0.999564826
Energy Industries—Gaseous Fuels	Methane (CH_4)	6.160468217	6.160468217	0.000131923	0.99969675
Energy Industries—Gaseous Fuels	Nitrous Oxide (N_2O)	5.830443134	5.830443134	0.000124856	0.999821606
Glass Production	Carbon dioxide (CO_2)	5.5427295	5.5427295	0.000118695	0.999940301
Oil	Nitrous Oxide (N_2O)	0.742143128	0.742143128	1.58926E-05	0.999956193
Water-borne Navigation—Liquid Fuels	Nitrous Oxide (N_2O)	0.504559934	0.504559934	1.08049E-05	0.999966998
Civil Aviation	Carbon dioxide (CO_2)	0.381012902	0.381012902	8.15921E-06	0.999975157
Natural Gas	Nitrous Oxide (N_2O)	0.32384738	0.32384738	6.93504E-06	0.999982092
Energy Industries—Liquid Fuels	Nitrous Oxide (N_2O)	0.275647827	0.275647827	5.90287E-06	0.999987995
Water-borne Navigation—Liquid Fuels	Methane (CH_4)	0.186591976	0.186591976	3.99578E-06	0.999991991
Energy Industries—Liquid Fuels	Methane (CH_4)	0.145625267	0.145625267	3.1185E-06	0.99999511
Non-Specified—Gaseous Fuels	Methane (CH_4)	0.088902972	0.088902972	1.90381E-06	0.999997013
Non-Specified—Gaseous Fuels	Nitrous Oxide (N_2O)	0.084140313	0.084140313	1.80182E-06	0.999998815
Wastewater Treatment and Discharge	Nitrous Oxide (N_2O)	0.032109891	0.032109891	6.87618E-07	0.999999503
Other (please specify)	Methane (CH_4)	0.0200928	0.0200928	4.30278E-07	0.999999933
Civil Aviation	Nitrous Oxide (N_2O)	0.002884812	0.002884812	6.17769E-08	0.999999995
Other Sectors—Liquid Fuels	Carbon dioxide (CO_2)	0.000163669	0.000163669	3.50489E-09	0.999999998
Civil Aviation	Methane (CH_4)	7.62026E-05	7.62026E-05	1.63184E-09	1
Other Sectors—Liquid Fuels	Methane (CH_4)	6.54676E-07	6.54676E-07	1.40196E-11	1
Other Sectors—Liquid Fuels	Nitrous Oxide (N_2O)	3.71762E-07	3.71762E-07	7.96111E-12	1

TABLE 2.5 Sectoral Results—T&T's Energy Sector

	Emissions (Gg)			Emissions (Gg)						
Categories	**Net CO_2**	**CH_4**	**N_2O**	**HFCs**	**PFCs**	**SF_6**	**NO_x**	**CO**	**NMVOCs**	**SO_2**
1—Energy	**17057.18**	**78.09**	**0.16**				**0.00**	**0.00**	**0.00**	**0.00**
1.A—Fuel Combustion Activities	15283.84	0.93	0.15				NE	NE	NE	NE
1.B—Fugitive emissions from fuels	1773.33	77.16	0.00				NE	NE	NE	NE
1.C—Carbon dioxide Transport and Storage	NO						NO	NO	NO	NO

as illustrated in **TABLE 2.4**, with key categories shown in red. Categories within the Energy and IPPU sectors dominate the highlighted key categories with Ammonia Production and Gaseous Energy Fuels combining to account for over 60 percent of emissions. Other notable categories outside the Energy and IPPU sectors include Solid Waste Disposal and Forest Land Remaining Forest Land. It should also be noted that this KCA (level) was carried out using the IPCC 2006 software whilst the other tables in the report were completed using Excel calculation sheets. This contributed to a slight difference in total values reported due to the rounding-off of decimal places. KCA (trend) was not completed during this report but will be completed during the next reporting cycle.

2.8 The Energy Sector

The sectoral summary results for energy are presented in **TABLE 2.5**. In addition, the general emission trend, based on the sectoral approach can be seen in **FIGURE 2.5**. This figure illustrates a gradual increase in energy sector emissions from 19,817 Gg CO_2e in 2006, to 22,266 Gg CO_2e in 2010, followed by a general decrease from 2010 onwards to 19,285 Gg CO_2e in 2018. This mirrors the same trend presented earlier for total emissions.

This emission trend in energy sector emissions can be mirrored with natural gas usage in the country (**FIGURE 2.6**). As such, natural gas usage can be identified as the main driver of emissions within T&T's energy sector.

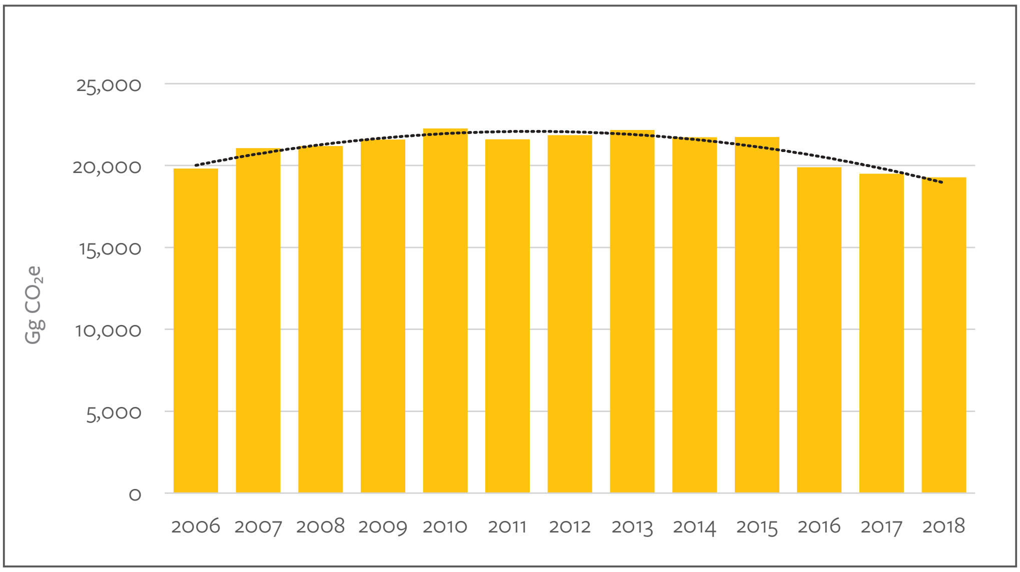


FIGURE 2.5 Total CO_2e Emissions in T&T's Energy Sector in Gg (2006–2018)

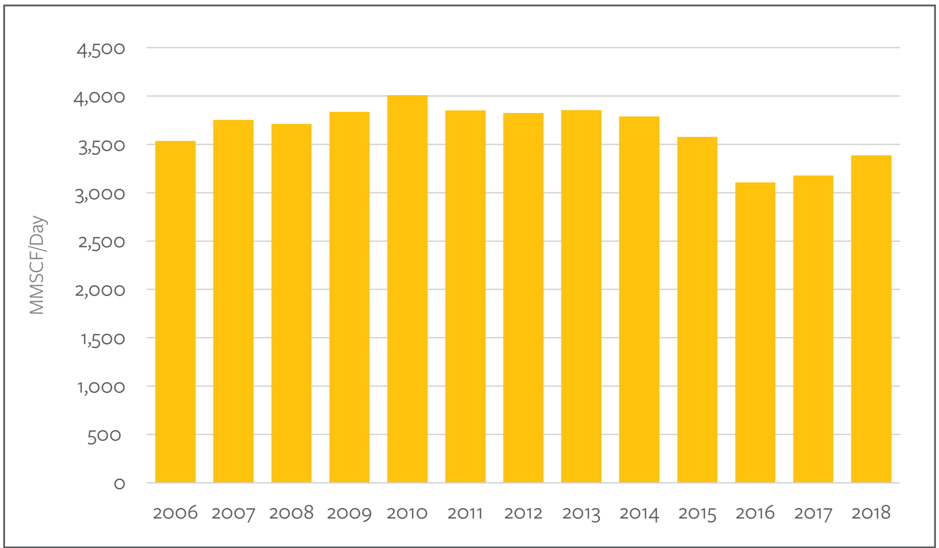


FIGURE 2.6 Natural Gas Consumption in T&T, MMSCF/Day (2006–2018)

For the latest inventory year in this time series (2018), the energy sector sub-categories are shown in **FIGURE 2.7** and a key category analysis is illustrated in **TABLE 2.6**.

With respect to trends in the power generation sub-category, emissions gradually increased at an average rate of 213.17 Gg CO_2e per annum, from 5,856 Gg CO_2e in 2006 and peaking in 2012 at 7,135 Gg CO_2e, before decreasing steadily at a similar average rate of 232.17 per annum to 5,742 Gg CO_2e in 2018. Overall, when compared with 2006, the associated emissions in 2018 decreased by 2 percent.

When examining the same for the transport sector sub-category, emissions gradually increased at an average rate of 62 Gg CO_2e per annum from 2,560 Gg CO_2e in 2006, peaking in 2015 at 3,268 Gg CO_2e, before decreasing drastically at an average rate of 193.3 per annum to 2,,688 Gg CO_2e in 2018. In spite of this recent decreasing trend overall, the associated emissions in 2018 increased by 5 percent when compared with 2006. International bunkers are reported separately in the detailed sheets which are available upon request.

A comparison of the results of the Reference Approach (RA) and Sectoral Approach (SA) shows a difference of 10 percent between the RA of 21.3 Gg and the SA of 19.3 Gg. This same difference is typical for recent years with a steady decline of 21 percent having

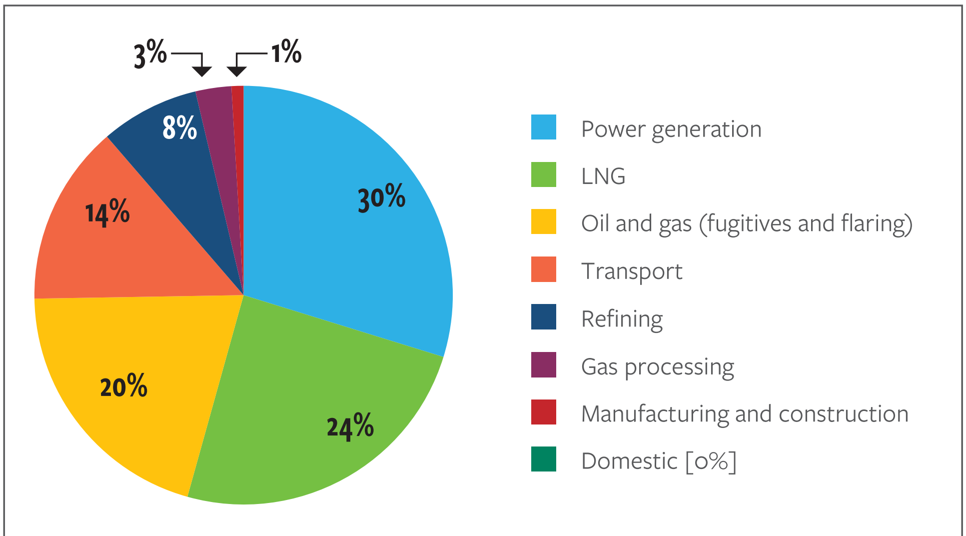


FIGURE 2.7 Sub-sectoral Breakdown of T&T's Energy Sector Emissions (%), 2018

TABLE 2.6 Key Category Analysis—Energy Sector

Categories	Emissions (Gg CO_2e)	Percentage	Cumulative Percentage
Power Generation	5,742	29.77222	29.77222
Oil and Gas (Fugitives and Flaring)	3,935	20.40215	50.17438
LNG	4,736	24.56056	74.73494
Transport	2,688	13.93756	88.67250
Refining	1,471	7.62748	96.29998
Gas Processing	535	2.77363	99.07361
Manufacturing and Construction	179	0.92639	100.00000
Domestic Cooking (LPG)	0.0002	0.00000	
Total	**19,285**	**100**	

been recorded in 2006. This is a marked improvement from that reported in the SNC. This improvement can be attributed to improved data sets being available during this reporting period when compared with that for the SNC. As such, it was possible to identify *excluded* totals used in other sectors, such as IPPU.

Key Assumptions and Guiding Statements (Energy Sector)

The following guiding statements and assumptions were applied in estimating the results for the energy sector.

- Since fuel densities can vary based on compositions, temperatures and pressures, the fuel density values used were based on average values at normal room temperature and pressure.
- For associated emissions with respect to stationary combustion, the following applied:
  + Since country-specific emission factors were not available, the associated default factors were applied using the Tier 1 approach.
  + Auto-generation was taken into account.
  + Since data were not disaggregated for the sub-categories under manufacturing and construction, these related emissions were "Included Elsewhere (IE)" as applicable and reported under "non-specified".
  + Related activity data were acquired through primary data collection in units of volume.
  + Prevailing activity data gaps were then filled using national statistics.
- For associated emissions with respect to mobile combustion, the following applied:
  + Since country-specific emission factors were not available, associated default factors were applied using the Tier 1 approach.
  + Only fuel sales activity data were available and these were acquired through primary data collection in units of volume.
  + Prevailing activity data gaps were then filled using national statistics.
  + Since fuel sales data were not disaggregated within categories, the reported values under road transportation all include off-road, agriculture and military as part of transport emissions, as a whole.
  + Fuel blending (diesel oil with kerosene) was integrated into these estimations.
  + Although fuel smuggling has been reported by the media, this could not be integrated into the estimate since the relevant volumes are not known.
  + Gasoline vehicles were assumed to be low mileage and light duty, as categorisation data were not readily available for motor gasoline.
  + Diesel road vehicles were assumed to be heavy duty diesel trucks as categorisation data were not readily available for diesel.
- For associated emissions with respect to fugitive emissions, since country-specific emission factors were not known, IPCC defaults (lower limits for developing countries) were used.

TABLE 2.7 Sectoral Results—T&T's IPPU Sector

	Emissions (Gg)			Emissions (Gg)						
Categories	**Net CO_2**	**CH_4**	**N_2O**	**HFCs**	**PFCs**	**SF_6**	**NO_x**	**CO**	**NMVOCs**	**SO_2**
2—Industrial Processes and Product Use	**20668.78**	**12.48**	**3.87**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
2.A—Mineral Industry	328.27	NE	NE				NE	NE	NE	NE
2.B—Chemical Industry	19787.42	11.69	3.87	NE	NE	NE	NE	NE	NE	NE
2.C—Metal Industry	553.10	0.79	NE	NE	NE	NE	NE	NE	NE	NE
2.D—Non-Energy Products from Fuels and Solvent Use	NE	NE	NE				NE	NE	NE	NE
2.E—Electronics Industry	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2.F—Product Uses as Substitutes for Ozone Depleting Substances				NE	NE		NE	NE	NE	NE
2.G—Other Product Manufacture and Use	NO	NO	NO	0	0	0	NO	NO	NO	NO
2.H—Other	NO	NO	NO				NO	NO	NO	NO

2.9 The IPPU Sector

TABLE 2.7 illustrates the sectoral results for T&T's IPPU sector while **FIGURE 2.8** illustrates the associated emissions and trends for this sector over the inventory period. As with total emissions and energy sector emissions, this sector also appears to be driven by natural gas consumption, owing to the intensities of the ammonia and methanol-related emissions which, together, account for over 90 percent of sectoral emissions. To further exemplify this, a detailed breakdown of this sector is presented in **FIGURE 2.9**, followed by a key sub-category analysis in **TABLE 2.8** with the key sub-categories, all natural gas-based, shown in red.

Key Assumptions and Guiding Statements

The following guiding statements and assumptions were applied in estimating the results for the IPPU sector.

- For associated emissions with respect to ammonia production:
  - + Data were not received from all stakeholders and the ensuing data gaps were filled using national statistics from the Ministry of Energy and Energy Industries, and the Central Bank of Trinidad and Tobago.
  - + A Tier 1 level of estimation was used with country-specific emission factors that are

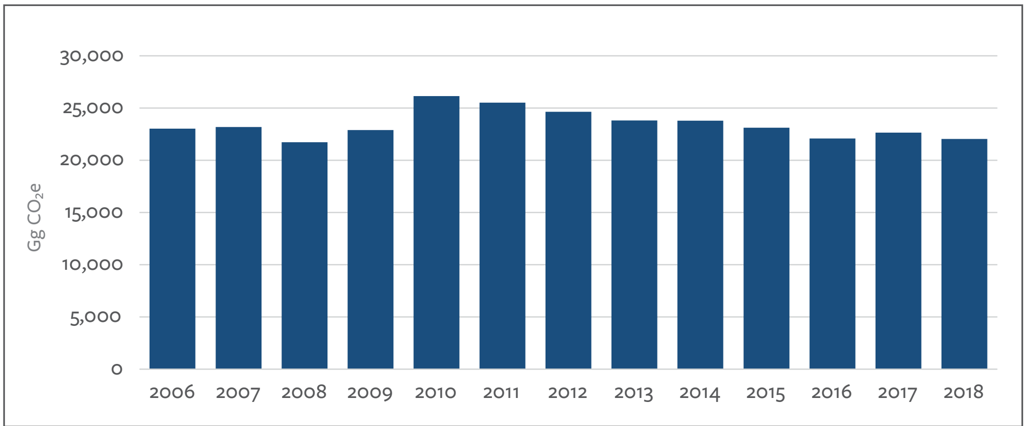
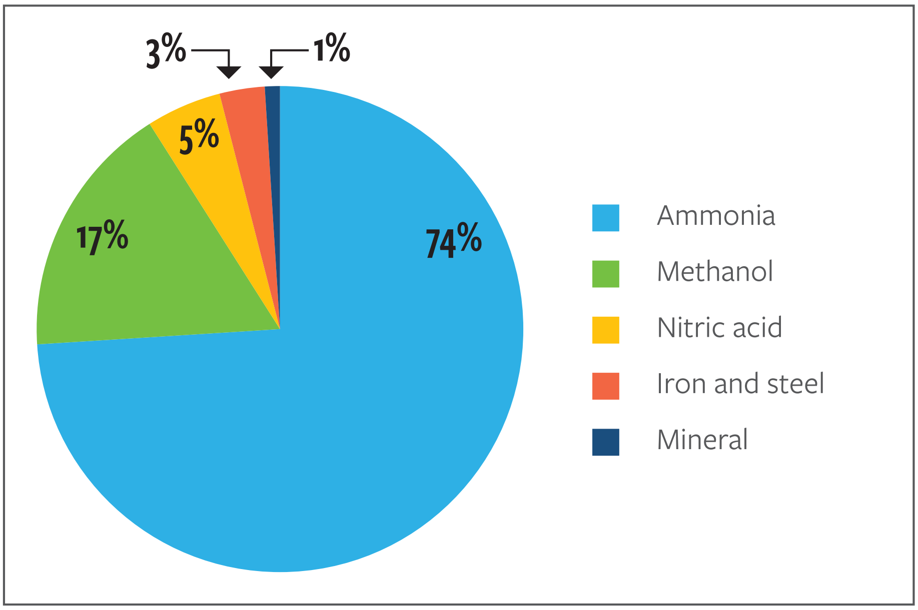


FIGURE 2.8 Total Gg CO_2e Emissions in T&T's IPPU Sector (2006–2018)

FIGURE 2.9 Sub-sectoral Breakdown of T&T's IPPU Sector, Emissions (%), 2018



expected to be validated before the next reporting cycle.

- For associated emissions with respect to methanol production:
  + Data were not received from all stakeholders and the ensuing data gaps were filled using national statistics from the Ministry of Energy and Energy Industries, and the Central Bank of Trinidad and Tobago.
  + A Tier 1 level of estimation was used with country-specific emission factors[1] that are expected to be validated before the next reporting cycle.
- For associated emissions with respect to cement production, the following applied:
  + Since only cement production and clinker fraction data were received, a Tier 1 level of estimation was applied.
- For Iron and Steel, a Tier 1 estimation was done using data received from both manufacturing facilities. However, one manufacturing facility ceased operations in 2015 and this is reflected in the data files as zeros.
- Due to the unavailability of activity data for this reporting period, it was not possible to estimate emissions from activities such as Lime Production, Non-energy Products from Fuel and Solvent Use. These areas are expected to be included in future reporting cycles.
- The "*F*" Gases were not included in these tables but are being assessed and should be submitted as a supplementary report.
- All other categories were also estimated using a Tier 1 approach with default emission factors.

TABLE 2.8 Key Category Analysis—T&T's IPPU Sector ▼

IPPU Key Category Analysis, 2018		Percentage	Cumulative
Ammonia	16383	74.31940989	74.31940989
Methanol	3732	16.92927719	91.24868709
Nitric Acid	1026	4.652728255	95.90141534
Iron and Steel	575	2.60943178	98.51084712
Mineral	328	1.489152877	100
Total	**22043.79**	**100.00**	

1 The country-specific emission factor will be validated for the next reporting cycle and therefore, subject to that validation, the current estimated emissions will need to be interpreted in that context. Accordingly, the next reporting cycle would therefore contain any revisions to this estimate.

TABLE 2.9 Sectoral Results—T&T's AFOLU Sector

	Emissions (Gg)			Emissions (Gg)						
Categories	**Net CO_2**	**CH_4**	**N_2O**	**HFCs**	**PFCs**	**SF_6**	**NO_x**	**CO**	**NMVOCs**	**SO_2**
3—Agriculture, Forestry, and Other Land Use	**-2674.42**	**5.26**	**0.04**	**0.00**	**0.00**	**0.00**	**0.35**	**22.79**	**0.00**	**0.00**
3.A—Livestock		3.77	NE				NE	NE	NE	NE
3.B—Land	-2708.32		NE				NE	NE	NE	NE
3.C—Aggregate sources and non-CO_2 emissions sources on land	33.90	1.49	0.04				0.35	22.79	NE	NE
3.D—Other	NO	NO	NO				NO	NO	NO	NO

2.10 The AFOLU Sector

The sectoral summary is presented in **TABLE 2.9** and the trends in emissions for T&T's AFOLU sector over the time horizon are presented in **FIGURE 2.10**. From this, we can see that this sector is a net sink owing to the large contribution of the forestland biomass sub-category. A related key category analysis is presented in **TABLE 2.10** with the key categories shown in red.

Key Assumptions and Guiding Statements (AFOLU Sector)

Estimation of T&T's emissions from the AFOLU sector was very challenging owing to large data gaps over the reported time series. As such, this is one area identified for data collection and data archiving capacity-building.

In order to compute associated emissions, a fair number of assumptions, expert judgement and

FIGURE 2.10 Total Gg CO_2e Emissions in T&T's AFOLU Sector (2006-2018)

TABLE 2.10 Key Category Analysis for AFOLU Sector (2018)

Sub-categories	Total	%	Cumulative %
FL remaining FL (Biomass) (Gg CO_2e)	2708.313857	83.12536388	83.12536388
Indirect N20 Emissions (Gg CO_2e)	356.9006682	10.95423185	94.07959573
Enteric Emissions (Gg CO_2e)	105.4764945	3.237354475	97.31695021
Biomass Burnt (Forest) (Gg CO_2e)	53.26199137	1.63475234	98.95170255
Urea (Gg CO_2e)	33.89906667	1.040452621	99.99215517
Rice (Gg CO_2e)	0.200928	0.006167015	99.99832218
Biomass Burnt (Grassland) (Gg CO_2e)	0.054665122	0.001677818	100
TOTAL	**3258.107671**	**100**	

omissions had to be adopted. An outline of these assumptions, judgements and some useful guiding statements are provided below and were necessary where country-specific data were not available. These assumptions are consistent with that prescribed in the IPCC 2006 methodology.

- Emissions from enteric fermentation and manure management were quantified largely from activity data gathered from FAOSTATS and default emission factors from the IPCC 2006 methodology.
- Since the data for cattle were not obtained in a disaggregated manner, a 50:50 split was assumed with respect to dairy cows and other cattle.
- To acquire default factors for livestock as needed, the Latin America Region was assumed to apply to T&T.
- With respect to manure management, daily spread was assumed for all categories.
- With respect to land use, though some data were acquired from the Forestry Division of the Ministry of Agriculture, Land and Fisheries (MALF), data sets from the FAOSTATS were more complete and were consequently used.
- Data on the nature of conversion between land categories were not available. As such, this was not integrated into the estimations.
- The definitions of each land type were taken as outlined in the IPCC 2006 methodology as country-specific formal definitions were not yet formulated.
- The Tropical Rain Forest Ecological zone was applied for all land categories.
- Croplands were further divided into two sub-categories for assessing carbon stock changes and associated GHG emissions and removals. These were woody and non-woody. The basis for the division was provided by the Forestry Division of the MALF.
- Grasslands were further divided into two sub-categories for assessing carbon stock changes and associated GHG emissions and removals. These were woody and non-woody. The basis for the division was provided by the Forestry Division of the MALF.
- No data were available to estimate loss in biomass due to removals, fuel wood or disturbances (FAO and otherwise) and as such, this was not factored into the estimation.
- High clay content mineral soil type was assumed in accordance with the IPCC 2006 methodology.
- Since liming data were not available by land area, this was not integrated into the estimations.

TABLE 2.11 Sectoral Results—T&T's Waste Sector

	Emissions (Gg)			Emissions (Gg)						
Categories	Net CO_2	CH_4	N_2O	HFCs	PFCs	SF_6	NO_x	CO	NMVOCs	SO_2
4—Waste	0.00	88.13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4.A—Solid Waste Disposal		78.54					NE	NE	NE	NE
4.B—Biological Treatment of Solid Waste		NE	NE				NE	NE	NE	NE
4.C—Incineration and Open Burning of Waste	NE	NE	NE				NE	NE	NE	NE
4.D—Wastewater Treatment and Discharge		9.59	0.00				NE	NE	NE	NE
4.E—Other (please specify)	NO	NO	NO				NO	NO	NO	NO
5—Other	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5.A—Indirect N_2O emissions from the atmospheric deposition of nitrogen in NO_x and NH_3			NE				NE	NE	NE	NE
5.B—Other (please specify)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO

2.11 The Waste Sector

The sectoral analysis summary is presented in **TABLE 2.11** and the trends in emissions for this sector over the time horizon is presented in **FIGURE 2.11**, followed by a key sub-category analysis in **TABLE 2.12**. These all illustrate that the main sub-categories for T&T's waste sector are the municipal solid waste, which follows the FOD model, and industrial wastewater, owing to the extent of industrialisation in T&T.

Key Assumptions and Guiding Statements (Waste Sector)

The following guiding statements and assumptions applied in estimating the results for the Waste sector and were necessary where country-specific data were not available. These assumptions are consistent with that prescribed in the IPCC 2006 methodology.

- For associated emissions with respect to solid waste, the following applied:

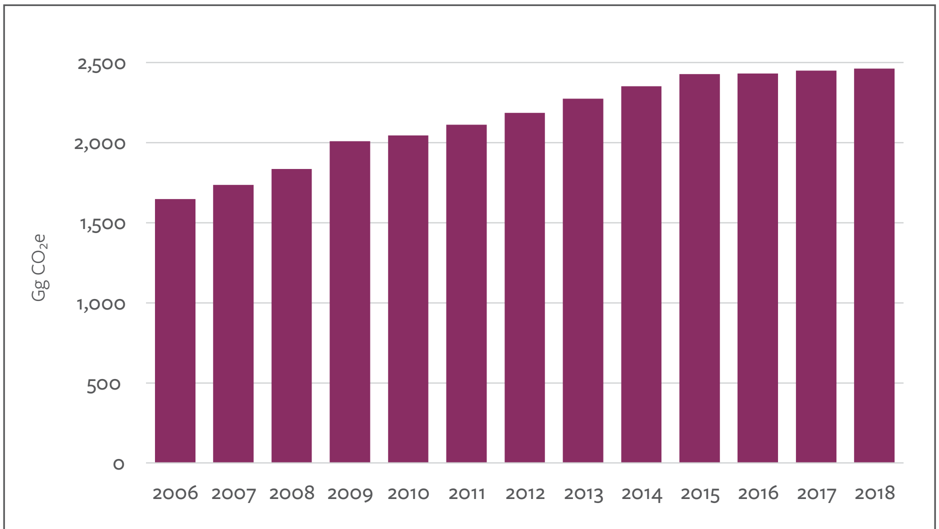


FIGURE 2.11 Total Gg CO_2e Emissions in T&T's Waste Sector (2006—2018)

TABLE 2.12 Key Category Analysis—T&T's Waste Sector (2018)

Sub-Categories	Gg CO_2e	Percentage	Cumulative %
Solid Waste	2193.088422	89.0658686	89.0658686
Liquid Industrial	223.9770456	9.096172281	98.16204088
Liquid Domestic	45.2247264	1.836669921	99.9987108
Indirect N_2O	0.031744274	0.001289201	100
Total	**2462.321938**	**100**	

- The first order decay model (Tier 1) was used.
- Activity data were received from the SWMCOL for waste characterisation but the default waste characterisation data were used as the submitted data varied by grouping categories with that needed in the FOD model.
- Country-specific values were used for waste generation rate, and percentage of industrial waste going to the SWDS with the intention that these would be validated by the next reporting cycle.
- Activity data were generated over a 50-year time horizon using waste generation rates and population size.
- The IPCC waste model was used.
- A delay time of six months was assumed.
- IPCC default values were applied for DOCf, MCF, methane fractions, and methane generation rates.
- Country-specific data were used to define the distribution of waste by waste management type.
- Based on guidance from the local stakeholder, it was assumed that one percent of industrial solid waste entered the landfills[2].
- No methane recovery was applied.

• For associated emissions with respect to domestic wastewater, the following applied:
  - Default BOD values were used (kgBOD/cap/year).
  - These activity data were then combined with IPCC defaults for maximum methane correction capacity (0.6) and methane correction factor (0.3) to estimate the emission factor for T&T.
  - Three income groups were used (rural, urban high and urban low) with the default distribution of 25 percent, 19 percent and 56 percent, respectively, to combine with IPCC's default utilisation rates to estimate the associated emission levels.

• For associated emissions with respect to industrial wastewater the following applied:
  - Due to limited activity data, only three sub-categories (beer & malt, pulp & paper and organics) were estimated.
  - It was assumed that 75 percent of the sludge from the waste basins are removed annually.
  - Since country-specific factors were not available, the IPCC defaults were consistently applied in making an estimate that could be improved upon for future reporting.

• For associated emissions with respect to indirect N_2O emissions, the following applied:
  - It was assumed that all nitrogen is discharged with the effluent.
  - It was assumed that N_2O production in rivers and estuaries is directly related to the nitrogen that is discharged into the river.
  - The IPCC defaults were consistently applied since country-specific factors were not available.
  - Related activity data and protein consumption rates were sourced from FAOSTATS.

2 Subject to the expected more accurate estimations, this assumption, and the resulting emissions estimate, may be subject to revision in the next reporting cycle.

2.12 Data/Information Gaps

Every effort was made to ensure a complete inventory. However, due to data limitations and gaps, some sub-categories could not be estimated in this inventory cycle or were included elsewhere. These are well noted and are listed below so that the gaps can be addressed in future reporting cycles.

- With respect to the energy sector:
  - manufacturing industry and construction (1.A.2) were Included Elsewhere (IE) under Non-specified stationary (1.A.5) as this data could not be appropriately disaggregated; and
  - road transportation (1.A.3.b) could not be disaggregated further into the different sub-categories.
- With respect to the IPPU sector, the following sub-categories were Not Estimated (NE) as the data were not readily available and the effort required to gather the data in this cycle was disproportionate with the expected change in results:
  - lime production (2.A.2)
  - non-energy products from fuels and solvents (2D)
  - product uses as substitutes for ozone depleting substance (2F)
- With respect to the AFOLU sector, the following categories were NE as data were not available:
  - all land conversions
  - emissions related to wetlands, settlements and other land
  - liming emissions
  - soil-related emissions
  - harvested wood-related emissions
- With respect to the waste sector, the following sub-category was NE as data were not available:
  - incineration and open burning (4C)

2.13 Improvement Plans

As articulated before, the GHG Inventory assignment for T&T's BUR-1 followed a consultant-based model. However, the country integrated many key procedural elements during the project to enable a transition towards institutionalising the inventory process for future reporting cycles. Some of these key aspects are listed as follows:

- The MRV/KMS system has been established and the enabling legislative environment is being created to facilitate mandatory reporting of GHG emissions.
- Training of key stakeholders, including the Ministry of Planning and Development's Environmental Planning and Policy Division (MPD-EPPD), the Environmental Management Authority (EMA) and sectoral experts in GHG Inventorying, using the IPCC 2006 guidelines and associated software
- Training of key sectoral stakeholders in the related activity data sets to assist in providing the activity data in the format required for GHG inventory
- Constituting the appropriately trained ministries, departments and agencies into a formalised GHG inventory National Management System (NMS) referred to as the Monitoring, Reporting and Verification (MRV) system
- All relevant ministries, departments, agencies and sectoral experts were appropriately trained with the MRV system and in the use of the KMS. In addition, related pilot projects were launched to test the system.
- Continued efforts towards the introduction of GHG inventory curriculum in relevant universities that could be pursued to assist with the integration into GHG-NMS for future GHG inventory support.

While there is recognition of good progress, the following gaps have been identified and will be addressed before the next inventory cycle.

- The need for more training with respect to activity data sets in the format required for GHG inventories in the AFOLU and Waste sectors
- The need for more training with respect to uncertainties in activity data to enable data providers to report such as required for GHG inventories
- The need to develop sectoral disaggregated category manuals, based on 2006 IPCC guidelines, as national sectoral workbooks for future GHG inventory training, preparation and institutional memory.

2.1

INSTITUTIONAL ARRANGEMENTS RELATED TO NATIONAL CLIMATE MITIGATION MONITORING, REPORTING AND VERIFICATION (MRV) SYSTEM

Photo Credit: Keegan Callender, Ministry of Planning and Development

▲ Launch Event: Knowledge Management System (KMS) and the Monitoring, Reporting and Verification (MRV) Pilot Project, 2019

The Government of the Republic of Trinidad and Tobago (GoRTT) through its Ministry with responsibility for the Environment has designed and operationalised a comprehensive National Climate Mitigation Monitoring, Reporting and Verification (MRV) System which is intended to:

- facilitate the inventorying of greenhouse gases from all emitting entities for the purposes of international reporting such as the Biennial Update Report (BUR) and Biennial Transparency Report (BTR), domestic tracking of national climate policy, and implementation of the Nationally Determined Contribution (NDC);
- facilitate tracking of resources deployed in mitigating greenhouse gas emissions whether internationally and/or domestically sourced;
- inform mitigation options for reducing emissions;
- determine regulatory interventions as appropriate.

The MRV system is facilitated through a series of System Templates and guides to assist the submission of data by emitting entities. These emitting entities include facilities and processes in the following sectors:

- Power Generation
- Road Transportation
- Domestic Air Transportation
- Domestic Sea Transportation
- Industrial Processes and Product Use
- Agriculture
- Land Use and Land Use Change
- Forestry
- Waste
- Wastewater

Within the MRV System, a Quality Assurance/Quality Control (QA/QC) protocol and guidance document has been developed to ensure transparency, accuracy, consistency, completeness, and comparability of Trinidad and Tobago's GHG inventories.

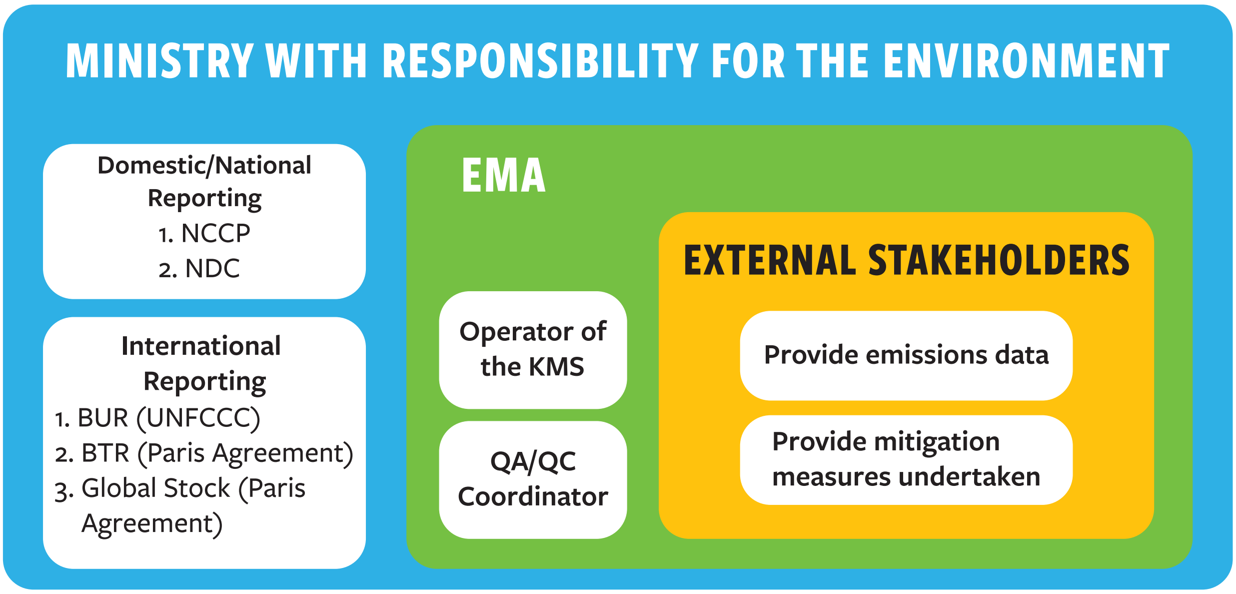


FIGURE 2.1.1 MRV system

The guidance document includes checklists for inventory and QA/QC coordinators, sector leads and specific management roles outlining the QA/QC procedures required.

The MRV's Knowledge Management System (KMS) was pilot-tested and the required adjustments are being made. The following sections describe the system's operationality which will be integrated into the legislative framework.

2.1.1 National Institutional Arrangements for MRV

The Knowledge Management System (KMS), which is the data repository and, therefore, the backbone of the MRV System, is housed at the Environmental Management Authority (EMA). As a regulatory agency, the EMA is the operator of the KMS and is responsible for collecting, collating and verifying all data related to greenhouse gas emissions, mitigation actions and financial support received for climate change-related initiatives. The Ministry with responsibility for the Environment which monitors, coordinates and reports on climate change, climate change impacts and climate change initiatives in Trinidad and Tobago is the official coordinator for MRV. One aspect of its responsibility is the verification of the information collected within the KMS prior to its approval for external use and official reporting to the UNFCCC, and for informing policy options nationally.

FIGURE 2.1.1 illustrates the MRV System.

2.1.2 Overall coordination of MRV

Trinidad and Tobago's MRV System has three components: MRV of emissions, MRV of mitigation actions, and MRV of support/resources utilised. The institutional framework of the MRV System includes the coordinating entity, host of the KMS and data suppliers (emitting entities) as described below.

1. Coordinating Entity of the MRV System

The designated coordinating entity for the National Climate Mitigation MRV System of Trinidad and Tobago is the Ministry with responsibility for the Environment which is responsible for:

- overall coordination of the National MRV System;
- receiving reports from the EMA to facilitate international reporting and to inform policy interventions as appropriate.

2. Host/Manager of the KMS

The EMA, as the host/manager of the KMS, is responsible for:

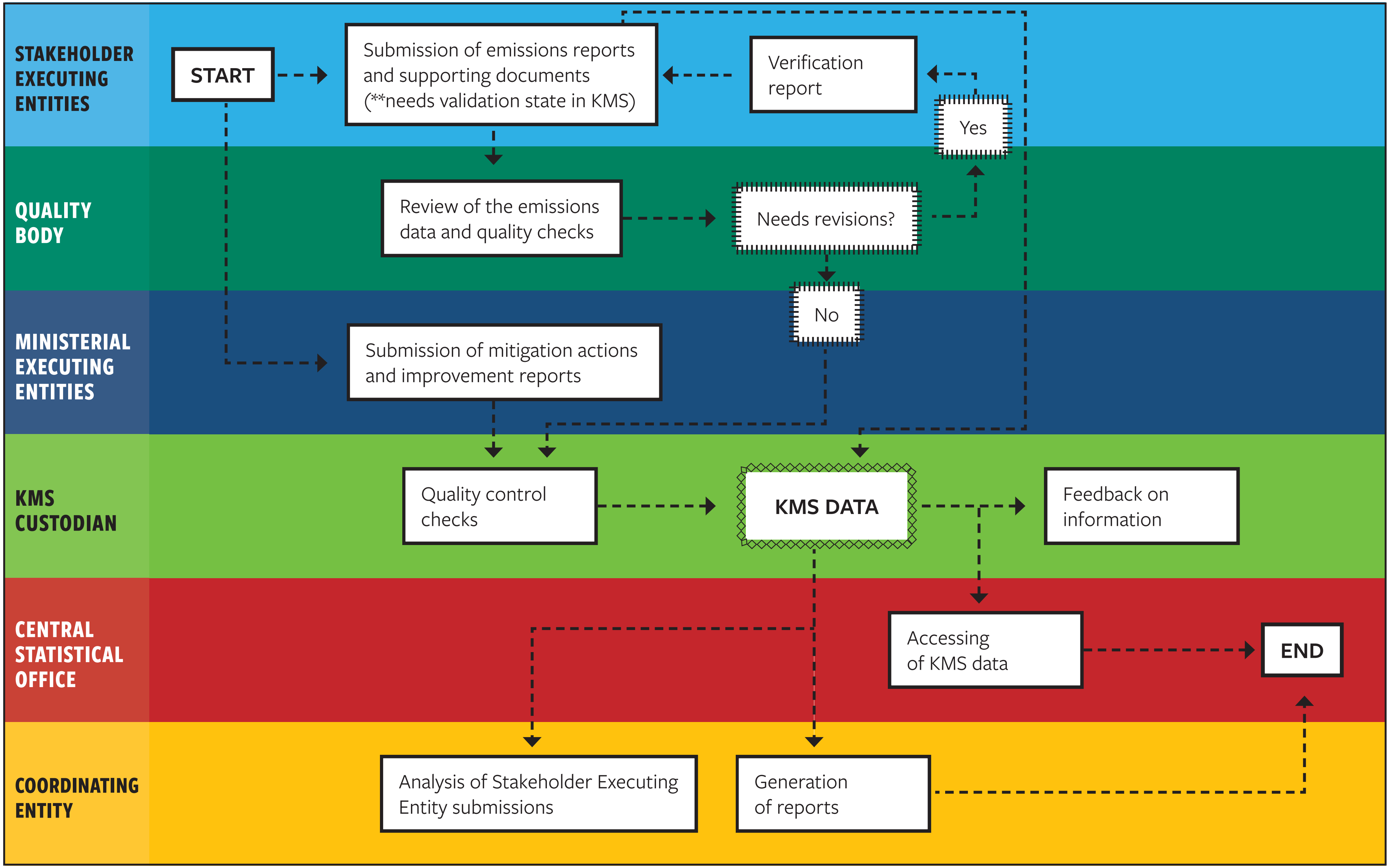


FIGURE 2.1.2 Data flows in the MRV System

- conducting QA/QC on submitted data/inventories and information by emitting entities;
- using the MOU and Confidentiality Agreement templates with the relevant stakeholders to ensure timely data flow and improve on data gaps;
- review and completion of the relevant QA/QC and data archiving system documents;
- ensuring optimum KMS functionalities within the MRV System;
- review and documentation of steps through consistent monitoring to identifiy barriers and facilitate future improvements;
- uploading of approved and verified data into a public registry;
- maintaining the public registry;
- ensuring independent verification of emissions as required.

Data and inventories compiled by emitting entities and uploaded to the KMS through a secure portal are subjected to the necessary QC/QA checks by the EMA. Once approved by the EMA, the information will be uploaded and used to develop reports, including National Communications, Biennial Update Reports (BURs), and Biennial Transparency Reports (BTRS) for submission to the UNFCCC Secretariat. The approved information will also be uploaded into a public registry.

3. Emitting entities and entities which coordinate and report on mitigation actions

Emitting entities are those involved in specified activities under the IPCC guidelines which give rise to greenhouse gas emissions. They provide all information related to greenhouse gas emissions and climate change mitigation activities to the KMS. Among their responsibilities are:

- the use and completion of the recommended MRV System templates;
- utilisation of the recommended methodology to compile inventories;
- application of QA/QC checks on inventories prior to submission using the required templates.

FIGURE 2.1.2 shows the data flow and the interaction with the KMS and relevant users within the system.

2.1.3 MRV of Mitigation actions

As the host of the KMS, the EMA is charged with the following duties with respect to the MRV of mitigation actions at the national level:

- Establishing reporting requirements for mitigation actions and relevant quality control procedures
- Uploading data and information from emitting entities involved in mitigation efforts into the KMS
- Collating data and information to be used in analyses
- Establishing procedures for monitoring and evaluating whether mitigation efforts have achieved their targets
- Submission of results regarding quality control, data analyses, and review of findings, for incorporation into the reporting processes at both the national and international level.

2.1.4 MRV of International Support and Domestic Resources

As the host/manager of the KMS, the EMA is responsible for coordinating the monitoring, reporting and verification of all international and domestic funding support for national mitigation actions. The main aspects of support and resource allocations to be addressed in this component of the MRV System include:

- sources of resources provided;
- type of entity providing resources such as public concessional (official development aid), private capital or investment;
- international and domestic intermediaries involved in channelling resources such as bilateral or multilateral banks and agencies through which finance is transferred, Government Ministries, public-private partnerships, etc.;

Photo Credit: Kishan Ramcharan

▲ Forestry Officers measure diameter of felled tree, Trinidad, 2020

- instruments for distributing resources such as grants, loans, guarantees, domestic policy support, domestic budget allocations, domestic mandates, etc.;
- detailing of the intended uses of the resources with a description of the mitigation activity;
- projected outcomes associated with the use of the resources provided, including both mitigation and sustainable development benefits.

2.1 Data/information gaps

As outlined in the national MRV System Implementation Plan, all entities including the coordinating body (currently the Ministry of Planning and Development), the host of the KMS (EMA) and executing agencies (ministries and stakeholders) are responsible for critically analysing their relationships and for collaborating with each other to identify and address data gaps and improve the flow of information through the MRV System. In addition, the Implementation Plan Templates such as the Coordinating Entity Checklist and the QA/QC Templates include actions for identifying and addressing data gaps.

3

MITIGATION ANALYSIS

Photo Credit: Ministry of Works and Transport

▲ Traffic flows in city of Port of Spain, Trinidad

3.1 Policies and Measures for GHG Emission Reduction

This chapter presents a summary of the mitigation measures and plans implemented by Trinidad and Tobago in fulfilment of the objectives of the United Nations Framework Convention on Climate Change. These measures are presented in the first Biennial Update Report (BUR) and refer to emission reduction measures that have already been completed, those that are currently being implemented and those that are planned and awaiting execution.

Programmes and measures implemented or planned

For the analysed sectors—power generation, industry, transport, waste/water and AFOLU—a total of 40 mitigation actions, measures and policies were identified. This section presents a complete list of these actions in each of the sectors, as well as a brief description of each measure. The purpose is to show the actions that are being implemented and will give rise to the generation of the trend scenarios.

TABLE 3.1 Measures for all sectors

Nº	Name of Measure	Sector	Description of measure
1	Solar Photovoltaic (PV) installation at the Queen's Park Savannah	Power generation	To construct a solar PV installation at the Queen's Park Savannah with electric vehicle (EV) charging stations
2	Piarco Solar Park	Power generation	To construct a solar park at the Piarco International Airport
3	Rural Solar Electrification	Power generation	This is a government-assisted electrification programme designed for households located far from the national grid, with a combined income below a defined ceiling and for whom it would not be economically feasible for T&TEC to extend the power grid.
4	Energy Conservation and Efficiency Policy and Action Plan for Trinidad and Tobago	Power generation	To develop a national policy document to guide all consumers in becoming more energy efficient and conservative
5	RE Pilot Installations at T&TEC and UTT	Power generation	Implementation of grid-tied solar and wind installations at T&TEC Mt. Hope and UTT O'Meara
6	Optimisation of spinning reserves at T&TEC	Power generation	The utility working with the IPPs to optimise spinning reserves to improve the efficiency of generation
7	T&TEC domestic bill rebate	Power generation	An automatic 25% rebate for customers with bills less than 300 TTD
8	Feed-in Tariff (FIT) Policy for the integration of Renewable Energy into the national grid	Power generation	MPU: Implementation of tariffs to allow utility customers to export renewable energy-sourced power to the national grid.
9	Large-scale Renewable Energy (RE) installation (10% Utility Scale Solar)	Power generation	Implementation of up to 130 MW of electricity generation from RE sources. The share of renewable generation will be at least 10% by 2050, given the established policy goal of achieving 10% RE by 2021. It should be noted that this is a conservative representation as increased penetration of RE between 2021 and 2050 is also possible.
10	New Single Cycle Units in Tobago	Power generation	Acquisition of new high efficiency Single-cycle generators in Tobago.
11	Light bulb replacement programme	Power generation	An estimated 1.6 million LEDs could boost the country's energy efficiency by replacing conventional bulbs.
12	Energy Audits	Industry	Quantification, categorisation and analysis of energy usage required for proper design of mitigation strategies
13	Carbon Capture and Storage (CCS) Studies	Industry	Analyse the potential of Trinidad and Tobago for the implementation of CCS technologies to capture CO2 emissions.
14	Improved Use of Energy and Heat in Industrial Processes	Industry	Promote the development of energy efficiency actions and the reduction of the produced waste heat in the industrial sector of Trinidad and Tobago (except oil and gas sectors).
15	Measure Complementary renewable energy sources	Industry	Install renewable energy technologies in industrial sites of Trinidad and Tobago to provide supply for low energy consuming processes.
16	Thermal Desalination	Industry	Improve energy efficiency in Trinidad and Tobago by establishing a desalination plant which would use waste heat from industrial sites to produce desalinated water for industrial purposes.
17	Reducing Venting and Flaring	Industry	Decrease the consumption of fuels in the oil and natural gas sectors by reducing venting and flaring emissions in the oil and natural gas sector of Trinidad and Tobago.
18	Efficient Technologies in the Oil and Natural Gas Sector	Industry	Implement more efficient technologies in the oil and natural gas sector in order to reduce fuel consumption in the production process.
19	Promotion of Energy Conservation and Lower Waste Generation	Industry	Promotion of best practices to reduce the consumption of resources and waste generation in the industrial sector of Trinidad and Tobago

TABLE 3.1 (CONTINUED) Measures for all sectors

Nº	Name of Measure	Sector	Description of measure
20	Hydrogen Economy	Industry	Report that initiatives are being pursued with the private sector to create green hydrogen for petrochemical use and for N_2O abatement.
21	Vehicle Energy Efficiency and Fuel-switching	Transport	Increasing the energy efficiency of vehicles and promoting a fuel switch
22	Parking Management	Transport	Energy conservation through parking management
23	Upgrading and Replacement of Aircraft	Transport	Upgrade and replacement of aircraft
24	Efficiency in Water Transport	Transport	Promotion of energy efficiency in water transport
25	Alternative Fuels in Marine Navigation	Transport	Introducing alternative fuels to the Marine Navigation sector
26	Information and Communication Technologies (ICTs)	Transport	Promotion of ICTs to avoid the need for travel
27	Low emission Driving Practices and Standards	Transport	Dissemination of low-emission driving practices and standards
28	Policy on e-Mobility	Transport	An e-mobility policy is being prepared with the aim of phasing in electric vehicles in the public and private transport sectors.
29	Air Traffic Management Systems	Transport	Implementation of an air traffic management system
30	Public Transport System	Transport	Analysis and proposal of actions to improve the public transport system
31	Review of Fuel Subsidies for the Transport Sector	Transport	Revision of fuel subsidies for the transport sector
32	Landfill Management—Reducing the Volume of Waste Entering the Landfill	Waste and Water	Landfill Management: Reduction of the volume of waste entering the landfill
33	Landfill Management-Establishing a Sustainable Disposal Infrastructure and Security of Sites	Waste and Water	Landfill Management: Establishing sustainable disposal infrastructure and security at these sites
34	Waste Recycling	Waste and Water	Establishment of a national waste recycling programme
35	Managed Agroforestry Programme: Exploration and Development of an Agroforestry Programme for Commercial Lumber	AFOLU	Development of an Agroforestry programme
36	Improving Forest Fire Protection Capacity	AFOLU	Sustainable management of Wetland Resources
37	Forest Conservation/ Preservation	AFOLU	Conservation/preservation of natural forests on State lands
38	Reducing Deforestation	AFOLU	Reverse deforestation trends.
39	Reforestation	AFOLU	Reforestation of denuded areas of land
40	Wetlands Management	AFOLU	Sustainable management of wetland resources

3.2 Assessment of the Potential for Mitigation of GHG Emissions

For effective mitigation planning, a future projection of the emissions profile is necessary. Accordingly, business-as-usual (BaU) scenarios were constructed using relevant and appropriate models and methodologies as described below.

Model and Methodology: GHG emission projections

GHG emissions in Trinidad and Tobago for the industry, power generation, transport, waste, and wastewater and AFOLU sectors are projected to the year 2050.

A simplified version of the BIOS model was used for consistency as this model was the basis of the projection model used in the development of the "Carbon Reduction Strategy of Trinidad and Tobago" that led to the development of the NDC.

Different scenarios are used to project future emissions. These scenarios summarise families of assumptions about the most relevant variables affecting GHG emissions. Four different scenarios are included. A 2x2 matrix of scenarios was developed that includes two "Business as Usual" scenarios and two Mitigation scenarios in which further mitigation actions are proposed for the different sectors.

It is important to highlight that the projections are not predictions, and therefore may change as circumstances change, and would therefore be periodically revisited and revised accordingly. The projections arising from the modeling conducted are therefore only indicative of the existing circumstances and assumptions. In this regard, the outputs generated by the model are derived from hypotheses of certain statistically relevant variables. As with simulation models, the objective is to cover a wide range of probable events and assess their impact in terms of climate change mitigation policies, using reliable baseline data and information in order to have confidence in the emissions projection. As such, the projections are generated using Trinidad and Tobago's GHG inventory as baseline data with the same emission and conversion factors.

In addition, other relevant information sources were used as secondary data including, among others, information on electricity demand extracted from the *BP Statistical Review of World Energy* (BP plc, 2019), the installed electricity generation capacity from the Energy Dossier TT (Espinasa & Humptert, 2016) and information on production outputs provided by the Central Bank of Trinidad and Tobago[1].

Model

BIOS® is an input-output-based emissions projection model that was first developed in 2010. Its core is a macroeconomic simulation model based on economic connections among economic sectors. It analyses how sectors are connected and how they supply goods and services to the final demand (input-output engine). The goal is to ascertain how much a sector needs from itself and from others in order to maintain a certain level of production and to link all of this to the value-added through Leontief coefficients[2]. Once those relationships are defined, based on a set of final demand scenarios, the model estimates the production levels of different sectors, the associated energy consumption and the linked GHG emissions. To do so, energy consumption for each sector is used as an input for the production process in a satellite approach. Emissions are the output, along with the production of goods and services.

Specifically, each sector has an output level (both in terms of economic output and GHG emissions) based on its specific inputs (both economic and energy-related). The BIOS® model therefore uses a holistic approach methodology that interrelates different economic sectors and is adjusted to variable economic scenarios over time. The GHG emission modelling framework is shown in **FIGURE 3.1**.

1 Central Bank of Trinidad and Tobago: https://www.central-bank.org.tt/

2 Leontief coefficients (economic multipliers) are a measure of the successive effects on the economy as a result of an initial increase in production of an economic activity branch.

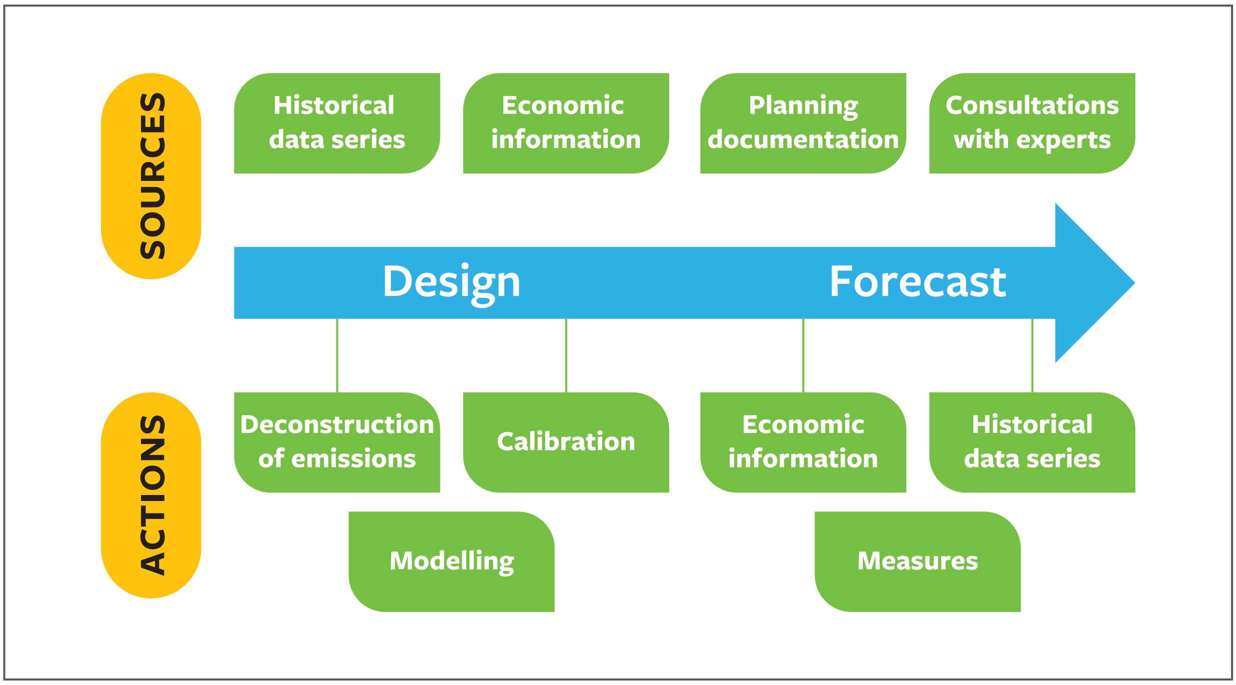


FIGURE 3.1 Framework for GHG emission modelling

The main features of the model are:

- The socio-economic module which forecasts the general economic growth and population growth of Trinidad and Tobago and that of the sectors (% GDP by sector), according to some assumptions and scenarios generated.
- The sectoral sub-models which develop the technical specificities of each sector considered, according to the forecasts of the socio-economic module and specific variables for each sector. In addition, a sub-module is introduced where the identified mitigation measures can be introduced. The inputs needed to complete this module are the tCO_2e reduced annually in each scenario due to the measure, the year of implementation and the sector of application. As an output, the model discounts these emissions from the total emissions of the sector from the year of implementation of the measure.
- The emissions module which converts the activity data into GHG emissions. This module is generated from the activity data and uses the same emission and conversion factors as in the Trinidad and Tobago GHG Inventory.

The general structure of the tool is shown in **FIGURE 3.2**.

The integration of an Efficiency module within the model allows the energy needs per production unit to be adjusted over time. Therefore, the model allowed for the introduction of efficiency improvements that show the potential decoupling between production and energy consumption or emissions.

It should be noted that only some of the modules of the BIOS® were used. The use of the BIOS® tool in its original format and structure was not possible due to the data gaps that were encountered when obtaining the information for the development of the projections. Particularly, the absence of input-output tables for Trinidad and Tobago made it impossible to use the tool as originally designed.

In its absence, a simplified socio-economic module was generated, where value-added per sector was connected to historical consumption and emissions. Expected evolution of GDP and value-added per sector, as well as population were the main variables for the socio-economic calculations.

Historical emission trends obtained from the GHG Inventory of Trinidad and Tobago were the first step for the development of the GHG emissions

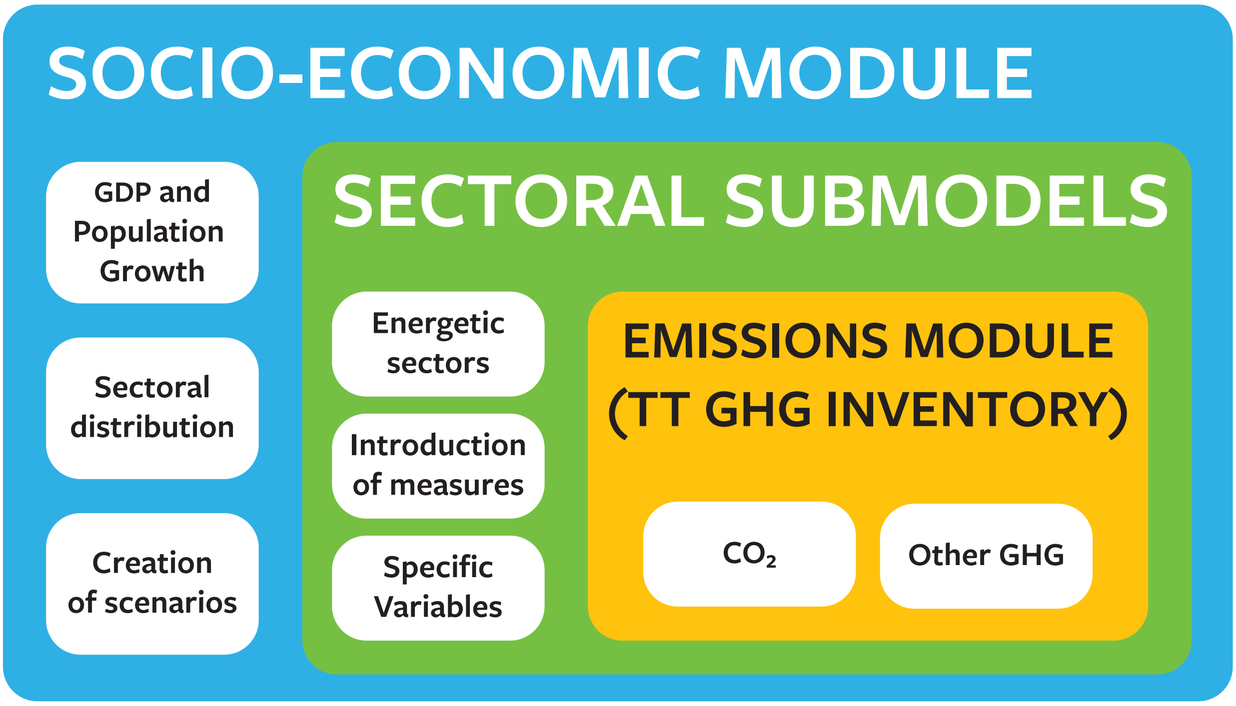


FIGURE 3.2 Structure of the emissions module for Trinidad and Tobago

projections. This was combined with the information obtained from different country-level sources, in order to reconstruct the historical patterns. This was a crucial step because the results of the historical reconstruction have a broad influence on the results of the emissions projections.

In addition, for every sector, different sources of data were available and the variables on which the projections depended were different. Therefore, ad hoc individual sub-models were constructed for each sector. The sub-models were connected through the economic module of the model. As a result, a *bottom-up* simulation model combined with *top-down* macroeconomic projections was the basis for the projections.

Development of Scenarios: General Assumptions

Scenarios are a key element in emissions projections and are the conceptual element that provides unity to the hypotheses applied to the variables, showing a coherent set of future visions and its consequences in the activity sectors.

Scenarios were based on socio-economic and technical-political variables within a 2x2 matrix reflecting four possible future perspectives: Business-as-Usual and Mitigation within conservative and optimistic economic scenarios.

Since the socio-economic perspective was chosen for the development of the scenarios, they were categorised considering economic factors. Therefore, the optimistic scenario had higher values of GHG emissions projected, because in this scenario the economic growth was expected to be higher, which would have also implied having higher GHG emissions.

Conservative scenario: lower economic growth, also leading to lower GHG emissions. This scenario keeps the current GDP rates for each sector. This means that services is the most important sector (largest share of GDP) followed by industry.

Optimistic scenario: higher economic growth, leading to higher GHG emissions. This scenario is based on the trends of the last historical years and provides a picture of 2050 dominated by the service sector, as most developed economies in the world. Other industry shows a declining trend, while manufacturing industry and agriculture basically keep their share.

TABLE 3.2 Socio-economic scenarios included in this report

SOCIO-ECONOMIC SCENARIOS		
	Conservative	**Optimistic**
Business as Usual	Business as Usual Conservative (BaUC) with existing measures	Business as Usual Optimistic (BaUO) with existing measures
Mitigation	Mitigation Conservative with further measures (MiC)	Mitigation Optimistic with further measures (MiO)

TABLE 3.2 shows the matrix of the four scenarios.

The main hypotheses considered in each socio-economic scenario are presented in **TABLE 3.3**.

The historical period 2006–2018 has been used to analyse the socio-economic variables as this is the same period for which the country's GHG emissions Inventory is available and oriented to analyse the synergies between emissions and economic and demographic growth during this historical period in order to establish a consistent trend.

Sectoral distribution of projected GDP was based on some assumptions as well. Considering the variation in the historical period (2006–2018), the trend of each sector was analysed. It should be noted that industry appears to be losing strength while the service sector appears to be gaining significance. These trends are reflected in the projections as shown in **TABLE 3.4**.

In addition, the projections considered other specific variables for each sector, such as energy efficiency parameters, degree of decoupling between consumption/production and demand/GDP, production limits of different industries and transportation modes. These indicators are calculated based on historical data for the period 2006–2018. The hypothesis section describes these assumptions in greater detail for each of the sectors.

Baseline emissions projection

The historical reconstruction of the GHG emissions of the sectors was a key step for the development of the emissions projections with the BIOS model. The application of the model, even if it is designed to cope with 'data gaps', relies to some extent on the availability of historical data, based on which the future projections are constructed.

In this regard, the GHG Inventory of Trinidad and Tobago was used as the basis for the projections.

TABLE 3.3 Main socio-economic assumptions

Assumption		**Sector**	**Scenario**	**Medium average annual growth**
GDP	Annual growth of the GDP considering the historical average growth[1] (2006–2018) in Trinidad and Tobago (Source: World Bank[2])	General	Conservative	+0.22%
GDP	Annual growth of the GDP considering the growth projections estimated in "World Bank World Development Indicators, International Financial Statistics of the IMF, IHS Global Insight and Oxford" report[3]	General	Optimistic	+1.8%
Population	Annual population growth considering the linear trend of population growth in the period 2006–2018 in Trinidad and Tobago (Source: World Bank)	General	Conservative	+0.56%
Population	Population is expected to grow in line with the regional population. (Source: World Bank)	General	Optimistic	+1.2%

1 Growth between 2006 and 2007 is the first to be considered for the trend. The calculation has been made: ((GDP 2018 – GDP 2006)/GDP 2006)/12 years of period analysed

2 World Bank indicators: https://data.worldbank.org/indicator

3 World Bank, World Development Indicators, International Financial Statistics of the IMF, IHS Global Insight and Oxford" (2018). Retrieved from https://www.ers.usda.gov › webdocs › DataFiles › ProjectedRealGDPValues

TABLE 3.4 Evolution of the sectoral distribution of GDP | *Source: World Bank Development Indicators*

Weight	2006	2018	Variation	2050 Conservative	2050 Optimistic
Services	38%	59%	21%	59%	68%
Agriculture	0.6%	0.5%	–0.09%	0.5%	0.5%
Manufacturing Industry	20%	16%	–4%	16%	7%
Other industry (mining, quarrying, construction, electricity, water and gas)	31%	24%	–7%	24%	24%
Industry (total)	51%	40%	–11%	40%	32%

GHG Inventory Overview

As Trinidad and Tobago's GHG Inventory was compiled using the Intergovernmental Panel on Climate Change (IPCC) 2006 methodology, it was necessary to reorganise it according to the economic sectors of the country in order to estimate the projections. Accordingly, the energy sector of the IPCC is divided between the sectors of energy generation, energy consumption in industries, and transport. The other sectors were similarly classified.

In this regard, prior to projecting emissions, a brief analysis of historical emissions was conducted in order to identify historical trends and the main sources for all sectors.

The emission sources within each sector are as follows:

- **Power generation sector:** This included emissions associated with the consumption of natural gas for electricity generation (98%) and a minor consumption of diesel for auto-generation (2%).
- **Industry sector:** This sector considered three main emission sources:
  + *Energy consumption* (natural gas and diesel) for energy industries
  + Emissions associated with *industrial processes and product use* (IPPU), mainly minerals, chemicals and metals
  + *Fugitive, venting and flaring emissions* released into the atmosphere due to the production of natural gas and oil
- **Transport sector:** This sector included emissions associated with the consumption of fuels: diesel, gasoline, CNG for road mobility, kerosene and avgas for aviation and diesel for navigation at the national level.
- **Waste and wastewater sector:** This included two main emissions sources:
  + *Solid Waste Disposal:* It considered methane emissions generated in landfills from municipal and industrial solid waste discharges. It should be noted that during the development of the GHG Inventory, the existence of incinerators had also been detected. However, no data was received to quantify the associated emissions for this inventory, although their contribution is known to be small.
  + *Wastewater:* This category considered emissions generated as a result of wastewater, both domestic and industrial. It also considered indirect N_2O emissions from effluents.
- **AFOLU sector:** This category considered the following emission sources:
  + *Enteric Fermentation:* Associated with the methane emitted by animals
  + *Manure:* Associated with CH_4 and N_2O that is generated due to manure management
  + *Burnt area:* CO_2 emissions related to hectares burned due to forest and grassland fires
  + *Urea application:* CO_2 emissions from the use of urea as a fertiliser
  + *Land use and land use change:* Absorption and emissions of CO_2 from varying carbon stocks in forests, grasslands, and cropland
  + *Rice cultivation and harvest*: CH_4 emissions from rice cultivation and harvest

Photo Credit: National Energy [facebook.com/nationalenergytt]

▲ Port of Galeota—owned and managed by National Energy

▼ Point Lisas Industrial Estate, Point Lisas, Trinidad, 2018

Photo Credit: Point Lisas Industrial Port Development Corporation Limited (PLIPDECO)

TABLE 3.5 Total emissions variation Historic Period

Total emissions (tCO_2e)	2006	2018	∆ 2006–2018
Electricity Generation	5,856,200	5,741,518	–2%
Industry	34,003,654	32,899,574	–3%
Transport	2,560,357	2,687,832	5%
Waste	1,649,023	2,460,045	49%
AFOLU	–2,303,432	–2,158,521	6%
Total	**41,765,801**	**41,630,448**	**–0.32%**

TABLE 3.5 and **FIGURE 3.3** show GHG emissions and removals evolution through the period 2006–2018 extracted from the GHG emissions inventory of Trinidad and Tobago.

Emissions have been surprisingly stable over time and have decreased by a mere 0.32 percent from 2006 to 2018. It should be noted that there was a notable upward trend, with an increase of 15 percent between 2006 and 2010 followed by a slight decrease in emissions since then.

The sector with the greatest influence is the industry sector, which contributed to more than 70 percent of total emissions during the entire period.

This is mainly because of the importance of oil and natural gas industries, including petrochemical industries, in the country. Trinidad and Tobago has slightly different characteristics from other SIDS, mainly because of its rich energy resources which make it a leading resource-exporting country. This also affects Trinidad and Tobago's industrial development compared to that of other SIDS, giving the industry an important role in the country's economy. In fact, in Trinidad and Tobago, apart from the extraction and processing of oil and natural gas, there are other industries that have a significant effect on the country's economy such as methanol production,

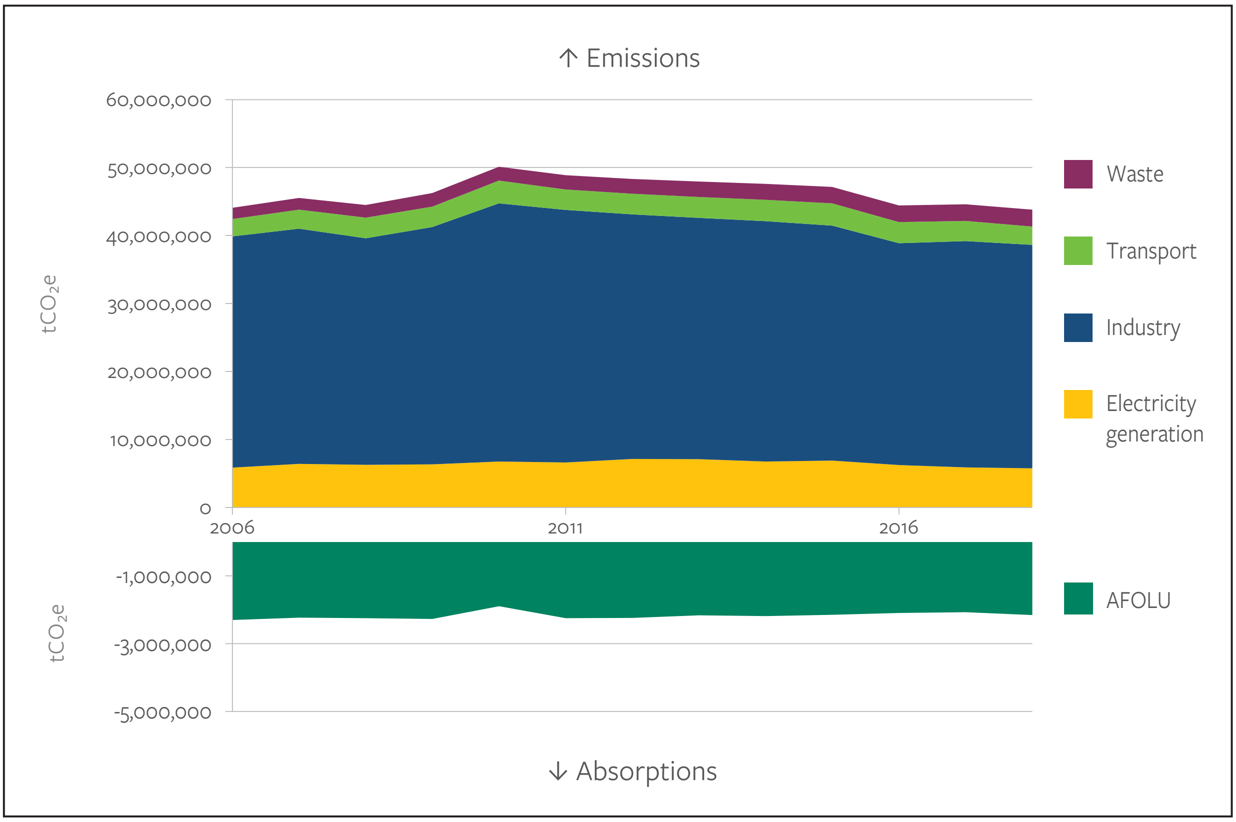


FIGURE 3.3 Historical GHG emissions and removals evolution

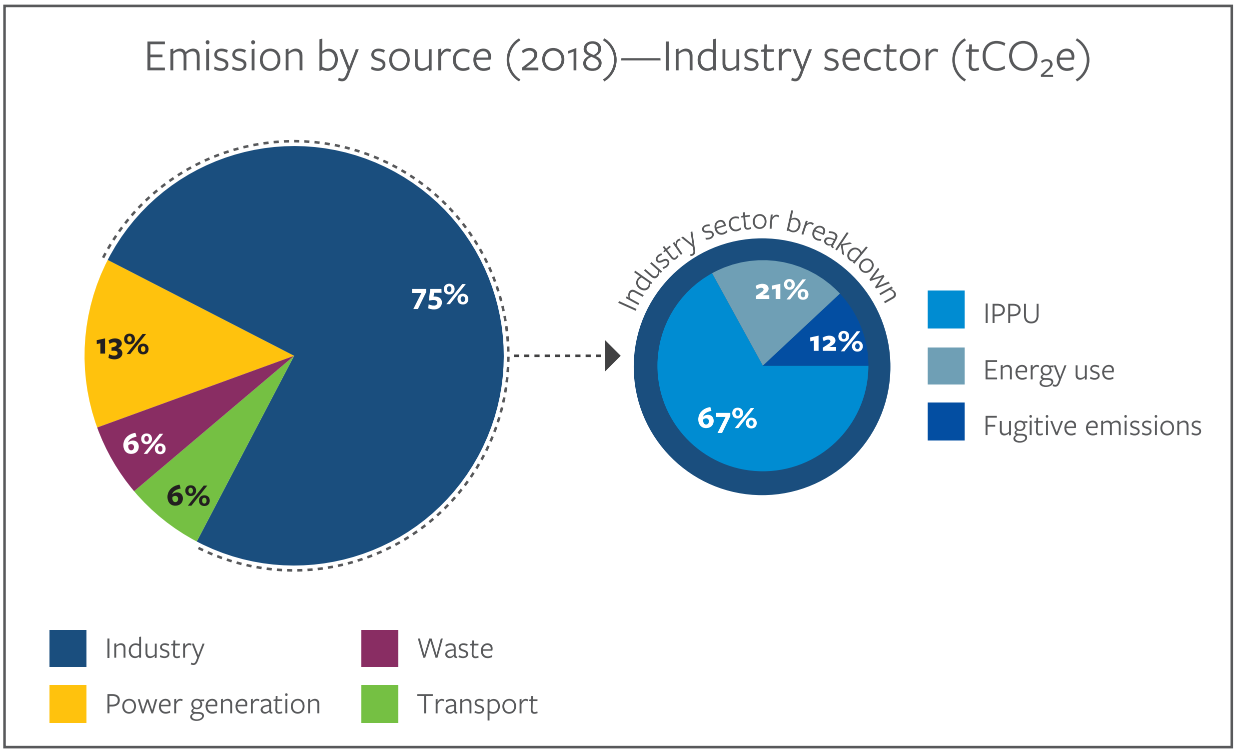


FIGURE 3.4 Emission by source (2018): Industry sector

steel production (with lower contribution since the closure of the Arcelor Mittal plant in March 2016), and ammonia production.

Within the industrial sector, the main sources of emissions are those associated with industrial processes and product use (IPPU), followed by energy consumption within the sector. It should be noted that the energy consumption here refers only to energy industries. The existence of natural gas consumption in manufacturing industries is well-known as it is used for energy purposes. However, there is not enough information to separate it from feedstock for the process. Given the impossibility of breaking it down, all-natural gas is considered a feedstock and is reported in the IPPU category, process emissions and product use. These results are shown in **FIGURE 3.4**.

However, it is worth noting the downward trend of the industrial sector in line with the sector's declining added value. **FIGURE 3.5** shows that most industrial sub-sectors reduced their production or their

◄ Port of Brighton, La Brea. Jointly owned and managed by National Energy and La Brea Industrial Development Company (LABIDCO)

Photo Credit: National Energy [facebook.com/nationalenergytt]

FIGURE 3.5 Production in the industry sector

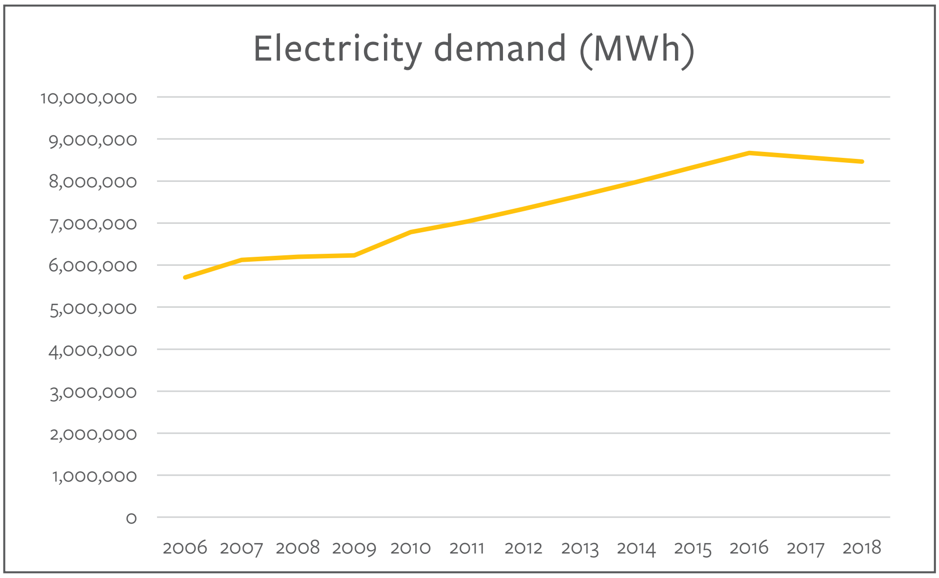


FIGURE 3.6 Evolution of the electricity demand
Based on information provided by the Ministry of Public Utilities

production was stabilised during the historical period, without returning to the production peaks of decades ago. (Espinasa & Humptert, 2016; BP plc, 2019)

The evolution of electricity demand was highly correlated with GDP (86%) during the period analysed (2006–2018). As shown in **FIGURE 3.6**, electricity demand reached a peak in 2016 and thereafter decreased. Due to the correlation between both variables a regression analysis was chosen as the main method for the projection.

The historical trend showed clearly that emissions from the transport sector followed a fairly constant path, where there was almost no variation in the shares of energy consumed by the road transport, aviation and navigation sub-sectors in the selected years. In absolute figures, there was an increase in energy consumption until 2016, when a peak was reached. The trend then slowed, even reversing the growth. Within the sector, road transport was the largest contributor to overall emissions as shown in **FIGURE 3.7**.

Regarding the waste sector, its contribution increased during the historical period (2006–2018), likely as a result of population growth. The increase in population increased the amount of municipal waste and domestic wastewater that was generated. With an upward population evolution, an increasing generation of waste would be likely.

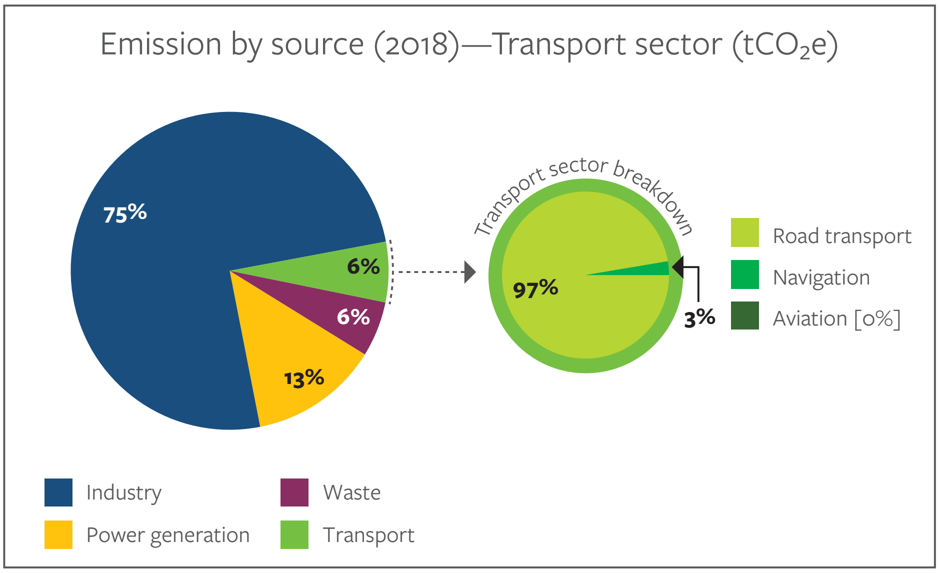


FIGURE 3.7 Emission by source (2018): Transport sector

Photo Credit: Carmel Best

▲ The port of Port of Spain, 2016

On the other hand, as previously stated, the industrial sector maintained an important weight during the period analysed (2006–2018). Industrial wastewater was directly linked to the industrial waste generated. It was therefore consistent that this stream of waste had increased and, consequently emissions from the waste sector as a whole.

As shown in **FIGURE 3.8**, within the waste sector the contribution of emissions associated with solid waste stood out. These emissions were related to the methane emitted from decomposing waste materials deposited in landfills.

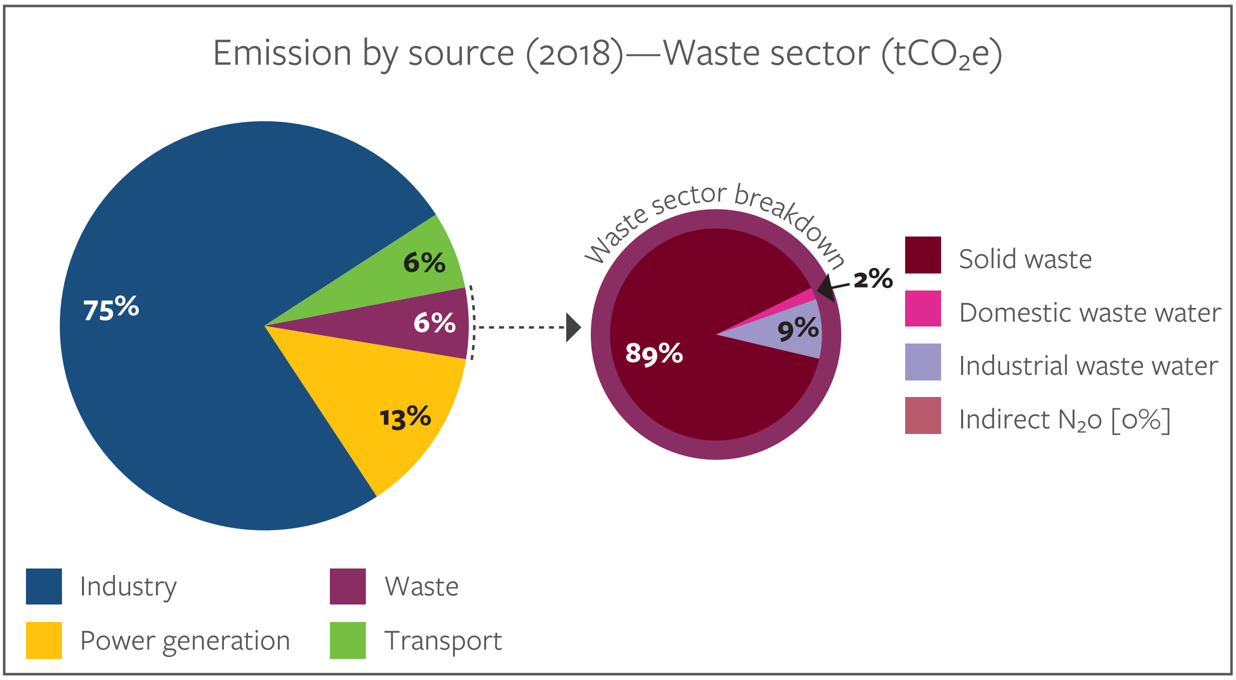


FIGURE 3.8 Emission by source (2018): Waste Sector

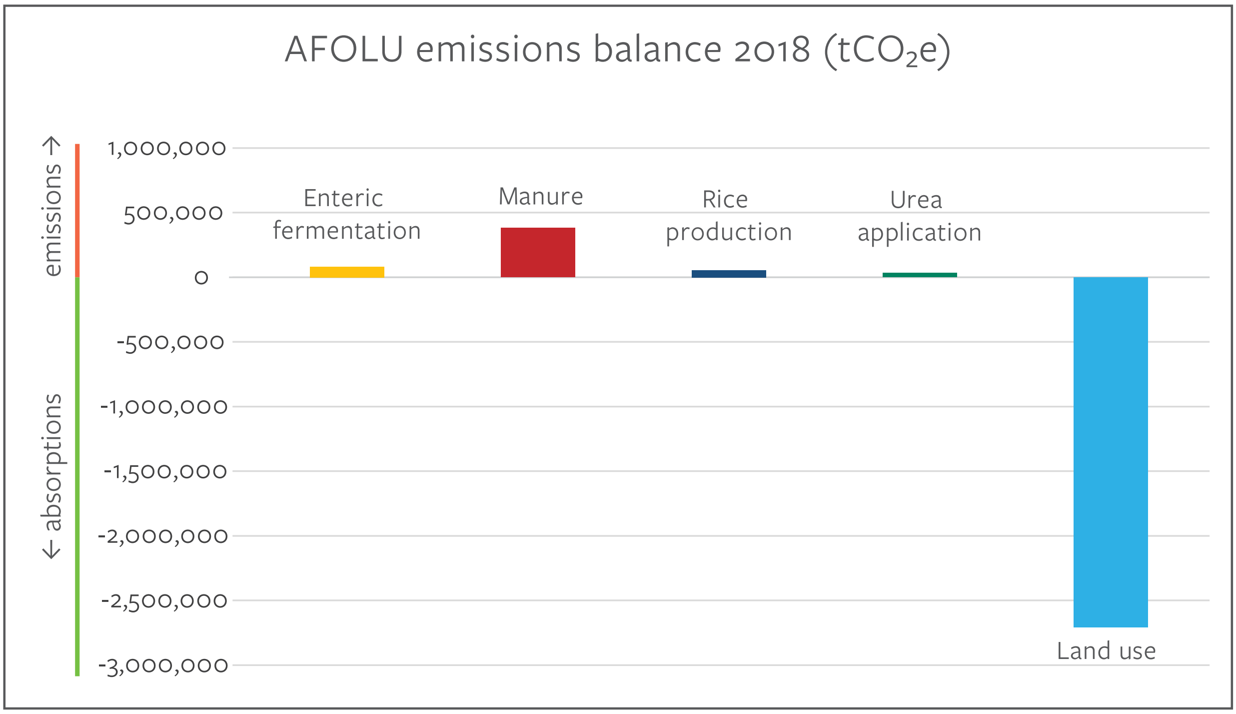


FIGURE 3.9 Emission by source (2018): AFOLU Sector

The AFOLU sector is handled differently from the other sectors, as it is the only one with both emissions associated with livestock farming, fertilisers and forest fires, and GHG removals from the available forest area that act as a CO_2 sink. As a result, the balance of emissions is negative since more CO_2 is absorbed than is emitted.

As far as emissions from the sector are concerned, all emission sources show an upward trend in the historical period analysed. As for absorption, these show a downward trend, indicating a decrease in the forest area. However, in the balance between emission and removal, removal is much higher as far as removals are concerned, throughout the historical period analysed. These results can be seen in **FIGURE 3.9**.

Sectoral hypotheses and primary data

This section elaborates on the hypotheses which defined the results obtained in the model for the projection period in each sector. All scenarios share some of the hypotheses since the evolution of each is affected to a certain extent by GDP and population growth. However, there are some particularities for each sector that are worth mentioning.

In addition to the sectoral characteristics, it should be noted that the scenarios also share several existing mitigation measures that are already being implemented. Thus, the BaU scenarios included these measures to the extent that they could be quantified.

These measures were assessed through a participatory process with stakeholders, quantified and used in the model as appropriate.

Below, the details of the hypotheses included in the model for every sector are explained. Additionally, the last section is devoted to the other hypotheses used in the Mitigation Scenarios.

Power Generation

The evolution of the electrical energy generation and demand is usually closely linked to the economic evolution of a country. Trinidad and Tobago is no exception to this. Based on the data from the historical period, a clear link can be seen between the evolution of electrical energy demand and economic growth. Therefore, for the projection of electrical energy demand, the evolution of the economy was used as the base in the scenarios.

A very high correlation between GDP and electricity demand was observed (86%) and no signs of decoupling between these variables have yet been

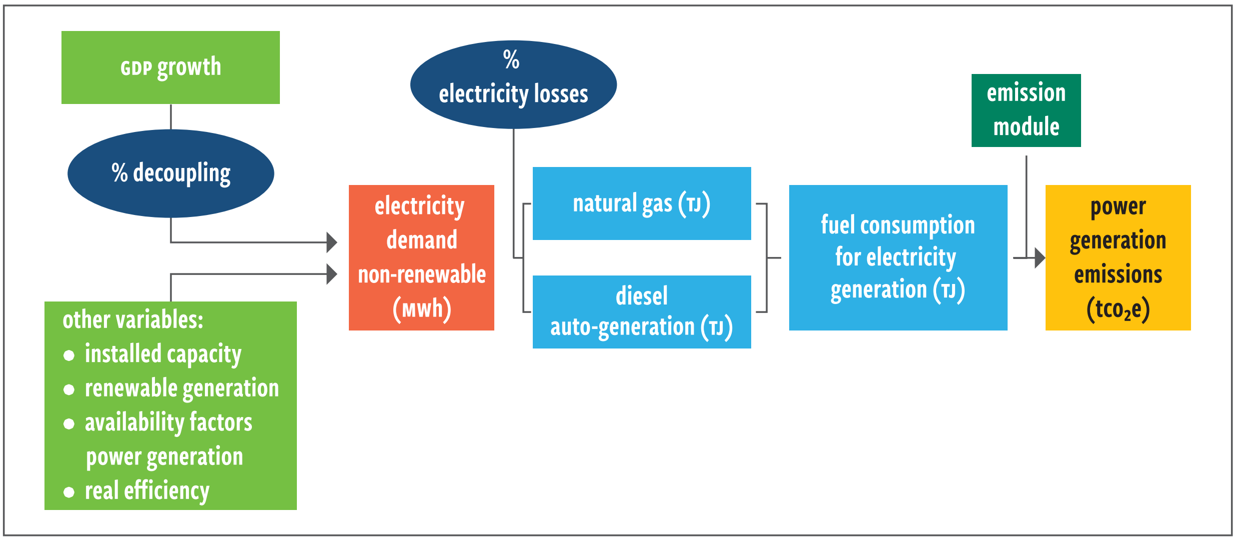


FIGURE 3.10 Relationship between variables for the power generation sector

discerned. However, some energy efficiency measures were implemented which may yield some benefits in the medium term. As a result, the GDP was considered as the main variable in order to project demand along with some decoupling factor.

Moreover, other variables had to be defined in the model to obtain the whole picture. To do so, using the demand as a basis, the total production output was projected and then distributed among the different technologies. Likewise, the projected installed capacity for each technology was contemplated considering existing plans for openings and closures of electricity generation plants.

Along the same lines, the penetration of renewable energies for electricity generation was taken into account given that the share of renewable generation would be at least 10 percent by 2050, according to the established policy goal of achieving 10 percent Renewable Energies (RE) by 2021 under a BaU Scenario and 30 percent by 2050 in the Mitigation scenarios. **FIGURE 3.10** and **TABLE 3.6** show the relation between variables and main assumptions for the sector.

TABLE 3.6 Assumption and variables for power generation sector

Assumption and variables for power generation sector		Scenario	Average annual growth
Non Renewable Fuels for Electricity Generation	98% natural gas and 2% diesel. These are the percentages that will be maintained during the projected period, being the average of the last 5 years.	All	-
Decoupling	A very clear correlation has been observed between GDP and Demand, so in BaU scenarios there is no decoupling factor, or, alternatively, there is a decoupling factor of 1.[1]	Conservative	1
		Optimistic	1
Availability Factor	Availability for each technology according to the Energy Information Administration (EIA).[2]	All	-
Installed Capacity	Evolution of installed MW according to TT's Energy Dossier	All	-
Real Efficiency	Average real efficiency of 36.3%. This is obtained from the ratio between the real and theoretical efficiency in the historical data multiplied by the theoretical efficiency of each technology for the projected years.	All	-

1 Historical data has been analysed where GDP has had a similar growth to that projected in the scenarios. In this sense, decoupling values have been chosen according to these observed data.
2 EIA: https://www.eia.gov/

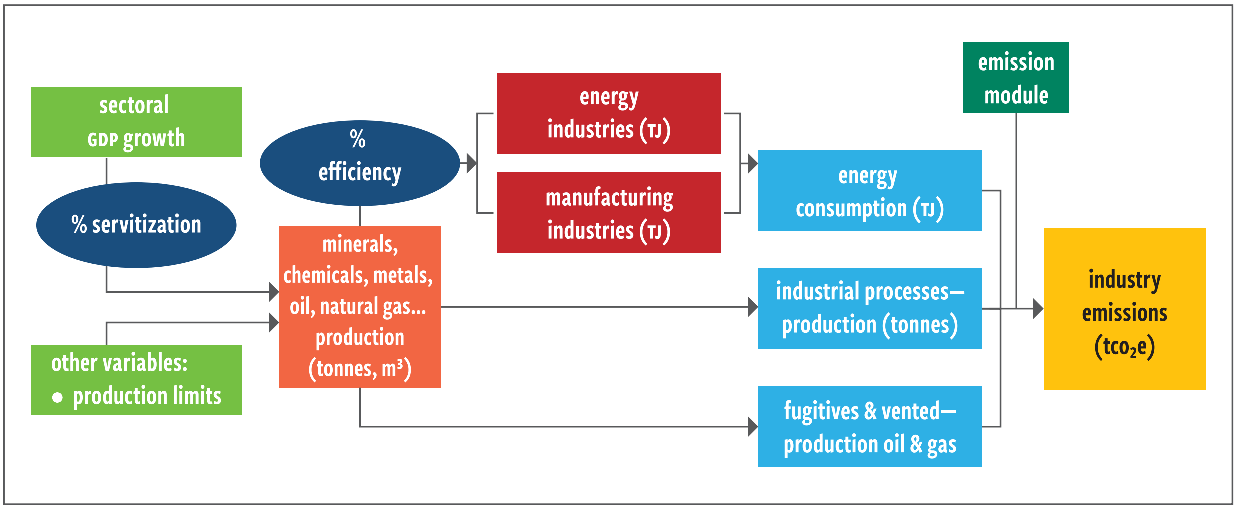


FIGURE 3.11 Relationship between variables for the industry sector

Industry

The cause-effect relationship between economic growth and production is not so straightforward when it comes to industry. Each specific variable must be addressed carefully, as the interdependence between them is often not linear, according to historical data.

Bearing in mind this complexity, a more sophisticated approach was used, combining a multiple-regression scheme for the projection of the variables with the establishment of limits based on the maximum capacity of the industrial sites of Trinidad and Tobago. Furthermore, a different approach was used for process-based emissions, combustion emissions and fugitive emissions.

In both the conservative and the optimistic scenarios, the industrial processes were projected based on the expected evolution of the sectoral value-added. The production of gas and oil was linked to the value-added of the "Other industry" sector, while

TABLE 3.7 Assumption and variables for industry sector

Assumption and variables for Industry sector		Scenario	Average annual growth[1]
% Servitization	% servitization between GDP and Natural Gas and Oil production. The production grows this percentage above the growth of the GDP. Source: Historic data[2]	All	+0.5%
	% servitization between GDP and Other products production. Production reduces this percentage above the growth of the GDP.	All	−0.4%
% Efficiency	Relationship between consumption and production in natural gas industries. Consumption reduces this percentage over production.	All	−0.1%
		All	+1%
	Relationship between consumption and production in oil industries. Consumption increases this percentage over production.	All	−0.4%
Production limits	The production limits are determined by the country-level bibliographic sources. The same limits that were considered in the development of the CRS have been considered.	All	–

1 Note that these are average values, but that each production considers its exact variation.
2 Historical data has been analysed where GDP has had a similar growth to that projected in the scenarios. Servitization values have been chosen according to these observed data.

Photo Credit: Caribbean Airlines

▲ Caribbean Airlines, the national airline of Trinidad and Tobago, 2020

the industries producing other materials (chemicals, metals, etc.) and the treatment of gas and oil (refining, etc.) were linked to the manufacturing industry. However, a hard cap was established in both cases, considering that growth in capacity would take place during the projection period, but having the current maximum capacity as the baseline for the growth, which was lower than the expected economic growth. Additionally, industry-specific servitization parameters between GDP and production were included, considering historical ratios.

In the case of the activity data for the fuels consumed in the industry sector, the approach was more complex than for the process-based emissions. In this case, for the projection, not only the evolution of the economy was considered, but also an efficiency parameter between historical consumption and production.

Finally, the process was taken one step further, because in a similar manner, as explained before for the industry production, capacity limits were also set for the energy consumption. To do so, for every subsector, a limit was established considering its features and the historical data.

In the case of fugitive, vented and flaring emissions, a direct correlation was established between the production of natural gas and oil and the emissions released into the atmosphere as a result of extraction and production activities. **FIGURE 3.11** and **TABLE 3.7** show the relationship between variables and main assumptions for the sector.

Transport

The evolution of the fuel consumption and, therefore, the GHG emissions of the transport sector, are closely tied to the economic evolution of the country. Thus, for the transport sector, the projections for both the conservative and optimistic scenarios were based on the projected evolution of the economy for Trinidad and Tobago, including the evolution of the kilometres travelled, and considering the degree of decoupling between GDP growth and fuel consumption/kilometres travelled.

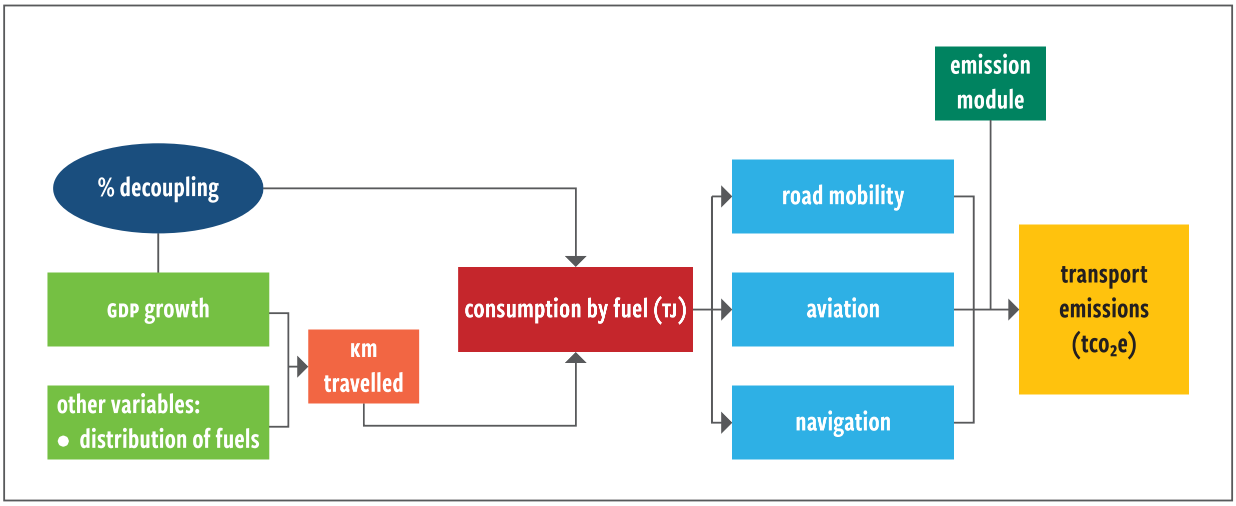


FIGURE 3.12 Relationship between variables for the transport sector

The GHG Inventory lacked high resolution data for a detailed analysis of the sector. Therefore, scenarios were solely based on economic projections in terms of different fuel consumption, not modes of transport. For a more accurate projection for the sector, other sources of data such as the number of vehicles in the country by type or the passengers–kilometre for every vehicle would be necessary.

The link between the economic growth and the number of kilometres travelled in the country was defined. The distribution of the kilometres travelled among the different fuels was based on the historical evolution of fuel consumption, maintaining the existing distribution. **FIGURE 3.12** and **TABLE 3.8** show the relationship between variables and main assumptions for the sector.

Waste and Wastewater

The cause–effect relationship between economic and population growth and waste generated seems clear in Trinidad and Tobago. Emissions from the sector were divided into emissions associated with solid waste, and emissions generated as a result of wastewater, in both cases making a distinction between industrial and domestic waste.

As a general consideration it should be noted that the socio-economic projections used in this sector were also presented in the previous section and were common to all sectors. Furthermore, regarding emission factors, the same factors were used which had been utilised in developing the national GHG Inventory which, in the absence of country-specific data, had used the default data provided by the IPCC guidelines specifically for the region.

TABLE 3.8 Assumption and variables for transport sector

Assumption and variables for transport sector		Scenario	Average annual growth
% Decoupling	% decoupling between GDP and fuel consumption in aviation and navigation. The consumption reduces this percentage above the growth of the GDP. Source: Historic data[1]. This decrease is due to the use of more efficient vehicles.	Both	–0.8%
Distribution of fuels	The distribution of fuels is estimated to be the same as at present: 0% electric mobility and biofuels, 0.1% CNG, 60% Gasoline, 39.9% Diesel.	Both	–

1 Historical data has been analysed where GDP has had a similar growth to that projected in the scenarios. In this sense, decoupling values have been chosen according to these observed data.

TABLE 3.9 Assumption and variables for the waste sector

Assumption and variables for waste		Scenario	Medium annual growth
Municipal Solid Waste Generation Rate (kg/cap/year)	Historical period: 550. This ratio could be further reduced with circular economy measures.	All	–
% SWDS (Solid Waste Disposal Sites)	Historical period: 83% → Projected BaU period: annual reduction of –0.01%. This means that in 2050, 80% of the waste generated will arrive at landfills. Projected Mitigation period: annual reduction of –0.3%. This means that in 2050, 60% of the waste generated will arrive at landfills. Related to Measures 1 and 3, reduce the volume of waste reaching the landfill by 50% by 2050 and recycle more materials. Influence on the % of waste going to landfill.	BaU	–0.01%
		Mitigation	–0.3%
Industrial Waste Generation Rate (Gg/$m GDP/yr)	Historical period: 5 → Projected period: 4.5. Assuming same reduction proportion as in Municipal solid waste.	All	–
% Industrial Waste	Historical period: 5% → Projected period: annual reduction of –0.032%. This means that in 2050, 4% of the waste generated in industries will arrive at landfills. Related to Measures: Reduction of industrial waste.	All	–0.032%
Methane Recovery	Historical period: 10 Gg → Projected period: 10.92 Gg: Cross-sectional measure: possible waste-to-energy plant, how much methane will be recovered. With the current waste composition, it has been calculated that the recovery of 750 tonnes of waste per day will mean the recovery of 916 tons of methane in one year. Calculated with the IPCC tool.	All	–
MCF Rate	Historical period MSW: 0.71, Industrial: 0.72 → Projected period: annual increase of 0.19%. This means that in 2050 the MCF value will be MSW: 0.77. Industrial: 0.78. Related to Measure: Sustainable disposal infrastructure: more managed sites. Improvement of facilities is linked to MCF ratio.	All	+0.19%
Wastewater	For domestic wastewater: the same fraction of population distribution is assumed as at present (GHG Inventory), (urban high income, urban low income and rural) and the same degree of utilisation. For industrial wastewater: the GHG Inventory assumes constant production over the historical period for Beer and Malt, Pulp and Paper and Organic Chemicals industries. Thus, the same production values are considered, until these values are updated. The treatment method is Anaerobic Shallow in all cases. For indirect N_2O Emissions: linked to per capita protein consumption. Assumed to be constant.	All	Constant

Bearing these general assumptions in mind, a different approach was used for each source of emission.

Regarding solid waste, methane emissions in landfills was projected using the tool developed by the IPCC (IPCC Waste Model) which was the same used in the GHG Inventory. This tool uses the IPCC's First Order Decay (FOD) methodology[3] in order to estimate the methane being generated, depending on the composition of the waste dumped over time and on the climatic conditions as well as those of the landfill itself.

The characterisation of the waste arriving at the landfill, both municipal and industrial, was assumed to be the same as in the historical period. In this regard,

3 The CH_4 generation potential of the waste that is disposed in a certain year will decrease gradually throughout the following decades. In this process, the release of CH_4 from this specific amount of waste decreases gradually. The FOD model is built on an exponential factor that describes the fraction of degradable material which each year is degraded into CH_4 and CO_2 (Pipatti et al., 2006).

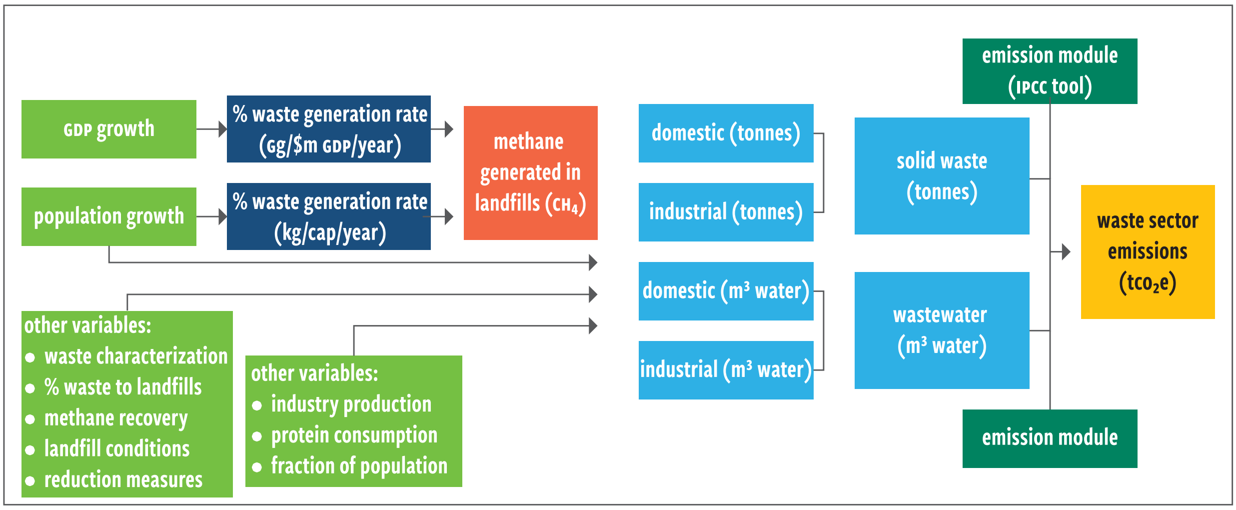


FIGURE 3.13 Relationship between variables for the waste sector

it was assumed that the conditions of the landfills had remained constant.

In the case of domestic wastewater, a direct link was established between the wastewater generated and the population. For industrial wastewater, the evolution of the production of each of the industries was considered, as well as the different rates of wastewater generation of each industry.

FIGURE 3.13 and **TABLE 3.9** show the relationship between the variables and main assumptions for the sector.

AFOLU

The AFOLU sector was one of the most difficult sectors to project due to its intrinsic complexity. The correlation between socioeconomic variables and sectoral emissions is not as straightforward as in other sectors. Therefore, each specific variable must be addressed carefully, as the interdependence between them is often not linear according to historical data.

Bearing in mind this complexity, a different approach was used for each source of emissions and absorptions/sequestration, in both the conservative and the optimistic scenarios. It should be noted that this was the only sector where carbon sinks were projected, associated with the CO_2 absorbed by lands.

The considerations for each emission source are described below.

Enteric fermentation (CH_4) and manure (CH_4 and N_2O) emissions depend on the number of livestock, so the projection of the evolution of the livestock was linked to the evolution of the sectoral GDP. According to the historical data, a strong positive correlation was observed between the two. If the GDP of the sector was increased, the number of livestock also increased.

The fraction of each group of livestock over the current total which currently exists was maintained in the projections, as the evolution in the historical period has not changed. It was expected that 99 percent of the livestock would be poultry.

Emissions from forest and grassland fires are independent of socio-economic variables and can only be reduced by fire prevention measures.

Regarding the use of fertilisers, the associated emissions will also depend on consumption trends and not on socio-economic variables. Since, the GHG Inventory had not yet collected information about the use of nitrogenous fertilisers, these were not projected. In relation to the use of urea as a fertiliser, the average historical consumption was maintained. In the case of rice production, it was also considered a trend consumption based on the historical average.

Finally, in terms of land use, emissions do have a clear socio-economic influence, given that population growth could mean fewer green areas due to new urban settlements, and therefore fewer carbon sinks. However, it was also necessary to consider conservation and reforestation measures to ensure the conservation of this area of land over time.

FIGURE 3.14 and **TABLE 3.10** show the relationship between variables used in the modelling:

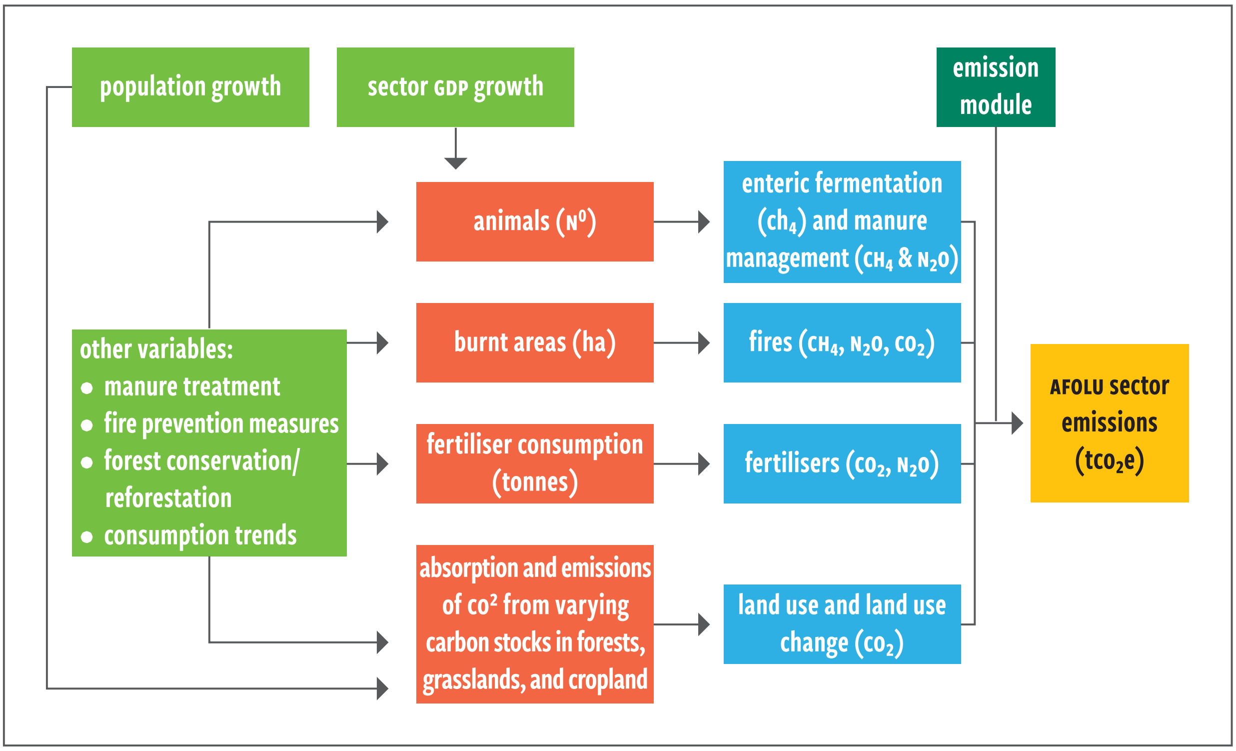


FIGURE 3.14 Relationship between variables for the AFOLU sector

TABLE 3.10 Assumption and variables for AFOLU sector

Assumption and variables for the AFOLU sector		Scenario	Medium annual growth
Livestock evolution	Growth proportional to the sector's GDP growth. Relationship extracted from historical data.	All	+0.3%
Fire prevention	Growth proportional to the sector's GDP growth. Relationship extracted from historical data.	Conservative	−0.6%
		Optimistic	−0.94%
Land use and land use change	Reforestation (absorptions—"minus" CO_2): there are several measures oriented to "Forest Conservation/ Reducing deforestation/ reforestation". In the long term, by 2050, the forest area could increase by 10% Conservative; 12% Optimistic (Food and Agriculture Organization of the United Nations, 2015b).	Conservative	+0.31%
		Optimistic	+0.38%
	The areas of plantations are inversely proportional to population growth.	Conservative	−1.5%
		Optimistic	−2.5%
Fertilisers	No data is available for nitrogenous fertilisers. Urea usage remains constant during the projected period: 30,202 tonnes of urea per year.	All	Constant
Rice Cultivation and Harvest	Growth proportional to the sector's GDP growth. Relationship extracted from historical data.	All	+0.17%

Identification of mitigation options related to the most important future sources and sinks sectors

After analysing the results obtained from model projections in BaU Scenarios, it was determined that GHG mitigation actions in the power generation sector needed to focus on a more efficient use of natural gas and diversification of the matrix, including a higher penetration of renewable sources. Trinidad and Tobago already generates electricity by natural gas, the cleanest fossil fuel, and opportunities for increased mitigation in this sector lie in increased generation efficiency and renewable energy. Beyond maximum efficiency using natural gas, renewable energy was the only area for enhanced mitigation.

In the industry sector, specific assessments needed to be made in order to determine if the best available technologies were being used in each industry, and if any measures could be implemented to improve the efficiency and reduce the GHG emissions as the mitigation analysis showed the most comprehensive emission reduction measures for the sector as a whole. Regarding the use of fuels in this sector, the energy and manufacturing plants consumed the biggest share of the energy in the country. Thus, the most effective reductions could be achieved if efforts were focused on reducing consumption in these facilities. The plants were diverse, and many differences could be found among them. For that reason, the application of general measures could be complicated.

Concerning fugitive and vented emissions, these were directly related to the production of natural gas and oil. In order to reduce their impact, measures must be oriented towards monitoring these leaks so that they could be rectified and on finding alternatives for their recapture and reuse.

In the transport sector, the main emissions were caused by, and likely to continue being road transport. In order to reduce those emissions, alternatives to the transport trends of Trinidad and Tobago needed to be analysed, focusing, on the one hand, on reducing the fuel consumption of road vehicles by adopting new technologies such as electric cars (provided that they were recharged with electricity from renewable sources) and biofuel vehicles and, on the other hand, providing alternatives in terms of public transport to reduce the number of cars on the roads.

With respect to the waste sector, emissions were generated by both solid and liquid industrial waste. Given this, more action plans based on circular economy principles could be implemented to reduce generation.

Finally, regarding the AFOLU sector, it should be noted that this was the only sector projected to reduce its emissions. The main reason for this reduction was the fact that in the historical period they had remained constant, and the projections were more influenced by specific measures than by socio-economic variables. Thus, the measures that were identified had a great influence on the results. It is also worth mentioning that data for the AFOLU sector were patchy, and that if the GHG Inventory were to be improved upon, the projection would be more robust.

It should be noted that these were the preliminary results obtained from the mitigation analysis of the existing measures in the country (either already implemented or in the process of implementation). The following sections show the set of measures that were proposed for reducing the country's emissions considering these guidelines for each of the sectors.

Potential Mitigation Actions

In addressing GHG emissions, the actions needed to be well designed in order to address the most relevant sources of emissions in every sector. Creating the enabling environment and overcoming some identified challenges would be necessary in order to realise the full efficacy of the proposed mitigation measures.

Proposed Mitigation Measures

It should be noted that both direct and indirect measures to reduce GHG emissions were identified. While some of the measures do not lead to direct GHG emissions reductions, they are considered necessary in order to enhance capacity, raise awareness and improve the quantity and quality of GHG emissions information and data.

The measures can be divided according to their main purpose:

- Knowledge: These measures aim to enhance knowledge on energy and climate change-related issues in Trinidad and Tobago. One of the key factors for the successful design and implementation of GHG mitigation actions is the availability of coherent and reliable information and these measures are designed to provide it.
- Action: The measures included in the action strategic axis are those leading to GHG emissions reductions. They include concrete tasks and their design is based on existing information.
- Awareness: Raising awareness is crucial to the promotion of GHG mitigation measures. The sectors addressed, as well as the general population, will be responsible for the implementation of several measures. Therefore, without their contribution, the stated objectives are not likely to be achieved. A set of well-designed measures for raising awareness will help to involve all stakeholders.
- Policy: The implementation of GHG mitigation measures should be facilitated through the appropriate policy environment. The measures proposed under the policy axis aim to facilitate the creation of that environment, promote coordinated implementation, and foster the relevance of climate change mitigation within Trinidad and Tobago's policy framework.

Additionally, these measures are also grouped into sub-categories within their sector according to their strategic purpose.

Organising the measures according to their purpose provides an idea of the main objective of each type of action, whether it is to gain knowledge, raise awareness, take action, or define/redefine a policy. Accordingly, organising the measures by Strategy Lines provides a mapping of the activities according to their strategic objectives.

For the analysed sectors—power generation, industry, transport, waste/water and AFOLU—a total of 33 potential mitigation actions, measures and policies were identified and shortlisted after a discussion with the most relevant stakeholders in the country. **TABLE 3.11** contains a summary of the potential actions proposed in this document.

TABLE 3.11 Quantified potential measures for all sectors

Sector	Action line	Code	Purpose	Measure	Timeframe[1]
Power Generation	Education/ Awareness-raising	**P.G.1**	Awareness	Conservation Education through Curriculum and Culture	Medium
		P.G.8	Awareness	Increased customer engagement	Short
	Renewable Energies	**P.G.2**	Action Awareness	Renewable Energy and Direct Electricity Replacement (REDER) Campus Initiative	Long
		P.G.5		Cooperative RE	Long
		P.G.6		Increased penetration of Utility Scale RE 30%	Long
		P.G.9		Use solar power for water treatment plants.	Medium–long
	Green Building	**P.G.3**	Awareness	Green Building Awareness and Incentive Programme	Short
	Energy Efficiency	**P.G.4**	Action	Supply Side Management: Generation Dispatch	Short
		P.G.7		Energy Efficient Appliance Programme	Short–medium
Industry	Renewable Energies	**I.1**	Action	Renewable fuels	Long
	Cross-sectoral	**I.2**		Captured Carbon Industry	Long

1 Timeframe: short-term (next 5 years), medium-term (5–10 years), long-term (> 10 years)

TABLE 3.11 (CONTINUED) Quantified potential measures for all sectors

Sector	Action line	Code	Purpose	Measure	Timeframe[1]
Transport	Public Transport and Road Network	T.3	Action	Introduction of park-and-ride system pilot	Short
		T.5		Transit Service Improvements	Short
	Incentives and Disincentives for Private Modes of Transport	T.1	Policy	Compact land use policies and mixing of land uses	Long
		T.2		Pay-as-you-drive auto insurance	Medium
		T.4		Parking pricing and parking supply management	Medium
Waste and Wastewater	Solid Waste	W.W.1	Action	Waste Reduction and Diversion	Short
		W.W.2		Segregation of solid organic waste for material recovery in composting plants	Long
	Wastewater	W.W.3		Installation of anaerobic sludge digesters at water treatment plants to capture and burn methane	Medium
		W.W.4		Use of treated wastewater	Short
	Agricultural residues	W.W.5		Urgent development of responsible disposal of end-of-life wood products	Short
AFOLU	Urban Greening	A.1	Action	Urban Greening Activities	Late short term to early medium term
	Forest	A.2		Rehabilitation of degraded forested land	Short term
		A.5		Forest Management and Protection	Short term
	Agriculture and Farming	A.3	Knowledge	Reduction, control and monitoring of agri-chemical application by farmers	Short term except the development of standards which is to be completed by early medium term
		A.4	Action	Halting of biomass burning—especially agricultural burning	Short term
		A.6	Knowledge	Biochar production and application	Late short term to early medium term for complete development of biochar production system

TABLE 3.12 Non-Quantified Potential Measures for all Sectors

Sector	Action line	Code	Purpose	Measure	Timeframe[1]
Power Generation	Education/ Awareness-raising	NQ 1	Knowledge	Electricity usage behavioural research	Short
		NQ 2	Policy	Economic instruments to foster carbon reductions	Short
AFOLU	Agriculture	NQ 3	Knowledge	Agriculture and Technology—Vertical Farming	Late short term
	Adaptation	NQ 4	Knowledge	Land Use Planning & Anticipatory Action to bolster Adaptation and Resilience	Short term
	Agriculture and Farming	NQ 5	Knowledge	Development of a National Climate Smart Agricultural (CSA) approach	Policy and non-physical = short term; Implementation= medium term
		NQ 6		Livestock—feeding and long-term management, breeding	Implementation in short term

1 Timeframe: short-term (next 5 years), medium-term (5–10 years), long-term (> 10 years)

Photo Credit: Ministry of Energy and Energy Industries

▲ Solar PV and Solar Stills, Parvati Girls' Hindu College, Debe Trinidad, 2014

TABLE 3.12 shows other measures, which were not quantifiable in emissions reductions terms, either because it is not possible to attribute a reduction in direct emissions, or because not enough data are currently available for their estimation.

Analysis of Measures by Sector

Power Generation

The power generation sector has a significant impact on the country's GHG emissions and is also strongly tied to its economic performance. This sector is inherently linked to industry since industry is the major user of electrical power.

There was general agreement in the power generation sector regarding the measures that need to be taken to reduce fossil fuel use emissions.

New initiatives in the power generation sector can be seen in the broad categories of behavioural modifiers (both long and short term), operational efficiency and renewable energy. Measures pertaining to behavioural modifiers in particular do not lend themselves to ready quantification of GHG emission reductions but are nonetheless important in laying the foundation for mitigation measures related to the power generation sector.

MEASURE P.G.1: Conservation Education through Curriculum and Culture

Description	Introduce conservation across the curriculum in ECCE, primary and secondary school systems.				
Purpose	Awareness	**Sectors**	Energy	**GHG gases**	CO_2, CH_4, N_2O
Mitigation potential in tCO_2e	The reduction of emissions in this measure is due to the development of a programme to carry out environmental education courses in schools that will lead to a reduction in energy consumption at home. The reduction in emissions is estimated at 0.3% of the total, which is 1% of the total for the residential sector.[1] **Accumulated:** 187,709 tCO_2e **Annual average:** 12,514 tCO_2e				

Tasks	**Task**
	1. Set up task force for planning and design of curriculum and specification of KPIs
	2. Pilot curriculum in a sample of schools at each level (ECCE, Primary and Secondary)
	3. Implement across all schools

Schedule

Task	2018		2019		2020		2021		2022		2023		2024		2025		2026		2027		2028		2029		2030		2031		2032		2033		2034		2035	
Task 1									■																											
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Task 3																■																				

Responsible entity	Ministry of Education, MPU, MPD, MEEI
Appropriateness and effectiveness	Long term cultural change can only take place through proper value education. Schools provide a ready opportunity for instilling positive values in children on a national scale.
Barriers	» There may be insufficient space in the school curriculum. » Teacher training and education may be costly.
Advantages/ opportunities/ co-benefits	» Air quality improvement which implies health benefits and less public health costs » Long-term nationwide impact » Increase of general comfort » Increase sensitivity to all kinds of environmental issues » Increase of general knowledge » Better prepared professionals for future careers » Opportunities for innovation
Synergies and/ or trade-off with adaptation	This measure can be incorporated into larger curriculum issues such as sustainability, green growth, circular economy or general environmental management.
Synergies and/ or trade-off with other development aspects	Can be fit into a larger programme of environmental consciousness and SDG implementation.
Methodologies, assumptions or other considerations	Pilot studies required to determine effectiveness of education on energy usage in local context (especially with subsidised electricity rates).

1 Value extracted from Gill and Lang (2018) and United States Environmental Protection Agency (2011), studies where citizen behaviour is analysed after the implementation of this type of course.

MEASURE P.G.2: REDER Campus Initiative

Description	Renewable Energy and Direct Electricity Replacement (REDER) installations at ECCE, Primary and Secondary Schools				
Purpose	Action	**Sectors**	Energy	**GHG gases**	CO_2, CH_4, N_2O
Mitigation potential in tCO_2e	The reduction of emissions is due to the use of emissions-free renewable energy. Mitigation potential is calculated from the equivalent grid-generated power and considers the installation of 250kW per year over a period of 20 years. **Accumulated:** 34,983 tCO_2e **Annual average:** 2,332 tCO_2e				
Tasks	**Task**				
	1. Identification of 15 pilot schools at each level for REDER installation				
	2. System requirements and specifications				
	3. Tendering and selection of contractors				
	4. Installation at pilot schools (5 per year for 3 years)				
	5. Continued roll out to other schools (5 per year). New schools should also be outfitted as appropriate.				

Schedule

Task	2018		2019		2020		2021		2022		2023		2024		2025		2026		2027		2028		2029		2030		2031		2032		2033		2034		2035	
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Responsible entity	MPU, MEEI, T&TEC
Appropriateness and effectiveness	» Direct Energy replacement refers to technologies such as solar thermal heating or light pipes which do not involve the conversion of energy electricity before reconversion to end use. » Installing REDER technologies in schools normalises their use in students' lives and makes them more comfortable with using the technologies while making them more conscious about energy usage. » Directly reduces GHG emissions by replacing fossil fuel generation » There are more than 400 educational institutions nationwide so there is sufficient potential for this measure to be effective.
Barriers	» High cost of installation » Installation regulations and feed-in tariffs
Advantages/ opportunities/ co-benefits	» Directly reduces GHGs by replacing fossil fuel generation » Brings REDER technologies to the consciousness of students in a tangible way. » Increase in general knowledge » Opportunities for innovation » Increase of energy efficiency and energy resilience/security » Better prepared professionals for future careers » Opportunities for innovation
Synergies and/or trade-off with adaptation	Contributes to enhanced climate resilience through loss of power from national grid during extreme weather events; improvement of public health through improved air quality
Synergies and/or trade-off with other development aspects	Increased employment for REDER technicians and contracting companies
Methodologies, assumptions or other considerations	Can be extended to government buildings

MEASURE P.G.3: Green Building Awareness and Incentive Programme

Description	Raise awareness on green building construction and direct electricity replacement (DER) technologies such as solar water heating and daylighting systems and night air cooling systems. Provide government incentives for using green building products or technologies where appropriate.
Purpose	Awareness — **Sectors:** Energy — **GHG gases:** CO_2, CH_4, N_2O
Mitigation potential in tCO_2e	The replacement of electrical water heating by solar systems will eliminate emissions. This measure also includes a reduction in emissions associated with improving the energy efficiency of the homes by conditioning the ventilation and natural lighting. The study considers the replacement of 4200 systems per year during the period analysed. (35TJ of energy replaced by renewable energy previously coming from natural gas) **Accumulated:** 888,877 tCO_2e **Annual average:** 59,258 tCO_2e
Tasks	**Task** 1. Establish task force for identifying relevant technologies and construction features for promotion and detailing incentives for adoption. 2. Develop awareness and education programmes for contractors and other stakeholders in construction industry (for technologies and incentives).

Schedule

Task	2018		2019		2020		2021		2022		2023		2024		2025		2026		2027		2028		2029		2030		2031		2032		2033		2034		2035	
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Task 2										■	■	■																								

Responsible entity	MoWT, MPU, MEEI, MPD, TTBS, T&TEC, RIC, SWMCOL
Appropriateness and effectiveness	Increases the adoption of technologies that would result in direct reduction in GHG through reduction in electricity usage
Barriers	» Lack of familiarity with technologies » Increased cost of construction and retrofitting with green technologies » Updating of Building Code
Advantages/ opportunities/ co-benefits	» This measure is innovative. If a monitoring system is applied, locations such as parks and beaches could be used in a pilot project for the implementation of new technologies and could be expanded if results are positive. » Air quality improvement that implies health benefits and less public health costs » Increase of general comfort due to the urban heat island reduction » Opportunities for innovation » Job opportunities
Synergies and/ or trade-off with adaptation	Increased climate resiliency
Synergies and/ or trade-off with other development aspects	Synergies with Sustainable Development Goals
Methodologies, assumptions or other considerations	NA

MEASURE P.G.4: Supply Side Management: Generation Dispatch

Description	Supply side management refers to optimising the efficiency of electric power generation, transmission and distribution. Supply side management involves, inter alia, updating generating plant and generation dispatch algorithms and analysis of PPAs. While updating generating plant is costly and has to be considered in long term planning, generation dispatch algorithms can be adjusted with little cost.

Purpose	Action	**Sectors**	Energy	**GHG gases**	CO_2, CH_4, N_2O

Mitigation potential in tCO_2e	This measure is aimed at designing models/programmes that help to optimise the energy consumption of the industry and therefore to improve its energy efficiency by reducing consumption and related emissions. Since energy industries are large consumers of energy, the study estimates that an annual reduction of 1% of total demand could be obtained (10–15MW). **Accumulated:** 751,916 tCO_2e **Annual average:** 50,128 tCO_2e
Tasks	**Task**
	1. Establishment of multi-stakeholder research team (T&TEC, IPPs and independent researchers)
	2. Identification and screening of methods, data requirements and additional measurement technology required
	3. Implementation by IPPs and T&TEC

Schedule

Task	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
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Task 2					■■													
Task 3						■■	■■	■■										

Responsible entity	T&TEC, IPPs	
Appropriateness and effectiveness	Results in direct reductions in GHG emissions by reducing power losses in the system	
Barriers	» Lack of installed technology to measure generator performance required for optimisation studies » Long term take-or-pay PPAs	
Advantages/ opportunities/ co-benefits	» Low cost if done in conjunction with local universities » Opportunities for innovation » Better prepared professionals	» Job opportunities » Increase in energy efficiency » Air quality improvement that implies health benefits and less public health costs
Synergies and/ or trade-off with adaptation	N/A	
Synergies and/ or trade-off with other development aspects	N/A	
Methodologies, assumptions or other considerations	N/A	

MEASURE P.G.5: Cooperative RE

Description	Small to medium scale renewable energy installations with potential private investment from local communities to allow RE participation by a wider economic cross-section				
Purpose	Action	**Sectors**	Energy	**GHG gases**	CO_2, CH_4, N_2O
Mitigation potential in tCO_2e	The reduction of emissions is due to the use of emissions-free renewable energy. Mitigation potential is calculated from the equivalent grid-generated power and considers the installation of 200kW per year over a period of 20 years. **Accumulated:** 27,723 tCO_2e **Annual average:** 1,848 tCO_2e				

Tasks	**Task**
	1. Feasibility studies (including business structure and potential sites)
	2. Establishment of coordinating body or government company to oversee deployment
	3. Development of pilot sites
	4. Nationwide expansion of programme

Schedule

Task	2018		2019		2020		2021		2022		2023		2024		2025		2026		2027		2028		2029		2030		2031		2032		2033		2034		2035	
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Task 4													■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■

Responsible entity	MPU, MEEI, MPD, T&TEC, RIC, AGLA
Appropriateness and effectiveness	Directly reduces GHGs by reducing fossil fuel generation
Barriers	» Lack of policies governing RE and feed-in tariffs
Advantages/ opportunities/ co-benefits	» Allows wider participation of the society » Opportunities for innovation » Increase in energy efficiency » Air quality improvement that implies health benefits and less public health costs
Synergies and/ or trade-off with adaptation	Builds climate and disaster resilience in communities
Synergies and/ or trade-off with other development aspects	Aids in creating new jobs for RE technicians
Methodologies, assumptions or other considerations	N/A

MEASURE P.G.6: Increased Penetration of Utility Scale RE

Description	Designing and Implementing utility scale RE Installations with appropriate storage capabilities. This would allow Utility Scale RE power generation to replace fossil-based power generation gradually, as the old fossil plants are retired and natural gas reserves are depleted.				
Purpose	Action	**Sectors**	Energy	**GHG gases**	CO_2, CH_4, N_2O
Mitigation potential in tCO_2e	The reduction of emissions is due to the use of emissions-free renewable energy. Mitigation potential is calculated from the equivalent grid-generated power and considers additional installed capacity of 100 MW of RE by 2050. **Accumulated:** 986,876 tCO_2e **Annual average:** 65,792 tCO_2e				
Tasks	**Task**				
	1. Feasibility studies (technical and economic)				
	2. RFPs				
	3. PPAs with IPPs				
	4. Installation of RE facilities				

Schedule

Task	2018		2019		2020		2021		2022		2023		2024		2025		2026		2027		2028		2029		2030		2031		2032		2033		2034		2035	
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Task 2																																				
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Task 4																																				

Responsible entity	MPU, T&TEC, RIC, MEEI	
Appropriateness and effectiveness	Directly reduces GHG emissions by replacing fossil fuel generation	
Barriers	» Cost of implementation » Low rates of Electricity using conventional generation	» Lack of legislative and policy frameworks » Compromised grid security and stability with increasing penetration of RE
Advantages/ opportunities/ co-benefits	» Directly reduces GHG emissions by replacing fossil fuel generation » Experience from already established utility-scale solar RE » Increase of general knowledge » Opportunities for innovation	» Job opportunities » Increased energy security » Air quality improvement that implies health benefits and reduced public health costs » Increased Energy Security
Synergies and/ or trade-off with adaptation	Increased climate resilience	
Synergies and/ or trade-off with other development aspects	Creation of new jobs for RE engineers and technicians; technology development and transfer; SDGs synergy	
Methodologies, assumptions or other considerations	N/A	

MEASURE P.G.7: Energy Efficient Appliance Programme

Description	Incentive programmes to encourage switching to higher energy efficiency appliances and devices				
Purpose	Action	**Sectors**	Energy	**GHG gases**	CO_2, CH_4, N_2O
Mitigation potential in tCO_2e	Measure to encourage the replacement of household appliances with more energy efficient ones, which would result in savings in electricity consumption and therefore in reduced emissions. The study considers the inclusion of the 5% of the users in the residential sector over a period of 5 years, or 1% per year. The reduction in consumption by switching to more efficient appliances is 20% according to the technical characteristics of the EnergyStar label. From the above, it can be concluded that the total electricity demand is reduced annually by 0.06%. **Accumulated:** 215,094 tCO_2e **Annual average:** 14,340 tCO_2e				
Tasks	**Task**				
	1. Establishment of task force to structure incentive programmes				
	2. Implementation of incentive programmes				
	3. Education and Awareness programmes for public				

Schedule

Task	2018		2019		2020		2021		2022		2023		2024		2025		2026		2027		2028		2029		2030		2031		2032		2033		2034		2035	
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Task 3											■																									

Responsible entity	MPU, MEEI, MPD, T&TEC, RIC, MSDaFS, TTBS
Appropriateness and effectiveness	Directly reduces electricity usage by using higher efficiency devices.
Barriers	» Higher efficiency devices are often more expensive making them unaffordable to lower income citizens. » Low cost of electricity makes savings negligible compared to increased cost of devices.
Advantages/ opportunities/ co-benefits	» Air quality improvement that implies health benefits and less public health costs » Increase of general comfort » Increase industry efficiency and independence
Synergies and/ or trade-off with adaptation	N/A
Synergies and/ or trade-off with other development aspects	N/A
Methodologies, assumptions or other considerations	N/A

MEASURE P.G.8: Increased Customer Engagement

<table>
<tr><td>Description</td><td colspan="37">Public education and awareness, and consumer empowerment</td></tr>
<tr><td>Purpose</td><td colspan="5">Action</td><td colspan="5">Sectors</td><td colspan="9">Energy</td><td colspan="9">GHG gases</td><td colspan="9">CO_2, CH_4, N_2O</td></tr>
<tr><td>Mitigation potential in tCO_2e</td><td colspan="37">The reduction of emissions through this measure will be achieved by promoting energy-saving programmes in homes aimed at shrinking emissions by an estimated 0.3% per home, which would in turn result in an overall reduction of 1% in emissions from the residential sector.[1]
Accumulated: 187,709 tCO_2e
Annual average: 12,514 tCO_2e</td></tr>
<tr><td rowspan="4">Tasks</td><td colspan="37">Task</td></tr>
<tr><td colspan="37">1. Set up task force for determining mechanisms for customer engagement</td></tr>
<tr><td colspan="37">2. Screening of methods and setting of timelines for implementation</td></tr>
<tr><td colspan="37">3. Implementation of engagement methods</td></tr>
<tr><td rowspan="4">Schedule</td><td>Task</td><td colspan="2">2018</td><td colspan="2">2019</td><td colspan="2">2020</td><td colspan="2">2021</td><td colspan="2">2022</td><td colspan="2">2023</td><td colspan="2">2024</td><td colspan="2">2025</td><td colspan="2">2026</td><td colspan="2">2027</td><td colspan="2">2028</td><td colspan="2">2029</td><td colspan="2">2030</td><td colspan="2">2031</td><td colspan="2">2032</td><td colspan="2">2033</td><td colspan="2">2034</td><td colspan="2">2035</td></tr>
<tr><td>Task 1</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>■</td><td>■</td><td>■</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
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<tr><td>Task 3</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>■</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Responsible entity</td><td colspan="37">T&TEC, RIC, TTBS</td></tr>
<tr><td>Appropriateness and effectiveness</td><td colspan="37">Increasing engagement with consumers leads to reductions in energy consumption by making them more aware of their energy usage and that of comparable customers. Such measures rely on customer self-regulation and are shown to lead to reductions in domestic electricity usage.</td></tr>
<tr><td>Barriers</td><td colspan="37">» The information required to create appropriate customer categories for comparisons may be difficult to obtain.
» The low cost of electricity reduces the effectiveness of any type of conservation initiative.</td></tr>
<tr><td>Advantages/ opportunities/ co-benefits</td><td colspan="37">» Increase in general confidence. Customers understand their needs and are better equipped to demand improved service.
» Increase in general knowledge
» Increase in innovation because the population is more informed and better able to recognise opportunities</td></tr>
<tr><td>Synergies and/ or trade-off with adaptation</td><td colspan="37">N/A</td></tr>
<tr><td>Synergies and/ or trade-off with other development aspects</td><td colspan="37">Can fit into a larger programme of environmental consciousness</td></tr>
<tr><td>Methodologies, as-sumptions or other considerations</td><td colspan="37">Scientific surveys are required to determine how customer categories can be set up to allow for accurate comparisons.</td></tr>
</table>

1 The value is extracted from the following studies where citizen behaviour is analysed after the implementation of this type of course: Gill and Lang (2018), United States Environmental Protection Agency (2011).

MEASURE P.G.9: Use of Solar Power In Water Treatment Plants

Description	Use of solar power in water treatment plants e.g. use of floating solar panels in dams/reservoirs				
Purpose	Action	**Sectors**	Power Generation–Water industry	**GHG gases**	CO_2, CH_4, N_2O
Mitigation potential in tCO_2e	The reduction of emissions is due to the use of emissions-free renewable energy. Mitigation potential is calculated from the equivalent grid-generated power and considers additional installed capacity of 1MW (which covers an area of about 5 acres). **Accumulated:** 20,248 tCO_2e **Annual average:** 1,350 tCO_2e				
Tasks	**Task** 1. Prepare Feasibility Study. 2. Project proposal approval, tender process, contract with private entity to supply, install and operate 3. Purchase panels—Install panels—Provide feedback on effectiveness and efficiency of panels in use.				

Schedule

Task	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
Task 1																		
Task 2																		
Task 3																		

Responsible entity	WASA, T&TEC, Ministry of Public Utilities, MEEI, Ministry of Trade and Industry - Customs and Excise Division, desalination plants, Ministry of Energy and Energy Industries
Appropriateness and effectiveness	Reduction in the utility's operating costs, and strengthening of the country's resilience in case of a natural disaster
Barriers	» Capital cost » Relatively inexpensive cost based on subsidised energy
Advantages/ opportunities/ co-benefits	» Reduction in utility costs over time » Job creation
Synergies and/ or trade-off with adaptation	N/A
Synergies and/ or trade-off with other development aspects	This would form part of the country's response to disasters such as hurricanes or floods. It is also linked to the country's commitment to GHG reductions.
Methodologies, assumptions or other considerations	N/A

Photo Credit: National Energy [facebook.com/nationalenergytt]

▲ Union Industrial Estate, La Brea, owned and managed by National Energy

Industry

The industry sector accounts for the majority of GHG emissions in the country and is also strongly linked to its economic performance. This sector is also intrinsically linked to the power generation sector since industry is the majority user of electrical energy.

The industrial sector is much more constrained in terms of options for GHG mitigation with industrial heating and process emissions accounting for the vast majority of emissions. As such, new methods look to decarbonisation through alternative means, such as developing new industries in carbon capture, renewable fuels, and hydrogen which can potentially stimulate economic growth as well.

In this regard, measures may require extensive feasibility studies to be carried out before definitive targets can be set.

MEASURE I.1: Renewable Fuels

Description	Increase the usage of renewable sources of fuels which have lower life cycle GHG costs than their fossil fuel counterparts.				
Purpose	Action	**Sectors**	Industry	**GHG gases**	CO_2, CH_4, N_2O
Mitigation potential in tCO_2e	The reduction of emissions in this measure is based on the substitution of natural gas by biofuels. It is estimated that 10% of natural gas consumption can be replaced by alternative fuels by 2050. Therefore, in the case of biogas[1] (considering that there will be a mix with more biofuels), 5% of consumption can be reached in 2050 (Replacement of 3,194 TJ of natural gas per year). **Accumulated:** 1,107,884 tCO_2e **Annual average:** 73,859 tCO_2e				
Tasks	**Task**				
	1. Feasibility studies (Renewable Fuel Production potential vs importation)				
	2. If RE Technology is feasible, the power generation sector is open for RFPs for new power generation				
	3. Tendering and contractor selection				
	4. Phased implementation continuing as required				

Schedule

Task	2018		2019		2020		2021		2022		2023		2024		2025		2026		2027		2028		2029		2030		2031		2032		2033		2034		2035	
Task 1									■	■																										
Task 2											■																									
Task 3												■																								
Task 4													■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■

Responsible entity	AGLA, MEEI, MPU MPD
Appropriateness and effectiveness	Renewable sources of fuels such as renewable natural gas (RNG) has lower life cycle GHG costs than its fossil fuel counterpart.
Barriers	» Natural Gas Subsidy » Availability of renewable fuels in adequate quantities
Advantages/opportunities/co-benefits	» Since Renewable fuels are chemically identical to their fossil fuel counterparts no change in operation process is necessary. » Opportunities for innovation » Air quality improvement that implies health benefits and less public health costs » Job creation
Synergies and/or trade-off with adaptation	N/A
Synergies and/or trade-off with other development aspects	New industry in the production of biofuels is possible which would create employment
Methodologies, assumptions or other considerations	N/A

1 It should be noted that the CO_2 fraction of biogas burning is of biogenic origin, since it comes from biomass materials that naturally retain CO_2 (carbon sinks). In this sense, these CO_2 emissions are not considered for the global computation and only CH_4 and N_2O emissions should be considered. As the contribution of these two is minimal, (> 5%), they are considered negligible. Therefore, an EF=0 for biogas combustion is assumed for the calculation.

MEASURE I.2: Captured Carbon Industry

Description	Development of downstream industries to make use of captured carbon so that it is feasible for industries to implement carbon capture technologies which would otherwise not be economically feasible.				
Purpose	Action	**Sectors**	Industry	**GHG gases**	CO_2
Mitigation potential in tCO_2e	Emission reductions are estimated based on carbon capture potential and associated technologies and the available potential could reduce emissions generated by the industrial sector by 10% under a trend scenario. **Accumulated:** 44,573,060 tCO_2e **Annual average:** 2,971,537 tCO_2e				
Tasks	**Task**				
	1. Establish task force to determine feasibility of downstream captured carbon industries and detail plans for industry development				
	2. If feasible: RFPs, Tendering and contractor selection				
	3. Implementation on a phased basis in the long term				

Schedule

Task	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
Task 1				■														
Task 2					■													
Task 3						■	■	■	■	■	■	■	■	■	■	■	■	■

Responsible entity	MEEI, MPD, Energy Chamber, Industry stakeholders
Appropriateness and effectiveness	Allows the monetisation of GHG gases and relax need for expensive reduction technology implementation by emitting industries
Barriers	» Unknown until feasibility studies performed.
Advantages/ opportunities/ co-benefits	» Opportunity for creation of new industries and jobs. » Air quality improvement that implies health benefits and less public health costs.
Synergies and/ or trade-off with adaptation	N/A
Synergies and/ or trade-off with other development aspects	Opportunity for creation of new industries and jobs
Methodologies, assumptions or other considerations	N/A

Transport

Given that the majority of transport-based emissions arise from road transport, attention is focused on this aspect of the transportation sector. Accordingly, the primary road-based factors on which efforts will be made are (a) vehicle kilometres (or miles) travelled; (b) fuels; (c) vehicles; (d) operational efficiency; and (e) construction, maintenance, and agency operations.

To successfully reduce the use of private vehicles and parking within urban areas, key policy changes are necessary. Some policy approaches contemplated are as follows:

Mixing of land uses: This refers to the proximity of different land uses (residential, commercial, institutional, etc.). Sometimes described as the jobs/housing balance, it refers to the ratio of jobs and residents in an area. Concentrating housing and employment within existing urban areas tends to increase transit system efficiency (by reducing travel distances between local destinations such as homes, services and workplaces). This is known as more compact land use management strategies and is also called Smart Growth. Regarding compact land use and mixing of land uses, this serves to encourage more compact, mixed, multi-modal development to allow more shared parking and use of alternative modes. Current land use policies limit development density, disperse destinations and favour automobile access over alternative modes. Smart growth policies reduce vehicle travel and create more complete and self-contained communities while promoting the locating of schools, parks and shops within neighbourhoods.

Pay-As-You-Drive (PAYD) Vehicle Insurance: This refers to vehicle insurance premiums that are based directly on how much a vehicle is driven during the policy term. The more you drive the more you pay and the less you drive the more you save. This can be done by changing how premiums are calculated from the vehicle-year to the vehicle-mile, vehicle-kilometre or vehicle-minute. Pay-As-You-Drive (PAYD) pricing helps achieve several public policy goals including fairness, affordability, road safety, consumer savings and choice, and reduced traffic problems such as traffic congestion, road and parking facility costs, pollution emissions and sprawl. PAYD should reduce average annual mileage of affected vehicles by 10-15%, reduce crash rates by a greater amount, increase equity, and save consumers money. It reduces the need for cross-subsidies currently required to provide "affordable" unlimited-mileage coverage to high-risk drivers. It can particularly benefit lower-income communities that currently pay excessive premiums. Some insurance companies now offer versions of PAYD pricing but implementation is limited.

Park and ride: This is another initiative to develop a system pilot project for remote and safe parking with return travel by bus on priority lanes to city centres.

Parking pricing and parking supply management: This is another potential initiative that serves to provide parking pricing and parking supply management.

The last line of action is focused on improvements in the Transit Service, including increased service routes, HOV priority, improved comfort, lower fares, more convenient payment options, improved user information, marketing programmes, transit-oriented development, improved security, and special services such as express commuter buses and Bus Rapid Transit.

MEASURE T.1: Compact Land Use Policies and Mixing of Land Uses

Description	Encourage more compact, mixed, multi-modal development to allow more parking sharing and use of alternative modes.
Purpose	Policy — **Sectors**: Planning and Construction Sectors — **GHG gases**: CO_2, CH_4, N_2O
Mitigation potential in tCO_2e	Mitigation potential is mainly due to vehicle travel time reduction. Its full impact, however, is complex to estimate. According to literature (Litman, 2003), smart growth programmes can reduce resident and employee vehicle travel by 10-30%, or even more, compared with automobile-oriented development. In order to re-scale this mitigation potential to a more realistic case, this reduction percentage was modified accordingly to some assumptions related to the application surface (one km2, 12 times less than the Port of Spain area) and considering only the 50% of its potential, because only the 50% of the measure considers already urbanised areas. Hence, mitigation potential reduction was assumed as 0.83% of the total expected emissions. **Accumulated:** 414,038 tCO_2e **Annual average:** 27,603 tCO_2e
Tasks	**Task** 1. Measure implemented throughout the country
Schedule	(see schedule below)
Responsible entity	Ministry of Planning and Development; Ministry of Works and Transport; Ministry of Rural Development and Local Government
Appropriateness and effectiveness	This serves to encourage more compact, mixed, multi-modal development to allow more parking sharing and use of alternative modes. Current land use policies limit development, density disperses destinations and favour automobile access over alternative modes. Smart growth policies reduce vehicle travel and create more complete, self-contained communities, and promote locating schools, parks and shops within neighbourhoods.
Barriers	» Reconciling existing development and revitalising urban centres to decentralise public services from PoS
Advantages/ opportunities/ co-benefits	» Job formation » Air quality improvement » Open land preservation » Decrease in the number of critical infrastructure needed (energy, water, healthcare, education) » Decrease in travel time » Decrease in population socioeconomic differences
Synergies and/ or trade-off with adaptation	
Synergies and/ or trade-off with other development aspects	» The complementarity of this measure with the wider national development agenda. The measure will (1) create employment for all skills in construction, including architecture, engineering, equipment and materials management and skilled labour, as well as in maintenance and facilities management; (2) provide housing for lower and middle-income earners.
Methodologies, assumptions or other considerations	N/A

Schedule

Task	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
Task 1																		

MEASURE T.2: Pay-As-You-Drive (PAYD) Auto Insurance

Description	Converting vehicle insurance and registration fees from fixed charges into per-mile charges. This provides a significant financial incentive to reduce driving while making these charges more reasonable and affordable. Pay-As-You-Drive pricing helps achieve several public policy goals including fairness, affordability, road safety, consumer savings and choice, and reduced traffic problems such as traffic congestion, road and parking facility costs, pollution emissions and sprawl. PAYD should reduce average annual mileage of affected vehicles by 10-15%, reduce crash rates by a greater amount, increase equity, and save consumers money. It reduces the need for cross-subsidies currently required to provide "affordable" unlimited-mileage coverage to high-risk drivers. It can particularly benefit lower-income communities that currently pay excessive premiums. Some insurance companies now offer versions of PAYD pricing, but implementation is limited.
Purpose	Policy — **Sectors**: Insurance Companies — **GHG gases**: CO_2, CH_4, N_2O
Mitigation potential in tCO_2e	Mitigation potential comes from the reduction of private vehicle use due to financial incentives. According to the literature (Litman, 2003), typical reductions by affected travel may rise to 15%. Assuming that the incentive would affect 30% of the transport, this measure has a mitigation potential of 3.75%. **Accumulated:** 1,863,170 tCO_2e **Annual average:** 124,211 tCO_2e
Tasks	**Task** 1. Develop framework for implementation including policy, legislative, institutional and administrative aspects. 2. Implementation

Schedule

Task	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
Task 1					■													
Task 2						■												

Responsible entity	Ministry of Finance, Association of Trinidad and Tobago Insurance Companies (ATTIC)
Appropriateness and effectiveness	Pay-As-You-Drive (PAYD) pricing requires annual odometer audits which can be incorporated into existing vehicle inspection regimes.
Barriers	» Requires Government acceptance as a policy.
Advantages/ opportunities/ co-benefits	» PAYD insurance can apply to virtually all private automobile travel, and PAYD registration fees and taxes could apply to all vehicles. » Air quality improvement » Decrease in travel time » Improve general comfort (less vehicles, more space for pedestrians) » Job formation
Synergies and/ or trade-off with adaptation	N/A
Synergies and/ or trade-off with other development aspects	» Reduces traffic jams and associated socio-economic impacts on productivity
Methodologies, assumptions or other considerations	N/A

MEASURE T.3: Introduction of Park-And-Ride (P&R) System Pilot

Description	This serves to park remotely and safely and travel by bus on priority lanes to POS from the east and south, and back.
Purpose	Action | **Sectors**: PTSC and Maxi Taxis | **GHG gases**: CO_2, CH_4, N_2O
Mitigation potential in tCO_2e	Off-site or urban fringe parking facilities can provide a typical reduction of vehicle trips by 10–30% (Litman, 2003). In order to apply It to a realistic situation, it was assumed that the measure would reach the 10% of its potential, leading to a 1.5% of transport emissions reduction. **Accumulated:** 745,268 tCO_2e **Annual average:** 49,685 tCO_2e
Tasks	**Task** 1. Develop framework for implementation including policy, legislative, institutional and administrative aspects. 2. Implementation
Responsible entity	Ministry of Works and Transport; Public Transport Service Corporation (PTSC); Maxi Taxi Association
Appropriateness and effectiveness	The main objective of P&R policies is to transfer parking demand from the central business district (CBD) to suburban/urban fringe locations to achieve the following benefits: » Reducing traffic and congestion levels on urban radial routes and in the CBD itself » Correspondingly reducing the need/pressure for increased road capacity and reducing emission levels, energy use and other environmental impacts » Reducing the amount of parking required in the CBD (where land is scarce and expensive and large car parks may be out of scale with the CBD townscape) and replacing it with parking in other locations (where land is cheaper and more readily available).
Barriers	» Lack of public awareness, resistance to changing cultural norms
Advantages/ opportunities/ co-benefits	» Bus priority measures are very important in increasing the competitiveness of P&R against direct car journeys and in enhancing the public perception of the P&R service. Bus lanes and bus-only links are the most directly visible form of bus priority, but signal priority can also help to improve bus time-keeping. » Air quality improvement » Decrease in travel time » Improve general comfort (less vehicles, more space for pedestrians) » Job creation
Synergies and/ or trade-off with adaptation	
Synergies and/ or trade-off with other development aspects	» Such a system is expected to increase the proportion of people who choose to use public transport to meet their travel needs, with corresponding community benefits in accessibility to opportunities, environmental quality and social inclusion.
Methodologies, assumptions or other considerations	

Schedule

Task	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
Task 1					■													
Task 2						■												

MEASURE T.4: Parking Pricing and Parking Supply Management

<table>
<tr><td>Description</td><td colspan="19">This serves to provide parking pricing and parking supply management. Parking pricing means that motorists pay directly for using parking facilities. This may be implemented as a parking management strategy (to reduce parking problems), as a mobility management strategy (to reduce transport problems), to recover parking facility costs, or to raise revenue for any purpose (such as funding local transport programmes or downtown improvements). It is often intended to achieve a combination of objectives.</td></tr>
<tr><td>Purpose</td><td colspan="3">Policy</td><td colspan="2">Sectors</td><td colspan="4">Planning and Construction Sectors</td><td colspan="5">GHG gases</td><td colspan="5">CO_2, CH_4, N_2O</td></tr>
<tr><td>Mitigation potential in tCO_2e</td><td colspan="19">Mitigation potential is due to vehicle travel reduction which, according to literature, may be of 5–15% if financial incentives (such as pricing) are excluded, and 10–30% if included (Litman, 2003). In order to match it to more realistic effectiveness, it was assumed that 10% of the transportation activities would be affected, leading to a reduction of 1.75% in transport emissions.
Accumulated: 869,479 tCO_2e
Annual average: 57,965 tCO_2e</td></tr>
<tr><td rowspan="3">Tasks</td><td colspan="19">Task</td></tr>
<tr><td colspan="19">1. Develop framework for implementation including policy, legislative, institutional and administrative aspects.</td></tr>
<tr><td colspan="19">2. Implementation</td></tr>
<tr><td rowspan="3">Schedule</td><td>Task</td><td>2018</td><td>2019</td><td>2020</td><td>2021</td><td>2022</td><td>2023</td><td>2024</td><td>2025</td><td>2026</td><td>2027</td><td>2028</td><td>2029</td><td>2030</td><td>2031</td><td>2032</td><td>2033</td><td>2034</td><td>2035</td></tr>
<tr><td>Task 1</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Task 2</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Responsible entity</td><td colspan="19">Ministry of Planning and Development, Ministry of Works and Transport, Ministry of Rural Development and Local Government</td></tr>
<tr><td>Appropriateness and effectiveness</td><td colspan="19">Currently, most parking is inefficiently priced; it is provided free, or significantly subsidised.</td></tr>
<tr><td>Barriers</td><td colspan="19">» Management solutions represent a change from current practices.</td></tr>
<tr><td>Advantages/ opportunities/ co-benefits</td><td colspan="19">» Many parking management strategies reduce vehicle travel directly, and all support more compact, multi-modal development.
» Air quality improvement that implies health benefits and less public health costs
» Decrease in travel time due to traffic reduction
» Job formation in relation to specialised companies and parking management</td></tr>
<tr><td>Synergies and/ or trade-off with adaptation</td><td colspan="19">N/A</td></tr>
<tr><td>Synergies and/ or trade-off with other development aspects</td><td colspan="19"></td></tr>
<tr><td>Methodologies, as-sumptions or other considerations</td><td colspan="19">N/A</td></tr>
</table>

MEASURE T.5: Transit Service Improvements

Description	To improve public transit services and encourage transit use, including increased service area and frequency, increased transit speed and reliability				
Purpose	Action	**Sectors**	PTSC and Maxi Taxis	**GHG gases**	CO_2, CH_4, N_2O
Mitigation potential in tCO_2e	Mitigation potential is due to the fact that residents of communities with good transit services tend to drive 10–20% less than in more automobile-oriented areas (Litman, 2003). In order to match it to more realistic effectiveness, it was assumed that 10% of the transportation activities would be affected, leading to a 2% reduction in transport emissions. **Accumulated:** 745,268 tCO_2e **Annual average:** 49,685 tCO_2e				
Tasks	**Task**				
	1. Develop framework for implementation including policy, legislative, institutional and administrative aspects.				
	2. Implementation				
Schedule	(see schedule below)				
Responsible entity	Ministry of Works and Transport, Public Transport Service Corporation (PTSC), Maxi Taxi Association				
Appropriateness and effectiveness					
Barriers	» No real barriers identified				
Advantages/ opportunities/ co-benefits	» Air quality improvement that implies health benefits and less public health costs » Decrease in travel time due to traffic reduction				
Synergies and/ or trade-off with adaptation	N/A				
Synergies and/ or trade-off with other development aspects	» More affordable to average commuter through mass transit				
Methodologies, assumptions or other considerations	N/A				

Schedule

Task	**2018**		**2019**		**2020**		**2021**		**2022**		**2023**		**2024**		**2025**		**2026**		**2027**		**2028**		**2029**		**2030**		**2031**		**2032**		**2033**		**2034**		**2035**	
Task 1										■	■																									
Task 2												■	■																							


Photo Credit: Kishan Ramcharan

▲ Mangrove clean-up, Trinidad, 2020

Waste and Wastewater

The approach for managing emissions from the waste and wastewater sector includes waste minimisation, adequate waste generation and segregation, selective waste collection, transport, material and energy recovery, and final disposal of solid waste. Additionally, capacity development and public awareness programmes are considered as a cross-cutting issue for the proper development of the country's waste management.

These steps respond to a comprehensive management approach which aims at three aspects. Firstly, the prevention or minimisation of waste generation compared to any other alternative. Secondly, with respect to the waste generated, material and energy recovery is preferred, among which reuse, recycling, composting and co-processing stand out. And, thirdly, as a last alternative, the final disposal of waste in suitable infrastructures, which should be carried out under adequate environmental conditions.

For waste management, it is important for the country to reduce the amount of waste that goes into the current waste disposal facilities through a combination of waste reduction and diversion activities. By reducing the amount of waste (especially organic waste) going to the landfill sites, the amount of methane gas released will be reduced. Organic waste can be diverted into community composting programmes. Complementary measures incorporating recycling programmes will also significantly reduce the country's dependence on landfill sites.

Regarding wastewater, centralised Integrated Wastewater Treatment Plants and Programmes can increase the current scope of sanitation services by considering technologies that allow the reduction of GHG emissions in treatment plants, such as coverage systems, digesters for sludge treatment and burners.

These new systems would replace smaller non-functional treatment plants. They would also include mechanisms that would treat sludge and would also have at least secondary treatment for effluent. Treating the sludge would reduce the amount of emissions from untreated sludge and would also produce a useful final product that can be incorporated into the agricultural sector. Likewise, treated wastewater effluent can be reused for the agricultural and industrial sectors.

MEASURE W.W.1: Waste Reduction and Diversion

Description	Reduce the amount of waste that reaches the country's landfills.				
Purpose	Action	**Sectors**	Waste	**GHG gases**	CH_4
Mitigation potential in tCO_2e	As the amount of waste that is prevented from going to landfills will be treated in a more sustainable way, this will mean less generation of methane in landfills due to less organic matter being broken down. It is estimated that there will be a 50% reduction in waste going to landfills by 2050 which is consistent with the National Integrated Solid Waste Management Policy (NISWMP). **Accumulated:** 750,112 tCO_2e **Annual average:** 50,007 tCO_2e				
Tasks	**Task**				
	1. Establish a series of Transfer Stations at the Beetham and Guanapo Landfill sites				
	2. Partner with the Ministry of Health and Municipal Corporations to develop a waste management system for the proper disposal of bio-medical wastes and similar hazardous wastes				
	3. Partner with the Ministry of Local Government and Rural Development and the Tobago House of Assembly to improve the operational efficiency of the waste collection systems for Trinidad and Tobago				
	4. Implement waste diversion programmes				
	5. Construct and operate waste-to-energy plant at Beetham				

Schedule

Task	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
Task 1					■													
Task 2						■												
Task 3						■	■	■	■									
Task 4							■	■	■	■	■							
Task 5													■	■	■	■	■	■

Responsible entity	SWMCOL, Ministry of Public Utilities, Ministry of Rural Development and Local Government, THA
Appropriateness and effectiveness	This is in keeping with the country's Recycling Policy
Barriers	» Cost of retrofitting, cost of developing waste diversion systems, public reluctance to accept change
Advantages/opportunities/co-benefits	» Cost-savings in the long run as less land space is needed for landfills » Business opportunities at the community level » Improvements in the water, soil, groundwater and air quality
Synergies and/or trade-off with adaptation	N/A
Synergies and/or trade-off with other development aspects	This is in keeping with Sustainable Development Goals (SDG). Likewise, proper waste disposal will have a positive health benefit as it would ensure that leachate is managed and that hazardous wastes do not enter the environment and affect the health of the population.
Methodologies, assumptions or other considerations	

MEASURE W.W.2: Segregation of Solid Organic Waste for Material Recovery in Composting Plants

Description	This measure requires the building of composting plants for the recovery of solid organic waste. The composting plants will receive the organic waste in a segregated manner, subsequently carrying out the operations of pre-treatment, crushing, mixing, decomposition, maturing and refinement of the waste. This produces a soil improver denominated compost.
Purpose	Action — **Sectors**: Waste — **GHG gases**: CH_4
Mitigation potential in tCO_2e	The reduction of emissions from this measure is caused by aerobic decomposition through the composting process, which prevents the anaerobic condition that would lead to the generation of methane. The base scenario considers that all organic waste is disposed of in landfills, where the decomposition of organic matter generates methane emissions as any composting currently done is on a very small scale. This can be a viable option if done at a community scale. The most recent waste characterisation study indicated that 27% of the waste collected was organic. This measure proposes the construction of 7 plants with a capacity of 50t/day which will result in a reduction of 50% of the organic waste going to landfill. **Accumulated:** 1,937,351 tCO_2e **Annual average:** 129,157 tCO_2e
Tasks	**Task** 1. Develop framework for implementation including policy, legislative, institutional and administrative aspects. 2. Develop waste segregation and collection routines. 3. Develop technical instruments for the design, operation and maintenance of the composting facilities. 4. Establish pilot composting facilities at selected Regional Corporations and identify commercial strategies for the development of the municipal solid waste compost market. 5. Expand and implement it in the rest of the country.

Schedule

Task	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
Task 1	□□	□□	□□	□□	■■	□□	□□	□□	□□	□□	□□	□□	□□	□□	□□	□□	□□	□□
Task 2	□□	□□	□□	□□	□□	■■	■□	□□	□□	□□	□□	□□	□□	□□	□□	□□	□□	□□
Task 3	□□	□□	□□	□□	□□	□□	■■	■■	■□	□□	□□	□□	□□	□□	□□	□□	□□	□□
Task 4	□□	□□	□□	□□	□□	□□	□■	■■	■□	□□	□□	□□	□□	□□	□□	□□	□□	□□
Task 5	□□	□□	□□	□□	□□	□□	□□	□□	□■	■■	■■	■■	■■	■■	■■	■■	■■	■■

Responsible entity	Regional Corporations, SWMCOL, Ministry of Public Utilities, Ministry of Rural Development and Local Government
Appropriateness and effectiveness	This would be an effective way to reduce waste entering the landfill sites as the amount of organic waste in the waste stream is at least 27% and, by extension, avoid GHG emissions in the form of methane.
Barriers	
Advantages/opportunities/co-benefits	» Reduces environmental pollution resulting from improper solid waste management » Increases the useful life of landfills through waste recovery which reduces the demand for final disposal services » The compost produced would be a saleable product » Reduces environmental liabilities by reducing landfill leachate
Synergies and/or trade-off with adaptation	N/A
Synergies and/or trade-off with other development aspects	This measure requires special conditions to be implemented, such as the approval of a technical regulation for the elaboration of compost based on organic solid waste. This regulation will allow the establishment of quality parameters for compost according to its different uses. This measure is aligned with Sustainable Development Goals.
Methodologies, assumptions or other considerations	N/A

MEASURE W.W.3: Installation of Sludge Digesters at Wastewater Treatment Plants (WWTP) to Capture and Burn Methane

Description	Installation of bio-digesters to treat the sludge so that the large amounts of methane generated by the sludge volumes can be reduced.				
Purpose	Action	**Sectors**	Waste	**GHG gases**	CH_4
Mitigation potential in tCO_2e	The installation of anaerobic digesters makes it possible to capture the methane generated, which is then burned, reducing about 20% of the methane generated during this treatment. **Accumulated:** 543,987 tCO_2e **Annual average:** 36,266 tCO_2e				
Tasks	**Task**				
	1. Develop framework for implementation including policy, legislative, institutional and administrative aspects.				
	2. Develop action plan including the identification of plants that can be expanded.				
	3. Implementation				

Schedule

Task	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
Task 1																		
Task 2																		
Task 3																		

Responsible entity	WASA, Ministry of Public Utilities, THA
Appropriateness and effectiveness	This would be more effective than having smaller, inefficient plants. Treating of sludge would reduce the amount of GHG emissions
Barriers	» Cost of development » Limitations of current sewerage networks
Advantages/ opportunities/ co-benefits	» This would also reduce pollution of the waterways by untreated effluent.
Synergies and/ or trade-off with adaptation	This is in keeping with the SDGs as sanitation is a key area of development.
Synergies and/ or trade-off with other develop-ment aspects	N/A
Methodologies, assumptions or other consider-ations	N/A

MEASURE W.W.4: Treatment and Use of Wastewater

Description	This measure proposes the reuse of treated wastewater for irrigation of green areas or for agriculture or industrial use as process water.				
Purpose	Action	**Sectors**	Waste	**GHG gases**	CH_4

Mitigation potential in tCO_2e	Reduced emissions from wastewater treatment and use. **Accumulated:** 523,758 tCO_2e **Annual average:** 34,917 tCO_2e
Tasks	**Task**
	1. Assess all existing wastewater treatment plants to determine the treatment technologies for effluent.
	2. Develop system that would allow the effluent to be treated at least to a secondary level.
	3. Develop budget and prioritise wastewater treatment plant systems that need to be retrofitted.
	4. Start the process and monitor the quality of the effluent.
	5. Develop system that allows the treated wastewater to reach final destination.

Schedule

Task	2018		2019		2020		2021		2022		2023		2024		2025		2026		2027		2028		2029		2030		2031		2032		2033		2034		2035	
Task 1									■	■																										
Task 2									■	■																										
Task 3											■	■																								
Task 4													■	■	■	■	■	■	■	■	■	■	■	■												
Task 5													■	■	■	■	■	■	■	■	■	■	■	■												

Responsible entity	WASA
Appropriateness and effectiveness	Reduction in emissions and environmental pollution
Barriers	» High cost of new infrastructure and retrofitting and dismantling of outdated plants
Advantages/ opportunities/ co-benefits	» Increased sewerage for the population thus reducing pollution to waterways » Reduced dependence on potable water by several sectors which would be able to access treated wastewater
Synergies and/ or trade-off with adaptation	N/A
Synergies and/ or trade-off with other development aspects	Sanitation is an important SDG. Additionally, worldwide, water is a scarce resource and recycling of this water would be a welcome relief to the already strained sector.
Methodologies, assumptions or other considerations	WASA

MEASURE W.W.5: Urgent Development of Responsible Disposal of End-of-life Wood Products

Description	Development of responsible disposal of end-of-life wood products				
Purpose	Action, policy & awareness	**Sectors**	This measure has a direct influence on emissions in the waste sector. However, it is an initiative proposed by the AFOLU sector.	**GHG gases**	Potentially all GHGs—depends on what is being burnt—generally refers to CH_4, CO_2
Mitigation potential in tCO_2e	Mitigation potential comes from preventing wood waste from being disposed of in a dump to degrade without treatment, avoiding the emissions that this implies (more than 250 tCO_2e per year). Emission potential is calculated based on wood disposal emission factor and wood disposal amount is obtained from FAOSTAT. Instead, this organic waste can be put to new uses, such as mulching of biochar. With their application, soils increase carbon sinks, increasing mitigation capacity. This potential is assessed at A10: Biochar production and application. **Accumulated:** 3,858 tCO_2e **Annual average:** 257 tCO_2e				
Tasks	**Task**				
	1. Public education programme to stop the burning of end-of-life wood products (e.g. scrap wood, discarded furniture); recycling (e.g. using wood shavings for mulch and sawdust in livestock pens)				
	2. Establish centres for collection and responsible disposal/recycling/processing of wood products or diverting to biochar production centres				
	3. Establish policy framework				

Schedule

Task	2018		2019		2020		2021		2022		2023		2024		2025		2026		2027		2028		2029		2030		2031		2032		2033		2034		2035	
Task 1									■																											
Task 2										■																										
Task 3									■																											

Responsible entity	Ministry of Agriculture, Land and Fisheries; Households, Sawmillers, Furniture Industry, Flower/Horticulture shops
Appropriateness and effectiveness	Preventing the burning of wood products prevents the release of the carbon stored in the wood into the atmosphere
Barriers	» Public awareness and education
Advantages/opportunities/co-benefits	» Opportunity for increasing the efficiency of waste disposal and recycling » Decreased carbon emissions » Wood mulches work as a protective layer that moderates soil conditions by absorbing moisture and slowly releasing it back. » Wood mulches reduce erosion risk providing protection from rain and wind. » Groundwater quality improvement by improving water filtration » Enrichment of organic material that improves soil quality and biodiversity
Synergies and/or trade-off with adaptation	No additional risks created
Synergies and/or trade-off with other development aspects	» Creation of jobs in direct and indirect recycling of timber products as well as in energy recovery » Synergy with Biochar production measure
Methodologies, assumptions or other considerations	N/A

Photo Credit: Tobago House of Assembly

▲ Forest planting material, Department of Natural Resources and the Environment's Nursery, Studley Park, Tobago, 2020

AFOLU

The mitigation measures seek to increase the capacity of Trinidad and Tobago's AFOLU sector to reduce GHG emissions in both the short and long term. These measures are interconnected and complementary at varying levels. While the majority of these strategies are aimed at direct reduction of GHG emissions, a few (e.g. Urban Greening, Forest Management and Protection, Biochar Production and Application, and Reforestation and Rehabilitation of Degraded Forested Lands and Improved Catchment Management) are mainly geared towards increasing carbon sequestration, and hence the negative emissions capacity of Trinidad and Tobago.

While some of these measures may require large initial financial and/or capacity investments, others are low cost and simply require introduction and training on the ground. Measures which are likely to require large initial investments such as 'Agriculture and Technology—Vertical Farming' and 'Development of a National Climate Smart Agricultural approach' (CSA) are important instruments in maintaining and progressing with GHG emissions reductions in the medium and long terms. Additionally, they are also key adaptation and resilience measures. CSA refers to a broad umbrella of best-practice agricultural techniques to enhance the adaptation, mitigation, resilience and, in some cases, sequestration potential of agricultural practices.

MEASURE A.1: Urban Greening Activities: Green Roofs and Urban Trees

Description	Urban Greening Activities				
Purpose	Action, policy, awareness	**Sectors**	AFOLU Sector & Planning and Development	**GHG gases**	CH_4, CO_2, N_2O

Mitigation potential in tCO_2e	Direct mitigation potential comes from carbon sequestration of urban trees and green roofs species. Assuming the installation of green roofs on 250 houses (with a roof area of $80m^2$), and the planting of 400 trees each year, the sequestered carbon is estimated to be, on average, 120 tCO_2e per year (Sequestration rates obtained from Luo et al., 2015; Davey Resource Group, 2008). **Accumulated:** 6,550 tCO_2e **Annual average:** 437 tCO_2e
Tasks	**Task** 1. Incentives for the establishment of urban roofs to be developed into green roofs on buildings 2. Increasing the green coverage within open urban areas

Schedule

Task	2018		2019		2020		2021		2022		2023		2024		2025		2026		2027		2028		2029		2030		2031		2032		2033		2034		2035	
Task 1										■																										
Task 2											■																									

Responsible entity	–
Appropriateness and effectiveness	» Green roofs increase carbon sequestration (green roofs) with soil and plant cover and also contributes to decreased flash flooding which occurs every year during the rainy season » Increases carbon sequestration, city cooling and simultaneously provides habitat for local flora and fauna
Barriers	» Costly, unfamiliar to cultural mindset
Advantages/ opportunities/ co-benefits	» Job creation » Improvement of air quality » Mitigation of Urban Heat Island » Increase in urban biodiversity » Increment of tourism
Synergies and/ or trade-off with adaptation	» Increases the adaptive capacities of urban areas to manage increasing ambient temperatures as climate continues to change » No additional risks are anticipated
Synergies and/ or trade-off with other development aspects	These measures all provide potential for job creation and capacity-building (in the case of mainstreaming green building designs)
Methodologies, assumptions or other considerations	N/A

MEASURE A.2: **Reforestation, Rehabilitation of Degraded Forested Lands and Improved Catchment Management**

Description	Reforestation, Improved Catchment Management and Rehabilitation of degraded forested lands				
Purpose	Action, policy, awareness	**Sectors**	AFOLU	**GHG gases**	Mainly CO_2 but could potentially include CH_4 and other GHGs
Mitigation potential in tCO_2e	Mitigation potential comes from carbon sequestration due to the expected new tropical rain forest surface each year. Assuming 100 ha of reforestation and 100 ha of restored land every year, in combination with the already expected new forestry area, it is estimated that around 4,700 tCO_2e more will be accumulated per year. **Accumulated:** 70,625 tCO_2e **Annual average:** 4,708 tCO_2e				

Tasks	**Task**
	1. Reforestation with efforts to achieve 100 ha/yr to include abandoned croplands, lastro, denuded hillsides
	2. Rehabilitation of degraded forested lands
	3. Soil rehabilitation, conservation and management
	Trees should be planted (as much as possible) on slopes under agricultural cultivation. Further, agricultural terracing and other Climate Smart Agriculture techniques for soil carbon conservation should be applied to such slopes which are already under cultivation.

Schedule	Task	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
	Task 1																		
	Task 2																		
	Task 3																		

Responsible entity	Ministries: (i) Agriculture, Land and Fisheries, (ii) Energy (under which quarrying falls)	
Appropriateness and effectiveness	Increasing forest stock (and underlying soil Ceq stocks) across the country will increase negative emissions.	
Barriers	» Resolution of illegal squatting on forest lands	» Resolution of Illegal quarry operations
Advantages/ opportunities/ co-benefits	» Increased forest cover results in increased resilience and adaptation capacities for the country under changing climate conditions. » Improve air quality » Reduce erosion risk » Groundwater quality improvement	» Soil quality improvement » Increase in biodiversity » Improve ecological tourism » Job creation for reforestation (e.g. planting and seedling cultivation in nurseries) particularly in rural areas—where employment opportunities tend to generally be fewer
Synergies and/ or trade-off with adaptation	» The measure effectively increases both the country's adaptation and resilience capacities to climate change. » Synergy with Climate Smart Agriculture Annex for task on the management of Agricultural terracing	
Synergies and/ or trade-off with other development aspects	Large potential to increase employment on a sustained basis—especially in rural areas—where employment levels tend to be lower.	
Methodologies, assumptions or other considerations		

MEASURE A.3: Reduction, Control and Monitoring of Agri-chemical Application by Farmers

Description	Reduction, control and monitoring of agri-chemical application by farmers				
Purpose	Knowledge, action, policy, awareness	**Sectors**	AFOLU Sector, Education Sector, Health Sector	**GHG gases**	GHG gases: N_2O
Mitigation potential in tCO_2e	Mitigation potential comes from the estimated annual reduction consumption of nitrogen (N), phosphorus (P) and potassium (K) fertilisers. **Accumulated:** 56,306 tCO_2e **Annual average:** 3,754 tCO_2e				
Tasks	**Task** 1. Enhance collection of quality data on agri-chemical usage and application by farmers 2. Educate farmers and public on negative impacts of improper application of fertilisers and its relation to climate change. 3. Promotion of sustainable and alternative means of farming which decrease the use of and dependency on agri-chemicals – including Climate Smart Agriculture (CSA), organic farming and aspects of precision farming (e.g. vertical farming). Agricultural Extension Services will be required to train and provide ongoing assistance for farmers.				

Schedule

Task	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
Task 1					■ (first half)													
Task 2					■ (second half)													
Task 3						■ (first half)												

Responsible entity	Ministries: MALF, Ministry of Education, Ministry of Health, ECIAF, NAMDEVCO
Appropriateness and effectiveness	Reducing GHG emissions
Barriers	» Resistance to cultural and traditional agricultural practices
Advantages/ opportunities/ co-benefits	» Reduction in agricultural run-off pollution due to surface and groundwater » Improvement of air quality » Soil quality improvement
Synergies and/ or trade-off with adaptation	Development of adaptive farming strategies (e.g. Climate Smart Agriculture) with less dependence on chemical fertilisers and other agri-chemicals will increase climate resiliency in the agricultural sector.
Synergies and/ or trade-off with other develop-ment aspects	Towards sustainable agriculture and achieving the SDGs
Methodologies, assumptions or other consider-ations	

MEASURE A.4: Halting of Biomass Burning—especially Agricultural Burning

Description	Reducing biomass burning—especially agricultural burning				
Purpose	Action, policy, awareness	**Sectors**	AFOLU sector	**GHG gases**	Mainly CO_2
Mitigation potential in tCO_2e	Reducing agricultural burning and the accidental fires associated with them prevents emissions from vegetation combustion. Wildfires consume woody biomass and emit a great amount of CO_2 and other GHG. Assuming an idealised situation where all agricultural burning disappears, together with the 50% of the savannahs, shrublands and grasslands fires, the avoided emission estimation may reach 455 tCO_2e per year. (FAOSTAT) **Accumulated:** 455 tCO_2e **Annual average:** 6,826 tCO_2e				
Tasks	**Task**				
	1. Develop framework for implementation including policy, legislative, institutional and administrative aspects.				
	2. Awareness and education				

Schedule

Task	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
Task 1					■													
Task 2					■													

Responsible entity	Ministry of Agriculture, Land and Fisheries, ECIAF, UWI (Faculty of Agriculture & Food Production), Sugarcane Feed Centre (MALF), Animal Production and Health Division (MALF)
Appropriateness and effectiveness	The burning of agricultural waste and by-products directly releases carbon (and potentially other GHGs) into the atmosphere. Burning of vegetation (as clearance for agriculture or any other reason) not only releases carbon in the above ground vegetation—but can also cause the release of belowground carbon—as roots and soil organisms are also burnt by these fires. The belowground carbon stores can be immense and are often underestimated or overlooked when calculating emissions.
Barriers	» Cultural practices of slash and burn » Education and awareness of farmers
Advantages/ opportunities/ co-benefits	» Creation of opportunities for newer, more sustainable ways of biomass recycling and processing » Decreases the potential of bush fires accidentally occurring from the burning of vegetation for clearance » Potential for unwanted biomass to be used to produce energy in a sustainable manner (e.g. biogas digestors or biochar) » Reduces erosion » Groundwater quality improvement » Soil quality improvement » Increase of biodiversity
Synergies and/or trade-off with adaptation	
Synergies and/ or trade-off with other development aspects	Job creation with the development of biomass recycling, processing as well as the generation of energy Synergy with Biochar production measure
Methodologies, assumptions or other considerations	

MEASURE A.5: Forest Management and Protection

Description	Forest Management				
Purpose	Action, policy, awareness	**Sectors**	AFOLU sector	**GHG gases**	Mainly CO_2
Mitigation potential in tCO_2e	Through this measure it is expected to maintain forest surface as it is, as an idealised situation, where neither deforestation nor degradation occurs. **Accumulated:** 8,515,489 tCO_2e **Annual average:** 567,699 tCO_2e				
Tasks	**Task**				
	1. Increased enforcement of forest protection				
	2. Resolution of conflicting policies that impact upon various aspects of forest management.				

Schedule

Task	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
Task 1																		
Task 2																		

Responsible entity	Ministries: Ministry of Agriculture, Land and Fisheries, Ministry of Energy and Energy Industries (Minerals Division)
Appropriateness and effectiveness	There is significant potential to increase carbon stock of forests by the replenishment of currently degraded and deforested areas with native tree species.
Barriers	» Unplanned forest fires (especially during the dry season)—with an acute paucity of resources to combat such fires » Severe lack of funding, personnel and resources allocated to the Forestry Division for the Management and Protection of Forests » Fines for trees that have been illegally harvested are too minimal and do not serve as a deterrent against illegal logging » Severe lack of resources for fighting annual forest fires » Reluctance of private land owners with forested lands to maintain forest cover
Advantages/ opportunities/ co-benefits	» Improve air quality » Reduce erosion risk » Groundwater quality improvement » Soil quality improvement » Increase of biodiversity » Improve ecological tourism
Synergies and/ or trade-off with adaptation	Forest conservation, protection and enhancement allows for adaptation in several ways including protection against landslides and flooding, buffering against temperature extremes, protection of the freshwater lens and protection from coastal inundation from storm surges from coastal mangrove forests, increased health of ecosystems and quality of ecosystem services
Synergies and/ or trade-off with other development aspects	Potential for job creation, especially for individuals from rural areas who could be hired for monitoring and protection activities
Methodologies, assumptions or other considerations	

MEASURE A.6: Biochar Production and Application

Description	Biochar production and application, using biomass waste material				
Purpose	Knowledge, action, policy, awareness	**Sectors**	AFOLU sector	**GHG gases**	CO_2, CH_4, N_2O
Mitigation potential in tCO_2e	Mitigation potential comes from the carbon sequestration potential of biochar which increases organic matter in soils. **Accumulated:** 2,517 tCO_2e **Annual average:** 37,760 tCO_2e				
Tasks	**Task**				
	1. Education of farmers and other agriculturalists on biochar, its uses, production and integration				
	2. Integrate biochar production and application into agriculture policies				
	3. Develop biochar production centres to facilitate distribution to farmers. Train and develop agricultural extension services to provide guidance on sustainable usage and application.				

Schedule	**Task**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**	**2033**	**2034**	**2035**
	Task 1					■													
	Task 2					■													
	Task 3						■												

Responsible entity	Ministries: MALF, ECIAF, NAMDEVCO, Tertiary and Agricultural research institutions
Appropriateness and effectiveness	» Of the several negative emissions technologies that have/are being explored Biochar presents a win–win option as it can act as both a carbon sink as well as an amendment for improving soil fertility, quality and water-holding capacity, thereby decreasing risks of land degradation. » Apart from its value as a CO_2 removal strategy, Biochar also decreases non-CO_2 GHG emissions including N_2O emissions from soils (especially from rice paddies) as well as methane emissions from rice paddies (but to a lesser extent than N_2O). » Its value as a soil amendment also provides a range of indirect climate mitigation benefits such as (but not limited to) increased yields (especially in sandy and tropical soils that are acidic), the enhancement of biological nitrogen fixation in soils (hence less need for nitrogen fertilisers) and the reduction of GHG emissions from compost. » The gases emitted from the production of biochar can also be captured, stored and used as a renewable energy source. The pyrolysis gas is mainly a mixture of carbon monoxide (CO) and hydrogen (H_2) with lower quantities of CO_2, CH_4, H_2O.
Barriers	» Education and awareness of farmers
Advantages/opportunities/co-benefits	» Biochar is one of the most affordable of current negative emissions technologies, with multiple indirect climate mitigatory benefits. » Jobs creation » Improves soil quality » Improves water quality
Synergies and/or trade-off with adaptation	» Biochar's soil amending properties such as improving soil fertility (increased crop yields), quality and water-holding capacity results in decreased risks of land degradation. » Its nitrogen-fixing properties decreases the need for use of artificial nitrogen fertilisers.
Synergies and/or trade-off with other development aspects	Job creation in biochar production as well as collection of biomass feedstock
Methodologies, assumptions or other considerations	

3.3 Screening of mitigation options

The following section outlines the approach in assessing the socio-economic and technical impacts of the mitigation measures identified.

Overview of decision-making methodologies

Scientific analysis can help environmental decision-making by providing an objective set of criteria to inform decision makers. Environmental decisions are difficult to encapsulate fully into a formula, but the application of some methods has proven to be very useful when planning the use of resources in the long-term.

There are alternative methodologies for assessing and prioritising climate change measures. Each requires different information, expertise, and processes.

1. The Cost-Benefit Analysis (CBA) is based on an updated comparison between costs and future expected benefits (Pearce et al., 2006). When evaluating public decisions, the CBA captures all social costs and benefits involved, including externalities. As such, benefits are usually described as increases in human well-being (utility), whereas costs are mostly defined as reductions in human well-being. CBA will monetise all the costs and benefits of the actions, including externalities and non-market benefits. The values will later be brought to the present by using discount rates.

The CBA can therefore provide a very comprehensive analysis of the consequences of implementing human actions. When it comes to climate change mitigation, however, monetising the benefits is complicated due to the uncertainty of calculating a social cost of carbon and the complexity of the assumptions. Global estimates provide hugely different values which hinder decisions at the local level (Pindyck, 2013).

2. It can be assumed that the cost of reducing one tonne of carbon dioxide is the same no matter the sector or the geographical area and, as a result, Cost-Effectiveness Analysis (CEA) is the most widely used tool in evaluating mitigation actions. Instead of assigning monetary values to the emissions reductions, the CEA can combine physical and monetary information.

The objective is to prioritise the different alternatives according to the quotient between Net present value of implementation (public and/or private, depending on the context) and the amount of CO_2e reduced. The Net Present Value not only includes costs but also market benefits (such as benefits provided by energy efficiency measures). The results of the CEA are usually expressed in the so-called "McKinsey curves" that illustrate the unitary cost of measures and the outcome in terms of emission reductions.

3. A third method that is often used in environmental decision-making is Multi-Criteria Analysis (MCA) which is based on the need to consider multiple criteria. With this method, any relevant information can be used, no matter its nature (quantitative, qualitative, mixed) as long as it can be attributed to all alternative projects (lowest common denominator) and it can be expressed in a proportional or ordinal scale (criteria).

The MCA allows for the consideration of variables that are too complex to consider in CEA or CBA, particularly social benefits and values, as well as indirect positive impacts of the measures.

For the analysis of the measures included in this report a combination of a Cost-Effectiveness Analysis and a Multi-Criteria Analysis has been used.

3.4 Integration of GHG reductions and costs across measures and sectors

After analysing the different decision-making options, this section shows the specific methodologies used as well as the results obtained for each of the potential measures. The purpose of this analysis was to quantify these measures in economic and GHG emissions terms in order to proceed with their prioritisation. Likewise, other co-benefits of these measures were analysed.

Cost-Effectiveness Analysis

The Cost-Effectiveness Analysis (CEA) is a form of economic analysis that compares relative costs with the outcomes (effects) of two or more courses of action. This means that the cost-effectiveness method combines financial and physical information. As a result, there is no need to assign a monetary value to the non-market benefits, such as CO_2e reductions.

The objective is to prioritise the different alternatives according to the quotient between:

- net present value of implementation (public and/or private, depending on the context) inclusive of market benefits and costs; and
- physical effects.

Therefore, alternatives are ranked by their cost per unit of effect (e.g. $/t$CO_2e$).

It should be noted that CEA is used to make comparisons between alternatives that have the same scope. It cannot be used for projects with different objectives or for a project with multiple objectives. In the instant analysis, it is considered an appropriate method since all measures are proposed as GHG emission reduction measures, which is their main objective, although they may have other co-benefits. Therefore, the analysis of the CEA will give an approximate value of how much it costs economically to reduce a tonne of CO_2.

Through this analysis, it is also possible to know whether the implementation of these mitigation measures will also have a positive impact on the economy, that is to say, that the benefits generated will be greater than the costs of implementation. It should be mentioned that often the reduction of emissions is associated with a reduction in energy consumption or the reuse and optimisation of resources, which also represents an economic saving.

It should be noted that the results of the CEA do not provide an absolute answer. The CEA must be transparent in the assumptions made and must use objective quantifying information that is consistent with the country's condition (primary data, pre-feasibility studies, bibliography of similar projects).

Finally, it is worth mentioning that the analysis has been conducted from a social perspective. This means that the sum of public and private costs has been considered. Therefore, for instance, transfers between the public and private sector (such as grants) are a net-zero game. It should also be pointed out that this is a preliminary assessment in order to facilitate decision-making. Results depend on critical assumptions for each measure. At a later stage, many of these actions may require a more detailed definition and even feasibility studies.

The methodology used in the analysis is presented below, detailing the formulas used in the calculations as well as the meaning of each parameter. The results are then presented.

Methodology

In order to calculate the CEA of each measure it is necessary to quantify the Net Present Value of the project's revenue generation. The net present value is calculated by taking the annual cash flows of the project and discounting the flows using a certain discount rate, in order to calculate the present value of that future cash flow. Therefore, particularly for long term projects, discount rates become an important factor in order to determine the economic viability of a project.

A discount rate has been applied for several economic reasons, such as simple time preference, interest rates, or expected economic growth. In the case of large public projects, the discount rate often accepted is the rate of a government-issued Treasury bond. The equation for calculating the Net Present Value (NPV) is the following:

$$NPV \quad \sum_{t=1}^{T} \frac{C_t}{(1+r)^t} - C_o$$

Where:

- *t is the period of time*
- *C_t is the net cash flow (Costs – Benefits) for the given period*
- *C_o is the initial investment*
- *r is the discount rate (% per annum), and*
- *T is timespan (number of years) from time now*

The calculation assumes that the present year is year 0. In this analysis, the timeframe of the project was applied. Year 2019 was considered as year 0 and year 2034 is the last year of the analysis in terms of costs, benefits and emissions reductions. This implies a time coverage of 15 years. In order to provide homogenous calculations, the Cost-Effectiveness Analysis has assumed that the initial investment for all measures takes place in the first years, even if they are planned for a later period.

It should also be noted that the discount rate used for the calculation of the Net Present Value was seven percent, which is the discount rate for the country-level measures taken from the *Central Bank of Trinidad and Tobago Economic Bulletin January 2020*, (Central Bank of Trinidad and Tobago, 2019).[4,5] While this discount rate may seem high given current international financial conditions, it represents the reality of public financing costs in Trinidad and Tobago. In addition, to analyse the impact of the discount rate on the costs and benefits calculated for the actions, a sensitivity analysis is included in the document which shows the results for a higher (5.5%) and lower (7.7%) discount rate, corresponding to actual rates related to public bonds in the country in 2019. These rates were chosen since government bonds issued in November 2019 with a maturity period of 15 years were sold at an annual rate of 5.5 percent and bonds issued on average in the year 2019, with a maturity period of 10 years were sold at an annual rate of 7.7 percent (Table 15, Central Bank of Trinidad & Tobago, 2019).

If the calculated Net Present Value is below zero, it means that the sum of the cash flows, in present value, is negative, and therefore the project has a net cost. If the Net Present Value is positive, it means that the sum of the cash flows, in present value, is positive, and therefore the project has a net benefit.

The Benefit/Cost ratio of the measures has been analysed as well, and calculated using the following formula:

$$CBA = \frac{PV_{Benefits}}{PV_{Costs}}$$

Where:

- *$PV_{Benefits}$ is the present value of the benefits and,*
- *PV_{Costs} is the present value of the costs*

Note that these total costs and benefits are discounted. This ratio explains how many times the total benefits exceed the total costs of the action. If the ratio is greater than 1, it means that the total benefits are greater than the total costs. For example, if the ratio is 2, it means that the total benefits are twice the total costs. However, if the ratio is 0.5, it means that the total costs are twice the total benefits.

The last step is the Cost-Effectiveness (CEA) of the measures which is calculated by taking the total discounted costs and subtracting the total discounted benefits. This number is then divided by the total tonnes of CO_2 equivalent reduced, giving a cost per tonne of CO_2 equivalent reduced.

$$CEA = \frac{(-1) * NPV}{\sum_{t=1}^{T} tCO_2e \ Avoided}$$

Where:

- *t is the period of time*
- *C_t is the net cash flow (Costs – Benefits) for the given period*
- *C_0 is the initial investment*
- *r is the discount rate (% per annum), and*
- *T is timespan (number of years) from time now*
- *tCO_2e Avoided: avoided or reduced emissions in the period analysed*

4 Table 25.
5 The discount rate corresponds to the selected interest rate by the Central Bank for the year 2019.

Provided by Curtis Boodoo, University of Trinidad and Tobago

▲ The 2-bedroom, 1-bath, fully inhabitable house is located at the University of Trinidad & Tobago's Point Lisas campus. It displays the feasibility of renewable energy technologies, specifically solar photovoltaic (PV) panels, for everyday use to provide all the electrical requirements of a regular dwelling home.

▼ 100 kW Solar PV rooftop-mounted system at the Preysal Service Station, installed by National Energy

Photo Credit: National Energy [facebook.com/nationalenergytt]

Photo Credit: NGC CNG Company Limited

▲ Commissioning of CNG refuelling station, 2017

Negative results describe measures that have a net benefit; not only do they reduce GHG emissions but there are also economic benefits associated with these emission reductions. Measures that have a positive result indicate that the measure has a net cost; the result shows the cost of reducing one tonne of CO_2 equivalent by implementing the measure.

Overview of the Results

The table below provides a summary of the Net Costs, Net Benefits, Net Present Value, and Cost Effectiveness of the Measures, with the economic results expressed in US Dollars. It should also be noted that all the results shown correspond to the cumulative value over the 15-year period (2019–2034).

It is important to acknowledge that the results are very sensitive to the assumptions. Specific local information has been used when available. In other cases, some assumptions have been made based on literature from other countries. Expert judgement has also been used when necessary.

As shown in **TABLE 3.13**, each measure was analysed independently of the others, as costs and benefits may change if more than one measure is applied at the same time. This has been done in order to analyse the Cost-Effectiveness of each measure specifically and to determine which measures are the most interesting for the country.

TABLE 3.13 Economic and technical analysis of the potential mitigation measures for the CEA

	Action code	Title	Total cost (USD)	Total benefit (USD)	Net present value (USD)	Cost Effectiveness (USD/tCO_2e)	Benefit–Cost Ratio (USD)	tCO_2e Avoided (Accumulated)
Energy Generation	**P.G.1**	Conservation Education through Curriculum and Culture	213,706	5,811,492	5,597,786	−29.82	27.19	187,709
	P.G.2	REDER Campus Initiative	2,532,615	752,632	−1,779,982	50.88	0.30	34,983
	P.G.3	Green Building Awareness and Incentive Programme	90,282,818	28,054,510	−62,228,308	70.01	0.31	888,877
	P.G.4	Supply Side Management: Generation Dispatch	170,829	17,429,290	17,258,461	−22.95	102.03	751,916
	P.G.5	Cooperative RE	1,916,165	981,598	−934,567	33.71	0.51	27,723
	P.G.6	Increased penetration of Grid-Scale RE	81,013,028	24,559,599	−56,453,429	57.20	0.30	986,876
	P.G.7	Energy Efficient Appliance Programme	6,204,116	7,004,755	800,639	−3.72	1.13	215,094
	P.G.8	Increased customer engagement	88,693	5,811,492	5,722,799	−30.49	65.52	187,709
	P.G.9	Use of solar power for water treatment plants	1,364,320	641,573	−722,748	35.69	0.47	20,248
Industry	**I.1**	Renewable Fuels	8,048,993	12,890,645	4,841,652	−4.37	1.60	1,107,884
	I.2	Captured Carbon Industry	2,651,277,197		−2,651,277,197	59.48	0.00	44,573,060
Transport	**T.1**	Compact land use policies and mixing of land uses	43,285,051	40,970,242	−2,314,809	5.59	0.95	414,038
	T.2	Pay-as-you-drive auto insurance	5,630,499	282,975,666	277,345,167	−148.86	50.26	1,863,170
	T.3	Introduction of park-and-ride system pilot	88,261,721	113,190,266	24,928,546	−33.45	1.28	745,268

TABLE 3.13 (CONTINUED) Economic and technical analysis of the potential mitigation measures for the CEA

	Action code	Title	Total cost (USD)	Total benefit (USD)	Net present value (USD)	Cost Effectiveness (USD/tCO_2e)	Benefit–Cost Ratio (USD)	tCO_2e Avoided (Accumulated)
Transport	T.4	Parking pricing and parking supply management	34,135,958	132,055,311	97,919,353	–112.62	3.87	869,479
	T.5	Transit Service Improvements	4,549,888	113,190,266	108,640,378	–145.77	24.88	745,268
Waste/Water	W.1	Waste Reduction and Diversion	61,665,303	54,140,545	–7,524,757	10.03	0.88	750,112
	W.2	Segregation of solid organic waste for material recovery in composting plants	9,284,563	59,364,579	50,080,016	–25.85	6.39	1,937,351
	W.3	Installation of anaerobic sludge digesters at Water Treatment Plants to capture and burn methane	831,811	0	–831,811	1.53	0.00	543,987
	W.4	Use of treated wastewater	24,654,257	5,677,194	–18,977,063	36.23	0.23	523,758
	W.5	Urgent development of responsible disposal of end-of-life wood products.	5,356,129	5,337,704	–18,425	5.13	1.00	3,593
AFOLU	A.1	Urban Greening Activities: Green roofs and urban trees	7,469,421	7,496,865	27,444	–4	1.00	6,550
	A.2	Reforestation, Rehabilitation of degraded forested lands and Improved Catchment Management	8,383,811	14,003,089	5,619,278	–80	1.67	70,625
	A.3	Reduction, control and monitoring of Agri-chemical application by farmers	361,419	10,955,800	10,594,381	–188.16	30.31	56,306
	A.4	Halting of Biomass burning—especially Agricultural Burning	317,747	106,783	–210,963	30.91	0.34	6,826
	A.5	Forest Management and Protection	29,363,807	13,646,042	–15,717,765	1.73	0.46	9,068,045
	A.6	Biochar production and application	185,184	38,778	–146,406	3.88	0.21	37,760

TABLE 3.14 Total potential for emission reductions by sector period 2019–2040 (tCO2e) ▼

Sector	Potential avoided Emissions (tCO2e)
Power Generation	3,301,134
Industry	46,789,905
Transport	4,637,223
Waste and Wastewater	3,758,801
AFOLU	9,246,111

TABLE 3.15 Total Avoided Emission (excluding A.5 and I.2) by sector period 2019–2040 (tCO2e) ▼

Sector	Potential Avoided Emissions (tCO2e)
Power Generation	3,301,134
Industry	2,216,845
Transport	4,637,223
Waste and Water	3,758,801
AFOLU	178,066

Total mitigation analysis

The impact of the combination of the identified measures on the national baseline was analysed. The following section evaluates these measures, and prioritises them for inclusion in the mitigation scenarios generated for the country.

The implementation of measures is aimed at achieving a reduction in the country's GHG emissions, promoting sustainability and improving Trinidad and Tobago's environment through a combination of the necessary policy, legislative, administrative and institutional framework, including consideration of appropriate incentives.

In order to illustrate the full potential of mitigation measures, **TABLE 3.14** presents a summary of the total theoretical potential for emission reductions throughout the entire period analysed. It has been assumed that all measures have been deployed to their maximum potential and there is no implementation trade-off. The specific potential of selected measures is then determined.

As shown in **TABLE 3.14** the sector with the greatest potential for emissions avoidance is industry. It has a total reduction potential of up to 46,789,905 tCO_2e. In this case, the greatest potential reduction in emissions is from carbon capture technologies (I.2). By adopting these technologies at a very conservative level, it will be possible to capture 10 percent of the total emissions generated by the industrial sector. A pre-feasibility study for Carbon Capture and Storage (CCS) in Trinidad and Tobago was conducted, and the UWI/UTT is looking into the development of a storage atlas which will help to determine the real potential for the country (CO_2 Emission Reduction Mobilization Trinidad and Tobago, 2019, 2018).

In the absence of specific data for the country, a literature of the different existing studies has been taken as a reference.[6] More comprehensive studies are therefore needed to determine the real potential of these technologies. According to the analysis, the reduction potential from this measure alone accounts for 39 percent of the total emission reduction potential. These results are an estimate of the reductions potential, according to the limited available data.

As for the AFOLU sector, it has the second largest mitigation potential. In this case, greatest potential comes from carbon sequestration of the already existing tropical rainforest in Trinidad and Tobago. Forest Management and Protection (A.5), which far outweighs the rest, seeks to increase enforcement of forest protection, hence avoiding deforestation and degradation of existing forest cover. It is a conservative measure which prevents the clearing of forest land.

In order to illustrate the significant potential of these mitigation measures, (I.2 and A.5) the distribution of emissions by sector excluding these are shown in **TABLE 3.15**.

6 Budinis et al., 2018; IPCC, 2005

TABLE 3.16 Cost-Effectiveness results of the potential measures (US$/tCO2e)

Code	Title	Cost Effectiveness (US$/tCO2e)	tCO2e Avoided (Accumulated)
A.3	Reduction, control and monitoring of Agri-chemical application by farmers	–188.2	56,306.3
T.2	Pay-as-you-drive auto insurance	–148.9	1,863,169.8
T.5	Transit Service Improvements	–145.8	745,267.9
T.4	Parking pricing and parking supply management	–112.6	869,479.2
A.2	Reforestation, Rehabilitation of degraded forested lands and Improved Catchment Management	–79.6	70,624.7
T.3	Introduction of park-and-ride system pilot	–33.4	745,267.9
P.G.8	Increased customer engagement	–30.5	187,709.1
P.G.1	Conservation Education through Curriculum and Culture	–29.8	187,709.1
W.2	Segregation of solid organic waste for material recovery in composting plants	–25.8	1,937,350.8
P.G.4	Supply Side Management: Generation Dispatch	–23.0	751,915.8
I.1	Renewable Fuels	–4.4	1,107,884.2
A.1	Urban Greening Activities: green roofs and urban trees	–4.2	6,549.7
P.G.7	Energy Efficient Appliance Programme	–3.7	215,093.9
W.3	Installation of anaerobic sludge digesters at Water Treatment Plants to capture and burn methane	1.5	543,986.9
A.5	Forest Management and Protection	1.7	9,068,045.0
A.6	Biochar production and application	3.9	37,760.0
W.5	Urgent development of responsible disposal of end-of-life wood products	5.1	3,593.0
T.1	Compact land use policies and mixing of land uses	5.6	414,037.7
W.1	Waste Reduction and Diversion	10.0	750,112.3
A.4	Halting of Biomass burning—especially Agricultural Burning	30.9	6,825.6
P.G.5	Cooperative RE	33.7	27,723.0
P.G.9	Use of solar power for water treatment plants	35.7	20,247.9
W.4	Use of treated wastewater	36.2	523,758.4
P.G.2	REDER Campus Initiative	50.9	34,983.1
P.G.6	Increased penetration of Grid-Scale RE	57.2	986,876.1
I.2	Captured Carbon Industry	59.5	44,573,060.0
P.G.3	Green Building Awareness and Incentive Programme	70.0	888,876.5

Ranking and recommendations

TABLE 3.16 shows the measures ordered by their Cost-Effectiveness, ranking the measures according to their effectiveness at reducing tonnes of CO_2 equivalent. They are colour-coded according to the sectors to which they belong: power generation (yellow), industry (grey), transport (light green), waste and wastewater (purple), and AFOLU (dark green).

These results are displayed in Marginal Abatement Cost Curves (McKinsey curves) in **FIGURE 3.15**. These curves show, on the Y-axis, the Cost-Effectiveness (US$/t$CO_2$e) of the measure and, on the X-axis, the

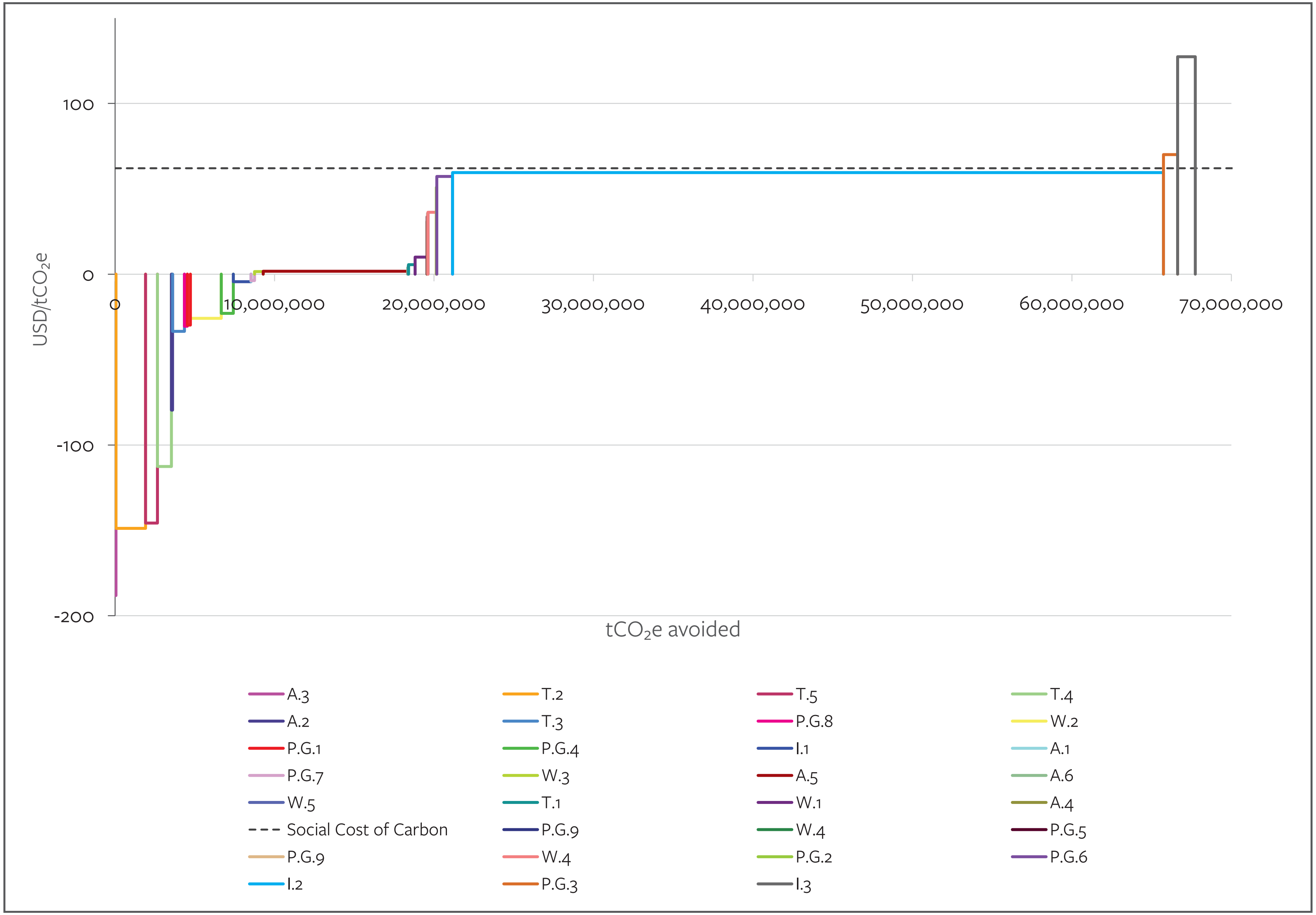


FIGURE 3.15 Marginal Abatement Cost Curve

estimated amount of tonnes of CO_2 equivalent that can be reduced through the implementation of this action. Therefore, the area of each bar on the graph represents the total cost (or benefit if the cost is negative) of the measure.

The measures are ordered from most to least effective. Measures with wider bars show that the measure has a high potential for reducing emissions, while tall measures show high effectiveness (if negative) or ineffectiveness (if positive).

As an example, A.3 is very cost-effective as there is a high benefit per tonne of CO_2 equivalent reduced (\$188.16/tCO_2e in benefits); however, the total amount of reductions available through its implementation is relatively low, namely 56,306.3 tCO_2e (the bar is relatively thin, meaning low result on the x-axis). Whereas, I.1 is less effective, at \$4.4/tCO_2e in benefits (therefore, fewer benefits per tonne of CO_2 equivalent reduced), it has the potential to reduce significantly more tCO_2e through its implementation, namely 1,107,884.2 tCO_2e (the bar is relatively wide, meaning a large result on the x-axis).

These results show that 8,744,328 tonnes of CO_2 equivalent can be avoided through measures that will have net social benefits. An additional 58,988,846 tonnes of CO_2 equivalent can be reduced through measures that have net costs.

TABLE 3.17 tCO_2e reduced through net benefit/cost measures by sector (period 2019–2034)

Sector	tCO_2 avoided
POWER GENERATION ▼	
tCO_2e reduced through net benefit measures	1,342,428
tCO_2e reduced through net cost measures	1,958,706
INDUSTRY ▼	
tCO_2e reduced through net benefit measures	1,107,884
tCO_2e reduced through net cost measures	45,682,020
TRANSPORT ▼	
tCO_2e reduced through net benefit measures	4,223,185
tCO_2e reduced through net cost measures	414,038
WASTE, WATER AND WASTEWATER ▼	
tCO_2e reduced though net benefit measures	1,937,351
tCO_2e reduced through net cost measures	1,821,451
AFOLU ▼	
tCO_2e reduced through net benefit measures	133,481
tCO_2e reduced through net cost measures	9,112,631

As shown in **TABLE 3.17**, measures in the power generation sector with net benefits are those associated with the promotion of energy efficiency and the optimisation of generation and distribution systems. The measures with net costs are those associated with the implementation of renewable energy facilities. In this context, it should be noted that the analysis covers a period of 15 years, so the lifespan of these facilities is not amortised. This means that if these measures were analysed over the entire lifespan of the installations, greater benefits would be obtained, both economically and in terms of emissions.

In the industrial sector, measures with associated costs are significant and linked to the implementation of Carbon Capture Technologies (I.2). It should be noted that no economic benefit related to this measure has been quantified. However, participation in carbon markets could lead to economic benefits for this measure.

In the case of transport, the main economic benefits come from fuel savings. Furthermore, these measures offer a large number of co-benefits, such as air quality improvement, which enhance the health of the population.

In the case of the Waste, Water and Wastewater sector, the measure that shows the best cost-effectiveness ratio is measure W.2, which has net economic benefits associated with the valorisation of compost as a product for agriculture. The measures identified have a direct impact on the quality of life of the population and translate into social, environmental and economic benefits. The measures are also expected to generate new jobs associated with the commercialisation of recovered waste.

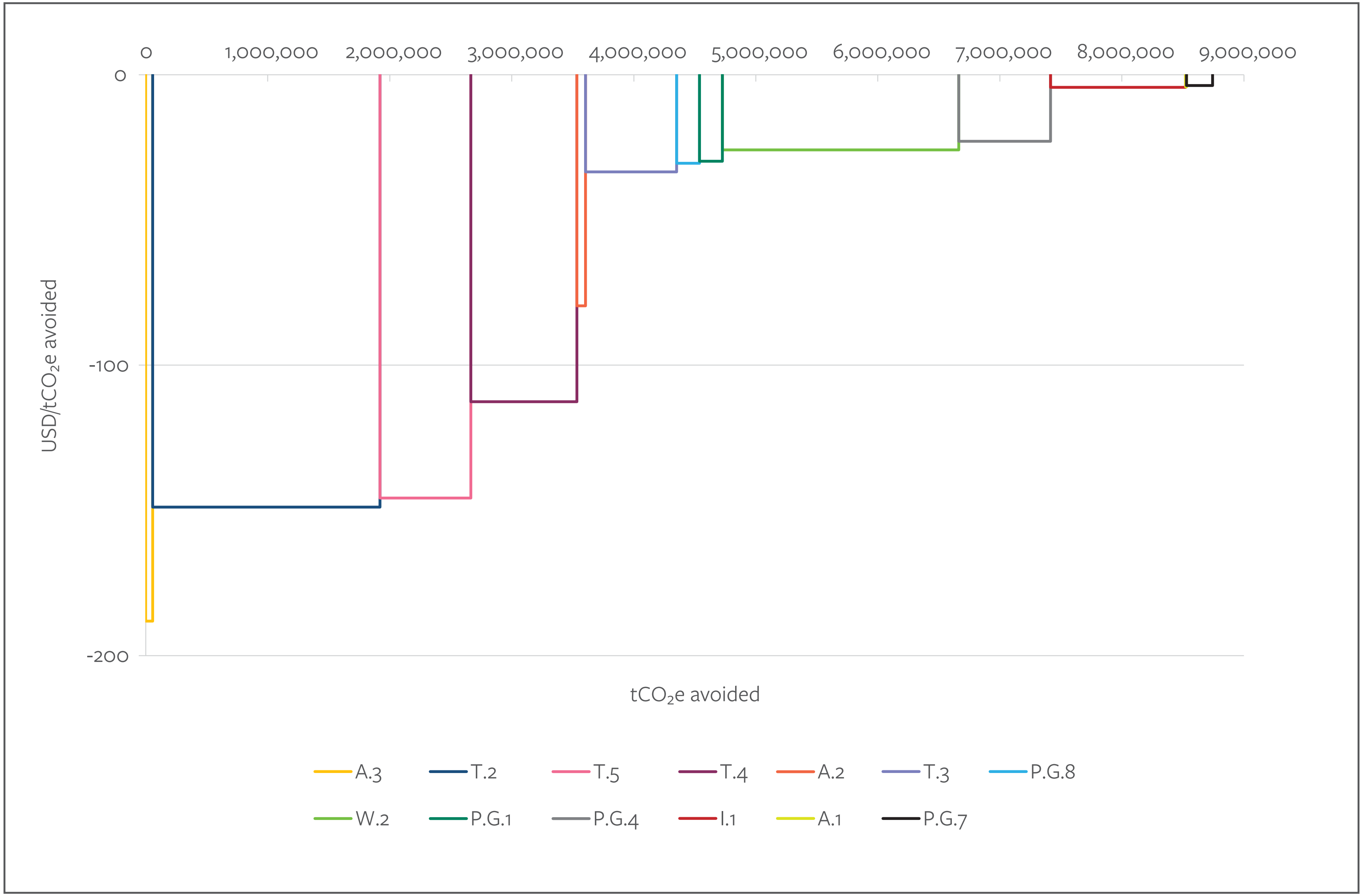


FIGURE 3.16 Marginal Abatement Cost Curve, Net Benefit Measures

▲ Seedlings and sown seeds of cedar, poui, mahogany, Caribbean pine and other trees, part of a reforestation programme, 2019

Finally, with regard to the AFOLU sector, the A.3 measure (reduction, control and monitoring of Agrichemical application by farmers), shows the lowest cost-effectiveness ratio and will require the education and training of farmers. Regarding the carbon sequestration potential of tropical rainforest, the cost-effectiveness ratio of A.2 (Reforestation, Rehabilitation of Degraded Forest Lands and Improved Catchment Management) is significant. Direct mitigation is due to the estimated new forest generated though reforestation and rehabilitation of degraded lands, while economic benefits can accrue from avoided fire-fighting costs and additional wood products, among others.

An interesting way to analyse the absolute values of the Cost-Effectiveness measures is by comparing these results with the Social Cost of Carbon or the cost to society of each tonne of CO_2 equivalent emitted to the atmosphere. According to the United States Environmental Protection Agency (US EPA)[7] the social cost of carbon "is meant to be a comprehensive estimate of climate change damages and includes, among other things, changes in net agricultural productivity, human health, and property damages from increased flood risk". By considering the social cost of carbon[8] of US$62/t$CO_2$e, according to the US EPA (2020, 2.5% discount rate), nearly all of the measures analysed have costs per tonne below the social cost of carbon. They would reduce a total of 65,735,337 tCO2e. There would be only one measure above this cost (P.G.3). This measure would avoid 1,997,837 tonnes of CO_2 in the analysed period.

The graphs shown in **FIGURE 3.16** and **FIGURE 3.17** provide close-up images of the measures with net-benefits and net costs.

7 https://www.epa.gov/
8 The price of CO_2 on current national and international markets is considerably lower than the social cost of carbon due to a variety of reasons. However, the social cost of carbon is considered a long-term, social indicator of the cost of carbon, and is therefore an interesting benchmark to be used to determine action, specifically by the public sector.

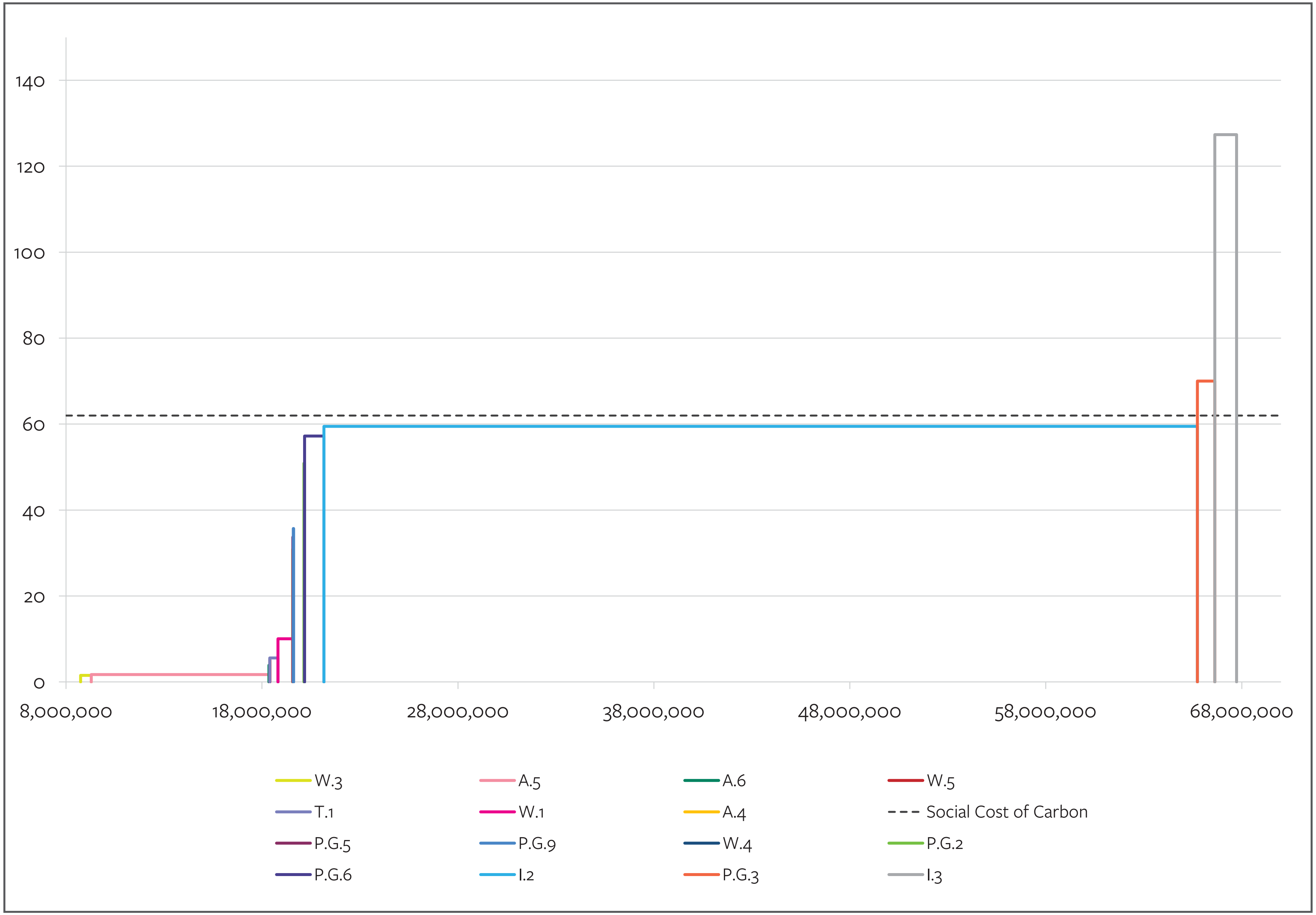


FIGURE 3.17 Marginal Abatement Cost Curve, Close-up of Net Cost Measures and Cost Measures

In general terms, knowledge and policy actions have the lowest ratios since the associated costs are also lower as they do not have specific tangible actions (**FIGURE 3.18**). As far as the strategic line is concerned (**FIGURE 3.19**), the public transport measures stand out as they do not involve major technical barriers and their investment costs are not disproportionate, while they present a significant potential reduction in emissions.

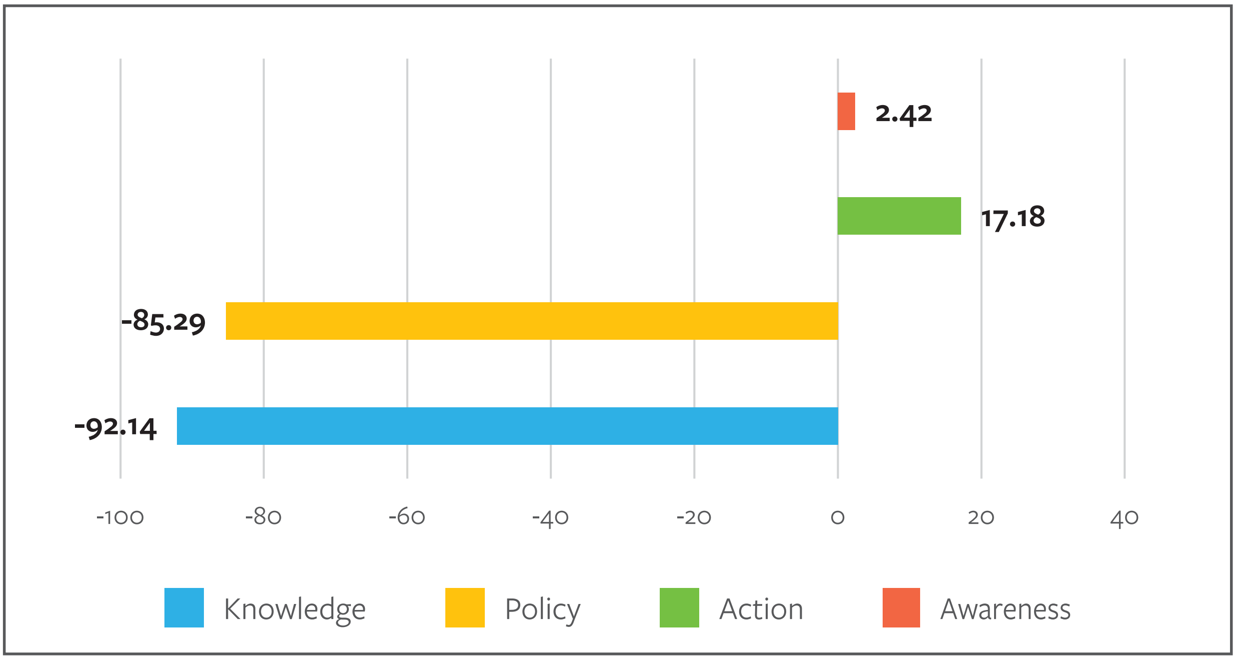


FIGURE 3.18 Overall results of the measures resulting from the CEA by their purpose (US$/t$CO_2$e)

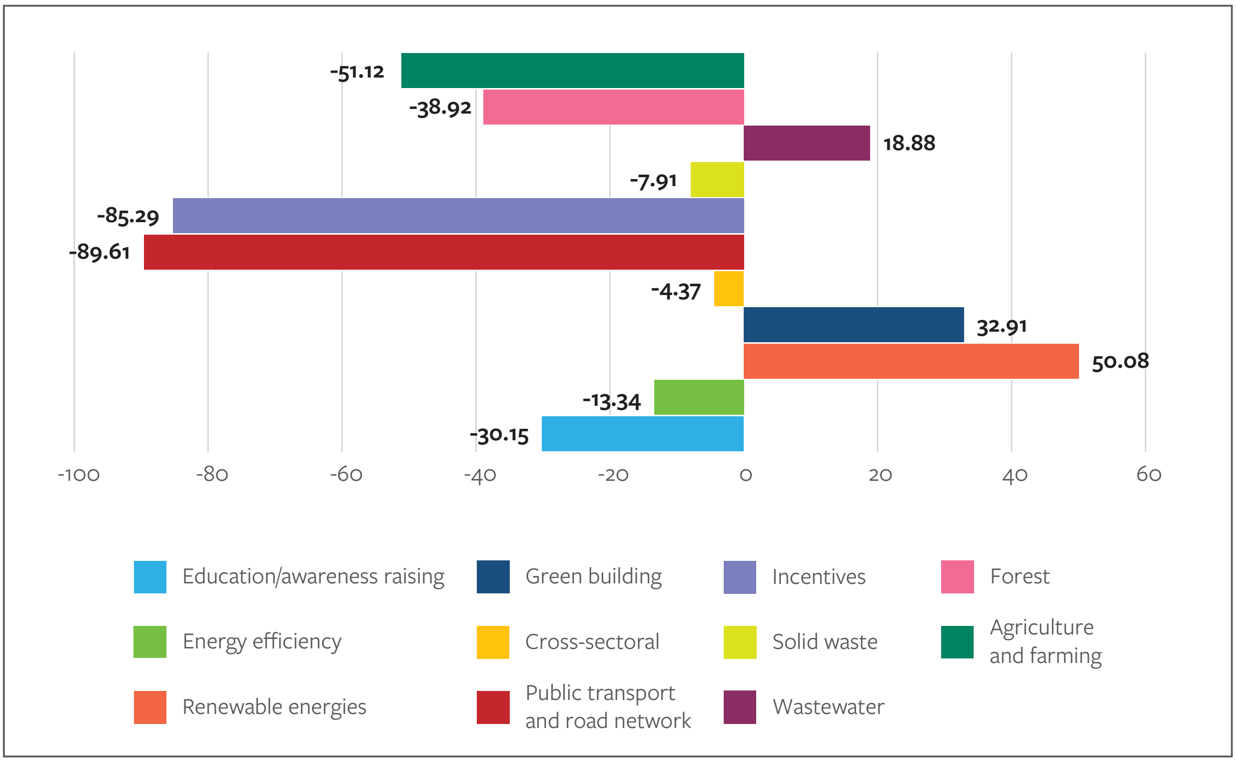


FIGURE 3.19 Overall results of the measures resulting from the CEA by their strategic line (US$/t$CO_2$e)

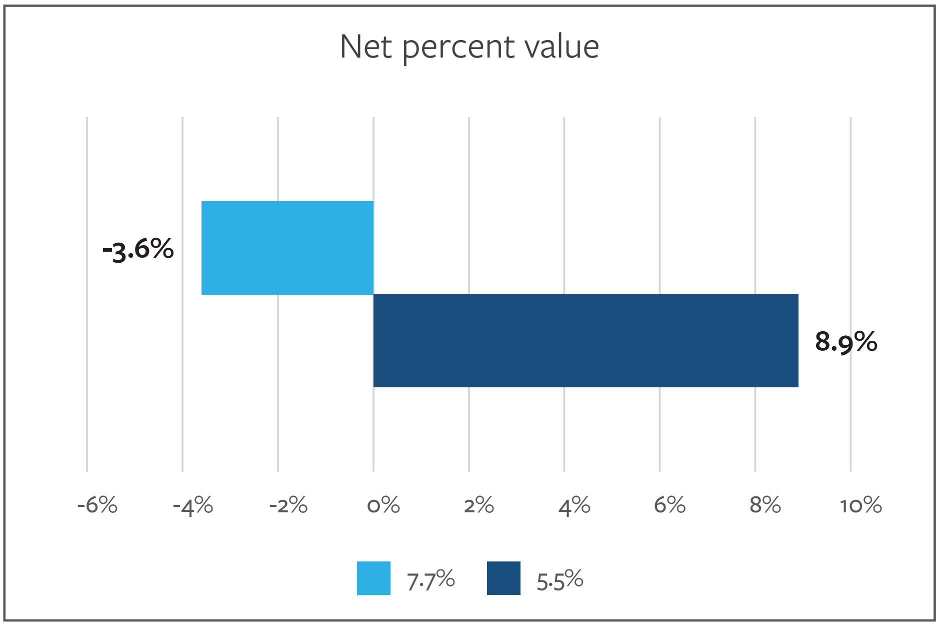


FIGURE 3.20 Change in Total Net Present Value for all measures using discount rates of 5.5% and 7.7%

It is important to note that these measures are based on the primary objective of mitigating GHG emissions in an economically effective manner and do not take into account other factors such as capital investment requirements and institutional capacity, etc. Implementation of these measures will incorporate other variables when making final decisions. The following section details another methodology for prioritising actions. In addition, since each measure was analysed independently of the other, in deciding on measures to implement, interdependencies and positive/negative feedbacks are also considered.

Sensitivity test

The discount rate applied to the costs and benefits in the calculations of the Cost-Effectiveness ratio is an important factor that is taken into account when analysing the results.

Measures with significant positive or negative cash flows over a long period of time tend to be more sensitive to the discount rate as these cash flows should be brought to present value. However, measures with relatively similar costs and benefits each year tend to be less affected by the discount rate. To take this aspect into consideration, a sensitivity analysis was performed. This section shows the results of this analysis, comparing the figures obtained with a seven percent discount rate, with other values of the proposed discount rate.

FIGURE 3.20 shows the results of the sensitivity tests. For this test, alternative discount rates of 5.5 percent and 7.7 percent were used. These rates were chosen due to the fact that government bonds issued in November of 2019, with a maturity period of 15 years were sold with a rate per annum of 5.5 percent and bonds issued in 2019, with a maturity period of only 10 years, were sold with an average rate per annum of 7.7 percent.

These results show how the Net Present Value for all of the measures changes according to the discount rate used, although the variation is not very significant. The Net Present Value increased by 8.9 percent at the lower discount rate of 5.5 percent while the Net Present Value decreased by 3.6 percent at the higher discount rate of 7.7 percent. A measure by measure analysis can be found in **TABLE 3.18**.

As shown in **TABLE 3.18**, the results per measure show that some are more sensitive than others to the discount rate, specifically those with a higher differential between costs and benefits.

It can therefore be concluded that while the discount rate can change the value of the cost effectiveness, in some cases by 30 percent, it does not have much importance on the order of the measures in terms of their effectiveness (with the exception of A.1 that if a higher discount rate were applied it would become a measure with associated net costs).

TABLE 3.18 Sensitivity Test on Cost Effectiveness Results (US$/$tCO_2e$)

7%		5.5%		7.7%	
A.3	−188.2	A.3	−209.9	A.3	−179.4
T.2	−148.9	T.2	−165.4	T.2	−142.2
T.5	−145.8	T.5	−162.4	T.5	−139.1
T.4	−112.6	T.4	−126.6	T.4	−106.9
A.2	−79.6	A.2	−92.7	A.2	−74.3
T.3	−33.4	T.3	−38.0	T.3	−31.6
P.G.8	−30.5	A.1	−37.5	P.G.8	−28.7
P.G.1	−29.8	P.G.8	−35.0	P.G.1	−28.1
W.2	−25.8	P.G.1	−34.2	W.2	−24.8
P.G.4	−23.0	W.2	−28.5	P.G.4	−21.8
I.1	−4.4	P.G.4	−25.8	I.1	−4.1
A.1	−4.2	P.G.7	−7.2	P.G.7	−2.4
P.G.7	−3.7	I.1	−5.1	W.3	1.5
W.3	1.5	W.3	1.6	A.5	1.7
A.5	1.7	A.5	1.9	A.6	3.8
A.6	3.9	T.1	3.2	W.5	5.6
W.5	5.1	W.5	3.9	T.1	6.6
T.1	5.6	A.6	4.1	A.1	9.0
W.1	10.0	W.1	9.0	W.1	10.4
A.4	30.9	A.4	33.2	A.4	30.0
P.G.5	33.7	P.G.9	33.4	P.G.5	33.1
P.G.9	35.7	P.G.5	35.2	W.4	34.7
W.4	36.2	W.4	40.1	P.G.9	36.6
P.G.2	50.9	P.G.2	54.9	P.G.2	49.3
P.G.6	57.2	P.G.6	60.1	P.G.6	56.0
I.2	59.5	I.2	65.0	I.2	57.3
P.G.3	70.0	P.G.3	76.8	P.G.3	67.3

In terms of using the Social Costs of Carbon as a benchmark for implementation, I.2 and P.G.7 move above this threshold in the case of a discount rate of 5.5 percent.

Multi-Criteria Analysis

Climate change mitigation actions require decisions and actions by a wide cross-section of society, including local communities, the private sector and public administration. It is therefore essential that formal processes are involved to support decision-making. The process of assessing the sustainability of mitigation solutions for subsequent prioritisation is cross-cutting and considers many varied and complex aspects of evaluation.

In order to consider multiple criteria in the decision-making process, a Multi-Criteria Analysis (MCA) is conducted which allows for a transparent consideration of a wider range of criteria.

The MCA involves a systematic methodology that allows the different experts from different fields to evaluate the measures, taking into account very diverse criteria, and within the same analysis framework. It focuses on the integration of the entire range of information that may be relevant to decision-making.

The MCA allows both the incorporation of quantitative considerations, as well as expert judgements. It also helps to assess complex problems in simpler terms and to consider aspects where the necessary data are not available. In this sense, any relevant information can be used, regardless of its nature (quantitative, qualitative, mixed) as long as:

- it can be attributed to all alternative projects (lowest common denominator); and
- it can be expressed in a proportional or ordinal scale (criteria).

The MCA completed the following steps:

- Problem definition
- Identification of alternatives
- Determination of the criteria
- Generation of the alternative matrix-criteria
- Assignment of weights to the criteria
- Evaluation of the alternatives
- Hierarchies and analysis of results

The MCA was based on qualitative assessments, but supporting certain criteria with quantitative data extracted from the Cost-Effectiveness analysis.

TABLE 3.19 List of criteria considered in the MCA

	Criteria	Description
1	Emission Reduction potential	Emission reduction potential indicates how the measure contributes to the reduction of greenhouse gases.
2	Consistency with national planning and strategies	This criterion analyses whether the measure is in line with national legislation and does not present barriers that could hinder its implementation in the country.
3	Economic co-benefits	Through this criterion, it is analysed whether the measure can bring benefits associated with economic savings.
4	Social co-benefits and acceptance	The purpose of this criterion is to assess whether the measure can bring benefits to society, as well as whether the measure has public acceptance in the country.
5	Feasibility	Feasibility assesses whether the measure presents no technical and economic impediments to its implementation in the country.

Selected criteria

The MCA used five criteria based on the most relevant issues considered when analysing a determined measure for mitigation purposes. **TABLE 3.19** shows these variables.

Weighting of criteria and assessment of measures

The weights were assigned according to a binomial weighting of criteria. Each of the criteria (column A) is compared with the rest (column B), forming a matrix, and it is decided which one is more important (and to what extent), in relation to the future mitigation solution.

The scores assigned are shown in **TABLE 3.20**. The inverse (1/x), if criterion A is less important than criterion B.

The layout of the matrix used is shown in **TABLE 3.21**.

The weight of the criteria is calculated by raising the multiplication of all the indexes assigned per measure to the number of criteria (5) and dividing them by the sum of all the previous results. It is calculated with the following formula:

$$w_j = \frac{N^{x_{ii}*x_{ij}*x_n}}{\sum(N^{x_{ii}*x_{ij}*x_n})}$$

Where,

- *N: Number of Criteria*
- *x_{ij}: importance index assigned to criterion i over criterion j*
- *w_j: weight of criterion i*

To assess the measures, the degree to which they comply with the criteria is analysed and they are scored according to the values (**TABLE 3.22**).

Using the following equation, the overall score of the measure is obtained by adding the multiplications of the individual score by its corresponding weight:

$$S = \sum_{j=1}^{n} w_j * s_{ij}$$

Where,

- *S: overall score of the measure*
- *s: score of measure i for criterion j.*
- *w: weight of criterion j (importance index)*

TABLE 3.20 Scores used for the criteria weightings ▼

How Important Is A Relative to B?	Preference index assigned
Strongly less important	0.2
Moderately less important	0.33
Equally important	1
Moderately more important	3
Strongly more important	5

MCA evaluation process

For the participatory process, the Delphi methodology was used. The Delphi method is part of the foresight methods, which study the future in terms of the evolution of the factors of the techno-socio-economic environment and their interactions.

It is a method of structuring a group communication process that is effective in enabling a group of individuals, as a whole, to address a complex problem (Mahajan, 1976). The predictability of Delphi is based on the systematic use of intuitive judgement by a group of experts.

Within the forecasting methods, the Delphi method is usually classified within the qualitative or subjective methods. In this sense, the quality of the results depends, above all, on the care taken in developing the criteria and in choosing the experts consulted.

This method of analysis was chosen because it allows information to be obtained from very broad or very specific points of view. The Delphi Exercises are considered "holistic" as they cover a wide range of fields and help to explore in a systematic and objective way the problems that require concurrence and qualified opinion. It also has another advantage. As it does not involve a "face-to-face" participatory process, it eliminates or diminishes the negative effects of group meetings.

The evaluation process consisted of the following steps:

- Firstly, all the experts involved in the project weighed the criteria according to their value judgement and their own experience. In this regard, each received a form with the contents of **TABLE 3.21**.
- Secondly, each sectoral expert proceeded to score the measures corresponding to their sector and assessed how effective the measures were for each criterion using the rating rates shown in **TABLE 3.22**.

TABLE 3.21 Aspect of the binomial criteria weighting matrix

A	B				
Binomial weighting of criteria	**Emission Reduction potential**	**Consistency with national planning and strategies**	**Economic co-benefits**	**Social co-benefits and acceptance**	**Feasibility**
Emission Reduction potential	1.00	2.30	2.83	2.83	2.50
Consistency with national planning and strategies	0.43	1.00	1.50	3.50	1.63
Economic co-benefits	0.35	0.67	1.00	2.33	1.30
Social co-benefits and acceptance	0.35	0.29	0.43	1.00	1.47
Feasibility	0.40	0.61	0.77	0.68	1.00

Photo Credit: Ministry of Planning and Development

▲ Participants from all sectors attend a Mitigation Analysis Workshop led by Factor Integral Services Limited to develop new and potential measures, 2020

▼ Participants then engaged in sectoral working groups to discuss new and potential mitigation measures, led by consulting firm Factor Ideas Integral Services, 2020

Photo Credit: Ministry of Planning and Development

Sharing of results from the various working groups, 2020 ►

- Thirdly, the results were consolidated and the matrix results were drawn up.
- Fourthly, each expert reviewed the results with the aim of validating and detecting whether they had changed their opinion on any of the measures by checking them all on the whole. The aim of this phase is to reduce dispersion and to specify the average consensus opinion. When the information was sent out for the second time, the experts were informed of the results of the first consultation and provided a new response. The reasons for the differences were extracted and evaluated.
- After this validation and review phase, the relevant changes were made in those cases where the experts had changed their mind, and the process was then completed.

Analysis of the Results

The MCA was carried out according to the methodology described in this section and following the evaluation procedure in the preceding section.

Results of the criteria weighting

The weights obtained are summarised in **TABLE 3.23**. The green colours represent the criteria that were given the most relevance, and the red ones the least, as a visual way of representing them.

TABLE 3.22 Scores used for the evaluation of the measures ▼

How effective is this measure for each of the criteria?	Rating Rate
Nothing or almost nothing	0
Little	1
Some	2
Quite	3
A lot	4

TABLE 3.23 Weighting of the criteria used for the MCA ▼

	Criteria	Weighting
1	Emission Reduction potential	0.38
2	Consistency with national planning and strategies	0.23
3	Economic co-benefits	0.17
4	Social co-benefits and acceptance	0.10
5	Feasibility	0.12

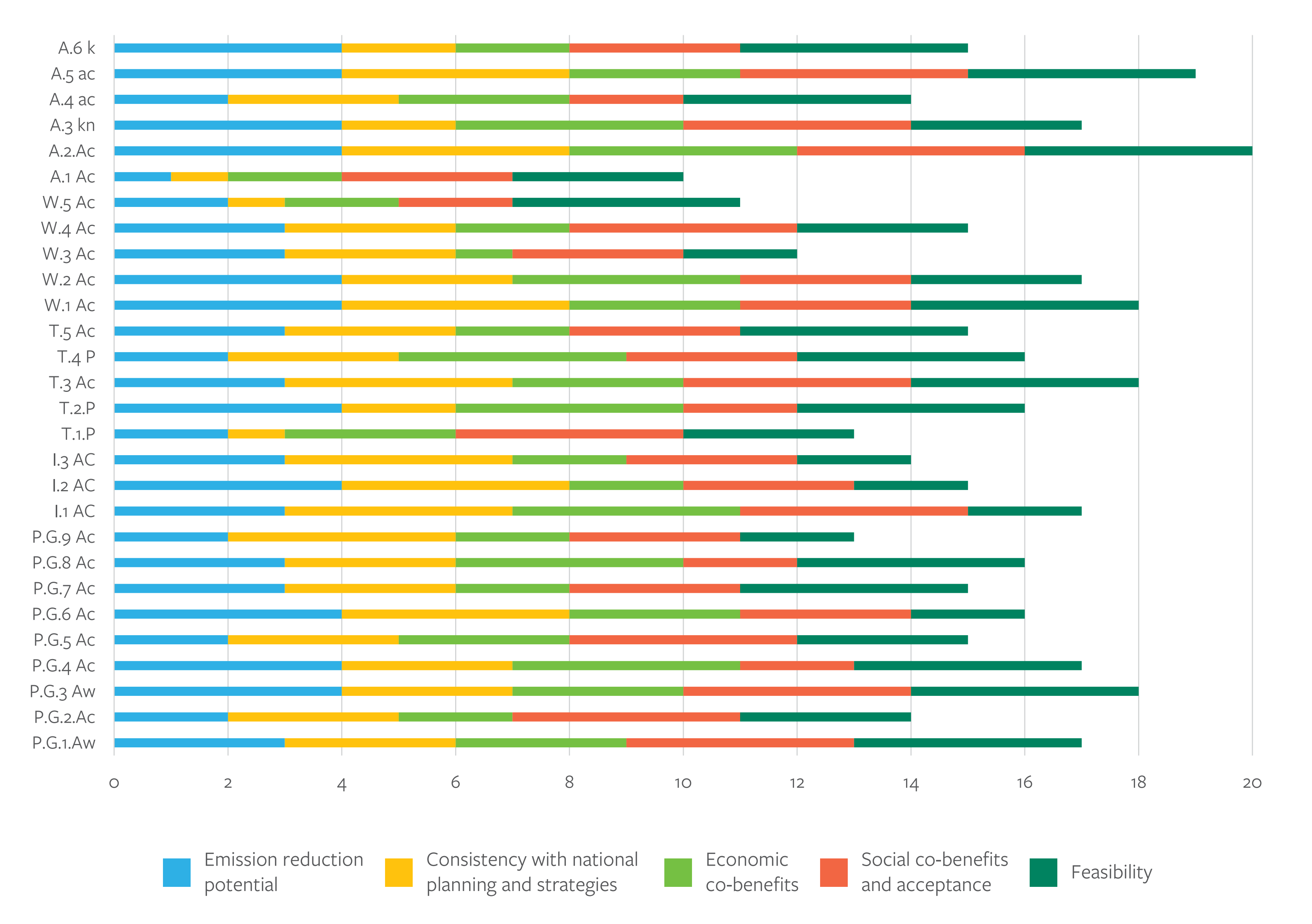


FIGURE 3.21 Assessment of measures disaggregated by CMA criteria

TABLE 3.24 Overall assessment of the measures resulting from the MCA, ranked from highest to lowest, regardless of sector

	Measure	Overall Evaluation
A.2.Ac	Reforestation, Rehabilitation of degraded forested lands and Improved Catchment Management	4.0
A.5 ac	Forest Management and Protection	3.8
W.1 Ac	Waste Reduction and Diversion	3.7
P.G.3 Aw	Green Building Awareness and Incentive Programme	3.6
P.G.4 Ac	Supply Side Management: Generation Dispatch	3.6
W.2 Ac	Segregation of solid organic waste for material recovery in composting plants	3.5
P.G.6 Ac	Increased penetration of Grid Scale RE	3.5
T.3 Ac	Introduction of park-and-ride system pilot	3.5
A.3 kn	Reduction, control and monitoring of Agri-chemical application by farmers	3.4
I.1 AC	Renewable Fuels	3.4
T.2.P	Pay-as-you-drive auto insurance	3.3
I.2 AC	Captured Carbon Industry	3.3
P.G.1.Aw	Conservation Education through Curriculum and Culture	3.2
P.G.8 Ac	Increased customer engagement	3.2
A.6 k	Biochar production and application	3.1
P.G.7 Ac	Energy Efficient Appliance Programme	3.0
T.5 Ac	Transit Service Improvements	3.0
W.4 Ac	Use of treated wastewater	2.9
T.4 P	Parking pricing and parking supply management	2.9
P.G.5 Ac	Cooperative RE	2.7
A.4 ac	Halting of Biomass burning—especially Agricultural Burning	2.6
P.G.9 Ac	Use of solar power for water treatment plants	2.6
P.G.2.Ac	REDER Campus Initiative	2.6
W.3 Ac	Installation of anaerobic sludge digesters at Water Treatment Plants to capture and burn methane	2.5
T.1.P	Compact land use policies and mixing of land uses	2.3
W.5 Ac	Urgent development of responsible disposal of end-of-life wood products	2.0
A.1 Ac	Urban Greening Activities	1.6

Results of the effectiveness of the measures for each criterion (without weighting)

After deciding on the weights, the experts assessed the extent to which the proposed mitigation alternatives met the criteria outlined above. **FIGURE 3.21** shows the average of the values for each criterion and measure.

Based on these results (which excludes the weighting of the different criteria), the most highly valued measures were those of Forest Management and Protection (A5) and A.2. Rehabilitation of degraded forested land, closely followed by measures T.3 Introduction of park-and-ride system pilot, P.G.3 Green Building Awareness and Incentive Programme and W.2 regarding the segregation of solid organic waste for material recovery in composting plants. The lowest evaluated measure were measures A.1 Urban Greening Activities and W.5 regarding the urgent development of responsible disposal of end-of-life wood products.

Weighted results of the effectiveness of the measures for each criterion

The overall assessment shown above does not consider the weighting of each criterion. **TABLE 3.24** shows the global scores obtained, considering both the individual assessments and the weights obtained previously. The measures are shown in descending order from the highest score to the lowest score. In

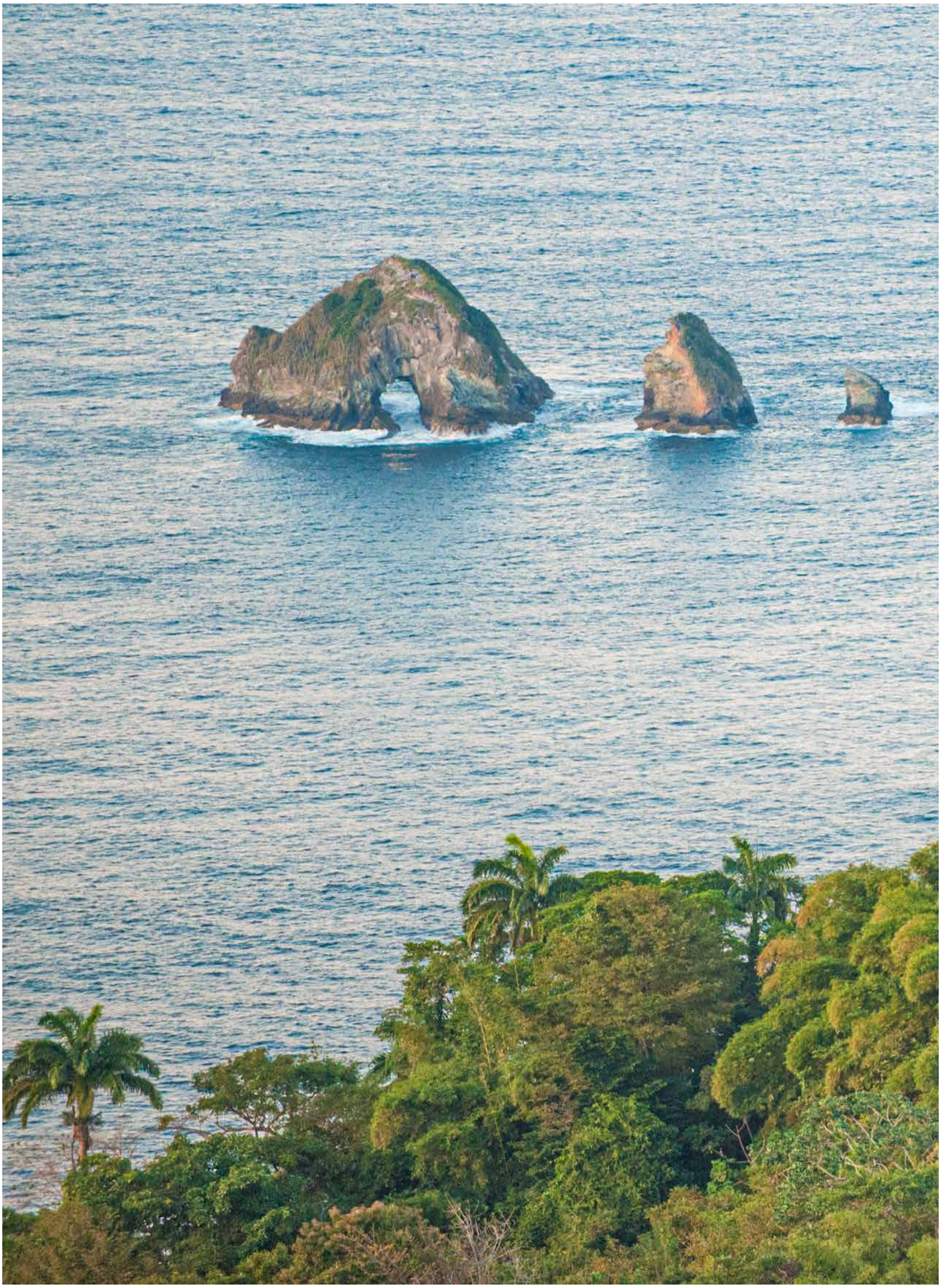


Photo Credit: Tobago House of Assembly

▲ L'Anse Fourmi Sister Rocks—a natural sea arch off the northeast coast of Tobago—is a popular scuba diving site when the sea allows, 2011

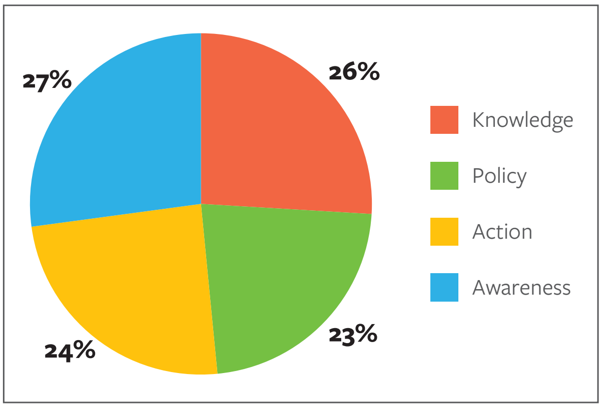


FIGURE 3.22 Overall results of the measures resulting from the MCA by their purpose ▲

this case, the fairly constant positions obtained can be appreciated. This is due to the fact that the weight of each criterion has been very similar in almost all cases.

A focus on the results by the purpose of the measures, as shown in **FIGURE 3.22**, reveals that the action measures are the most highly rated as they have the capacity to comply with the most weighted criterion—potential for reducing emissions.

An analysis of the strategic lines of the outlined measures shows that the measures associated with solid waste disposal, as well as the measures that encourage sustainable agriculture and forestry, stand out. Public awareness and capacity-building measures, despite having less direct emissions associated with them, also contribute and reinforce the rest of the measures. These results are shown in **FIGURE 3.23**.

An analysis by sector reveals that the following scored high: in electricity generation, the measures to promote renewable energies; in industry, the use of low carbon fuels; in transport, the plans and policies associated with reducing individual transport; in Waste, Water and Wastewater sector, the measures aimed at implementing reuse and recycling and, finally, with regard to the AFOLU sector, the reforestation and sustainable forest management measures.

Comparison of results according to different decision-making methods

Using different decision-making methods helps to cover a greater number of criteria (objective and subjective) in the prioritisation of measures. These methods can be pooled to evaluate and compare the results obtained.

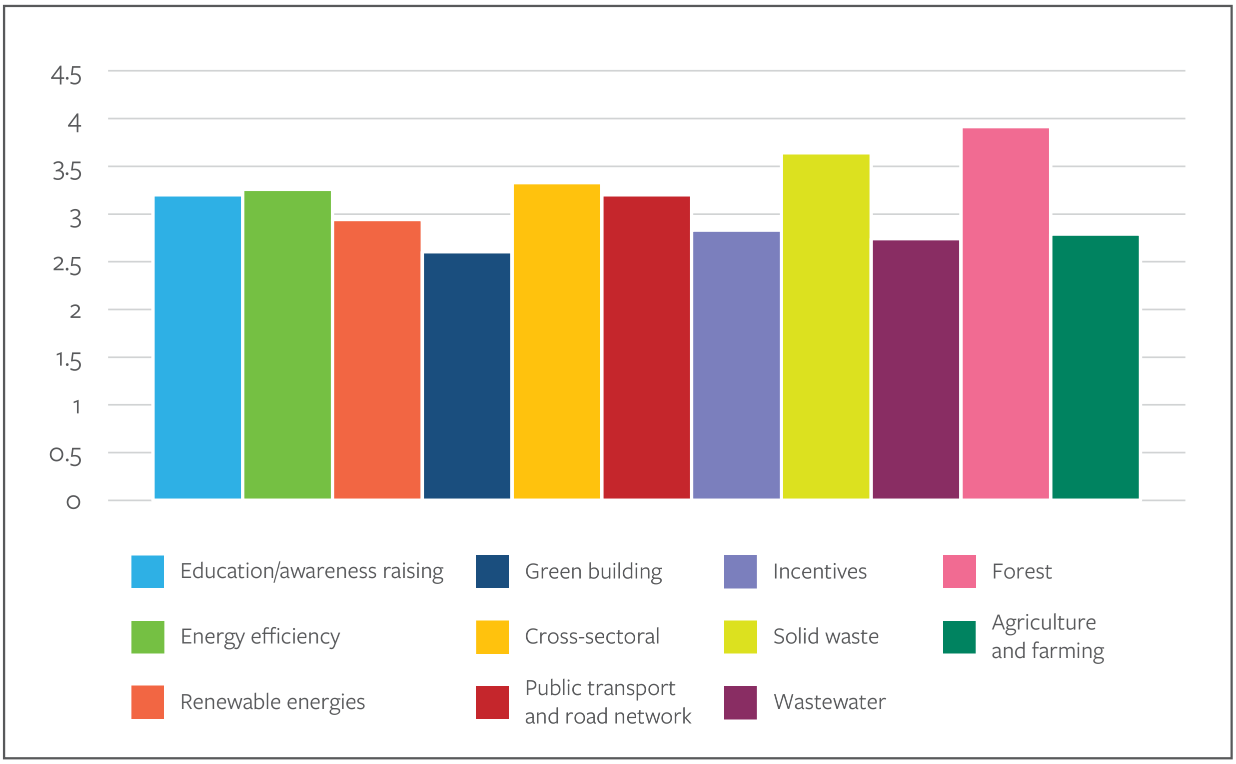


FIGURE 3.23 Overall results of the measures resulting from the MCA by their strategic line

It is therefore important to compare the results of both analyses so that measures with similar and different results can be identified, and a joint evaluation of all of them can be conducted.

In this regard, **TABLE 3.25** ranks the proposed measures from most to least relevant according to both decision-making methodologies.

As each decision-making methodology uses different criteria, results may differ. Nevertheless, some general conclusions can be drawn.

In the case of Power Generation, measure P.G.1 aimed at Conservation Education through Curriculum and Culture showed good results in both cases, while P.G.2 showed an unfavourable result.

With regard to the Industrial sector, MCA analysis placed these measures at the top of the ranking, while in the CEA they were placed further down. This is mainly as a result of this package of measures having relatively high implementation costs. In both methodologies, measure I.1, use of renewable fuels, stands out.

Regarding Transport measures, although the CEA analysis shows very favourable results in terms of the package of measures proposed, they have not been as highly valued in the MCA. Among the measures, T.3 and T.5 stand out positively as they are in the upper half of the measures evaluated in both cases.

As for the waste and wastewater sector, it shows favourable results according to both methodologies for measure W.2: segregation of solid organic waste for material recovery in composting plants. On the other hand, both methodologies coincide in placing W.5 and W.4 in the lower half of the ranking.

Finally, in the AFOLU sector, both measures A.2 and A.3 show fairly favourable results, indicating that they meet all the aspects analysed, both the objective and the not-so-objective ones, and that they have been estimated by value judgement.

Assessment of reduction potential and cost of mitigation

Based on the detailed analysis of the potential measures, mitigation scenarios were generated. The following is a description of the peculiarities of these scenarios and the final mitigation potential of the measures quantified for this scenario after their evaluation.

Mitigation Scenarios

The foundations of the mitigation scenarios are the same initial sectoral hypotheses defined for the BaU Scenarios. However, these scenarios show some peculiar characteristics that should be highlighted.

As a particular assumption of these scenarios, it is worth noting that the projection of renewable electricity demand reaches 30 percent by 2050 in these scenarios, while in the BaU Scenarios they reached 10 percent by 2050.

However, the most important hypothesis in the mitigation scenarios are the potential measures identified, which were quantified in terms of GHGs in order to include them in the model. These measures were defined through a participatory process with the country's stakeholders.

The stakeholder consultations involved consideration of the additional mitigation measures, their strengths and weaknesses which were considered when prioritising the mitigation actions identified, and which were then used for the calculation of technical and economic indicators to assess mitigation potential. The results of these analyses were then validated by stakeholders.

Following were the main conclusions of the stakeholder consultations:

- Sectoral results have shown that no changes are expected from the initial measures. The measures cover the mitigation possibilities in the country, having explored all potential pathways.
- Regarding the feasibility of implementation, no significant obstacles were identified justifying the removal of the measure. However, certain difficulties have been identified in the sectors which will need to be taken into account when implementing the measure.
- Concerning the mitigation potential, all the measures maintained the potential that were quantitatively assessed, with the exception of measure I.2 Captured Carbon Industry. This

TABLE 3.25 Comparison of the results obtained by the CEA and MCA analysis (from most to least relevant)

CEA		MCA	
A.3	Reduction, control and monitoring of Agri-chemical application by farmers	A.2	Reforestation, Rehabilitation of degraded forested lands and Improved Catchment Management
T.2	Pay-as-you-drive auto insurance	A.5	Forest Management and Protection
T.5	Transit Service Improvements	W.1	Waste Reduction and Diversion
T.4	Parking pricing and parking supply management	P.G.3	Green Building Awareness and Incentive Programme
A.2	Reforestation, Rehabilitation of degraded forested lands and Improved Catchment Management	P.G.4	Supply Side Management: Generation Dispatch
T.3	Introduction of park-and-ride system pilot	W.2	Segregation of solid organic waste for material recovery in composting plants
P.G.8	Increased customer engagement	P.G.6	Increased penetration of Grid-Scale RE
P.G.1	Conservation Education through Curriculum and Culture	T.3	Introduction of park-and-ride system pilot
W.2	Segregation of solid organic waste for material recovery in composting plants	A.3	Reduction, control and monitoring of Agri-chemical application by farmers
P.G.4	Supply Side Management: Generation Dispatch	I.1	Renewable Fuels
I.1	Renewable Fuels	T.2.	Pay-as-you-drive auto insurance
A.1	Urban Greening Activities: green roofs and urban trees	I.2	Captured Carbon Industry
P.G.7	Energy Efficient Appliance Programme	P.G.1	Conservation Education through Curriculum and Culture
W.3	Installation of anaerobic sludge digesters at Water Treatment Plants to capture and burn methane	P.G.8	Increased customer engagement
A.5	Forest Management and Protection	A.6	Biochar production and application
A.6	Biochar production and application	P.G.7	Energy Efficient Appliance Programme
W.5	Urgent development of responsible disposal of end-of-life wood products	T.5	Transit Service Improvements
T.1	Compact land use policies and mixing of land uses	W.4	Use of treated wastewater
W.1	Waste Reduction and Diversion	T.4	Parking pricing and parking supply management
A.4	Halting of Biomass burning—especially Agricultural Burning	P.G.5	Cooperative RE
P.G.5	Cooperative RE	A.4	Halting of Biomass burning—especially Agricultural Burning
P.G.9	Use of solar power for water treatment plants	P.G.9	Use of solar power for water treatment plants
W.4	Use of treated wastewater	P.G.2	REDER Campus Initiative
P.G.2	REDER Campus Initiative	W.3	Installation of anaerobic sludge digesters at Water Treatment Plants to capture and burn methane
P.G.6	Increased penetration of Grid-Scale RE	T.1	Compact land use policies and mixing of land uses
I.2	Captured Carbon Industry	W.5	Urgent development of responsible disposal of end-of-life wood products
P.G.3	Green Building Awareness and Incentive Programme	A.1	Urban Greening Activities

TABLE 3.26 Quantified potential measures for all sectors

Sector	Code	Measure	Timeframe[1]	Annual Mitigation potential by 2040 (tCO_2e)
Power Generation	P.G.1	Conservation Education through Curriculum and Culture	Medium	18,808
	P.G.8	Increased customer engagement	Short	18,808
	P.G.2	Renewable Energy and Direct Electricity Replacement (REDER) Campus Initiative	Long	5,929
	P.G.5	Cooperative RE	Long	3,425
	P.G.6	Increased penetration of Utility Scale RE.30%	Long	97,660
	P.G.9	Use solar power for water treatment plants	Medium–long	1,317
	P.G.3	Green Building Awareness and Incentive Programme	Short	147,262
	P.G.4	Supply Side Management: Generation Dispatch	Short	60,868
	P.G.7	Energy Efficient Appliance Programme	Short–medium	18,869
Industry	I.1	Renewable fuels	Long	317,479
	I.2	Captured Carbon Industry	Long	1,469,722
Transport	T.3	Introduction of park-and-ride system pilot	Short	58,935
	T.5	Transit Service Improvements	Short	58,935
	T.1	Compact land use policies and mixing of land uses	Long	32,742
	T.2	Pay-as-you-drive auto insurance	Medium	147,337
	T.4	Parking pricing and parking supply management	Medium	68,757
Waste and Wastewater	W.W.1	Waste Reduction and Diversion	Short	342,924
	W.W.2	Segregation of solid organic waste for material recovery in composting plants	Long	189,454
	W.W.3	Installation of anaerobic sludge digesters at Water Treatment Plants to capture and burn methane	Medium	45,332
	W.W.4	Use of treated wastewater	Short	38,092
	W.W.5	Urgent development of responsible disposal of end-of-life wood products	Short	287
AFOLU	A.1	Urban Greening Activities	Late short term to early medium term	532
	A.2	Rehabilitation of degraded forested land	Short term	5,357
	A.5	Forest Management and Protection	Short term	592,307
	A.3	Reduction, control and monitoring of Agri-chemical application by farmers	Short term [2]	4,095
	A.4	Halting of Biomass burning—especially agricultural burning	Short term	505.6
	A.6	Biochar production and application	Short-Medium[3]	2,880

1 Timeframe: short-term (next 5 years), medium-term (5-10 years), long-term (>10 years)
2 All tasks (except development of Standard) = short term BUT Standard completed by early medium term
3 Late short term to early medium term for complete development of biochar production system

measure considered the maximum capture potential which could cover 10 percent of the emissions from the industrial sector. However, it was considered that in reality it would not be feasible to reach this percentage, so it was reduced to five percent.

Some sectoral features:

- In the power generation and industry sector curriculum changes may be challenged by an already packed curriculum. Additionally, cooperative RE may have land acquisition issues and funding for RE installations in schools and public spaces may not be available.
- As far as the waste sector is concerned, composting plants may face some challenges in trade-offs with waste-to-energy.
- Finally, in the AFOLU sector, barriers to be overcome if successful implementation is targeted, include lack of awareness by farmers which would require changing the cultural mindset, and the need to train farmers in alternative techniques (e.g. CSA). The main barriers to the lack of implementation of measure A4 include a change in cultural mindset.

Additionally, since the economic growth in the optimistic scenarios is higher than in the conservative scenarios, it was assumed that in the optimistic scenarios the availability of financing for the implementation of GHG mitigation would be higher. Therefore, in the Conservative Mitigations scenario, a correction ratio is applied to link the economic growth of the scenario to the implementation of the action. Thus, it is expected that in the Optimistic Mitigation scenario the measures will be able to reach their maximum mitigation potential in a shorter period of time than in the Conservative Mitigation scenario. **TABLE 3.26** shows a summary of the final quantified actions considered for every sector.

The reduction potential shown in **TABLE 3.26** refers to the average annual reduction.

3.5 Results

Once the historical GHG baseline, the economic scenarios and the hypotheses were established, the main outputs of the model for the Business as Usual and Mitigation scenarios were analysed. In order to do that, an initial comparative analysis between the different scenarios was performed to provide a greater understanding of the overall results.

Total emissions

When comparing the four projected scenarios, the influence of the variables on the results can be observed. An overview of the total emissions of each scenario is displayed in **TABLE 3.27**, including the emissions evolution for each scenario in the period 2018–2030 and 2018–2050.

The greatest increase of emissions would take place in the Optimistic BaU scenario, compared to the Conservative Mitigation scenario, with a difference of approximately 15 MtCO2e projected in 2050 between these two scenarios.

The influence of economic and mitigation factors is intertwined, as can be seen in the results. Mitigation scenarios always show less emissions

TABLE 3.27 Comparison of total emissions by scenario

Total (tCO_2e)	2018	2030	2040	2050	∆ 2018–2030	∆ 2018–2050
Conservative BaU (BaUC)	41,630,448	41,963,134	42,383,528	42,888,311	1%	3%
Optimistic BaU (BaUO)	41,630,448	47,912,904	50,357,039	52,271,832	15%	26%
Conservative Mitigation (MiC)	41,630,448	38,278,193	37,048,945	37,513,286	–8%	–10%
Optimistic Mitigation (MiO)	41,630,448	44,130,391	44,733,501	46,443,882	3%	12%

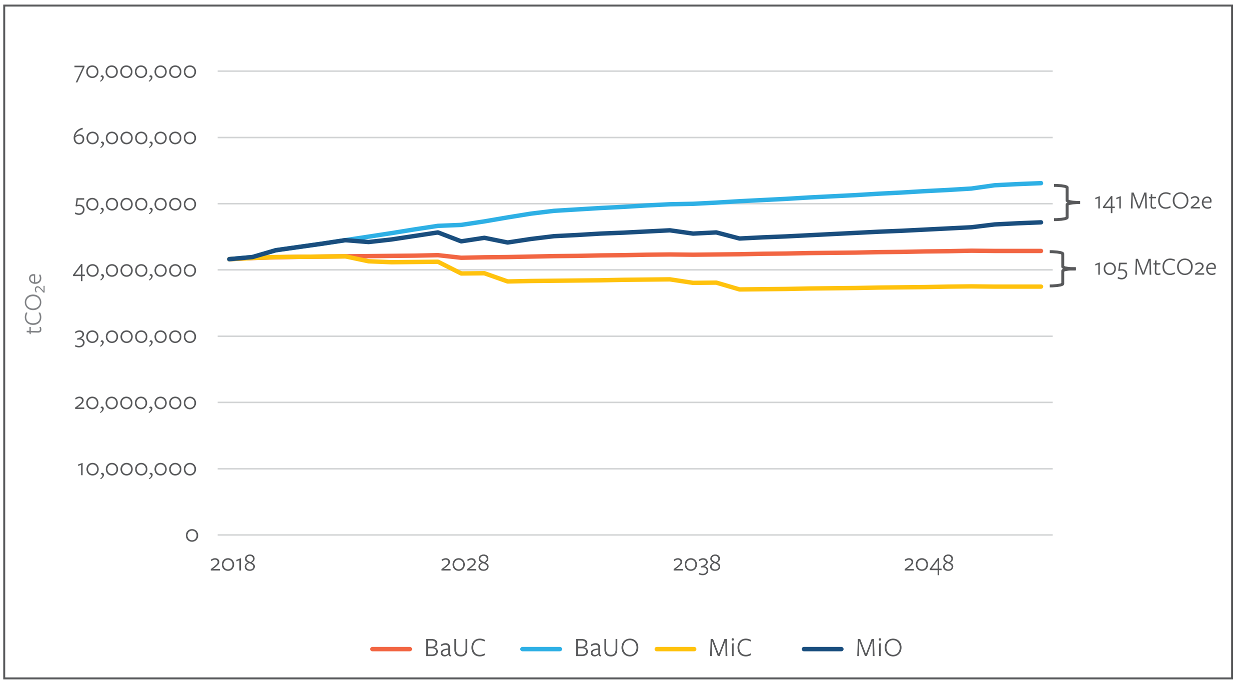


FIGURE 3.24 Comparison of the total projected emissions by scenario

than BaU scenarios, but their evolution over time is very much affected by the contrasting influence of economic growth and mitigation efforts. In the Conservative scenario, mitigation measures would gain relevance over time and, as such, projections are slightly lower in 2050 compared to 2030. In the Optimistic Mitigation scenario, however, the importance of economic growth would outweigh the impact of mitigation measures, resulting in higher emissions in 2050 than 2030.

The accumulated figures during the whole period provide more information on the different scenarios. As shown in **FIGURE 3.24** the implementation of GHG mitigation actions over the whole period would avoid 141 MtCO2e with the optimistic economic growth and 105 MtCO2e with the conservative economic growth.

In the case of the Conservative Mitigation scenario, it can be seen that the potential of the measures would be enough to reduce emissions compared to the base year, given that the economic increase in this scenario is very gradual, which means that the rates of activity do not evolve considerably.

In the case of the Optimistic Mitigation scenario, the effects of GHG mitigation measures would be outweighed by the significant increase in emissions due to the increase in expected economic activity in the country during the period. As a result, at the end of the period the emissions would be higher than at the beginning. This is because most GHG emissions reductions take place at the beginning of the period (short–medium term).

It is important to highlight that the difference in the reductions achieved through the implementation of the GHG measures in the Conservative and Optimistic scenarios is due to the hypotheses defined before. In the Conservative scenario there is a lower implementation of the actions due to the lower economic growth.

Likewise, it is worth noting that current BaU Scenarios already consider some mitigation measures that are currently being undertaken. In this regard, it is noteworthy that regardless of the difference in accumulated emissions between scenarios, both consider emission reduction actions. If no measures were currently in place, the difference would be even greater.

A more detailed analysis of the results by sector helps to explain the variables affecting the overall picture. The results of the electrical power generation sector are shown in **TABLE 3.28** for all four scenarios.

In this sector, the Optimistic BaU scenario shows higher emissions than the Conservative Mitigation

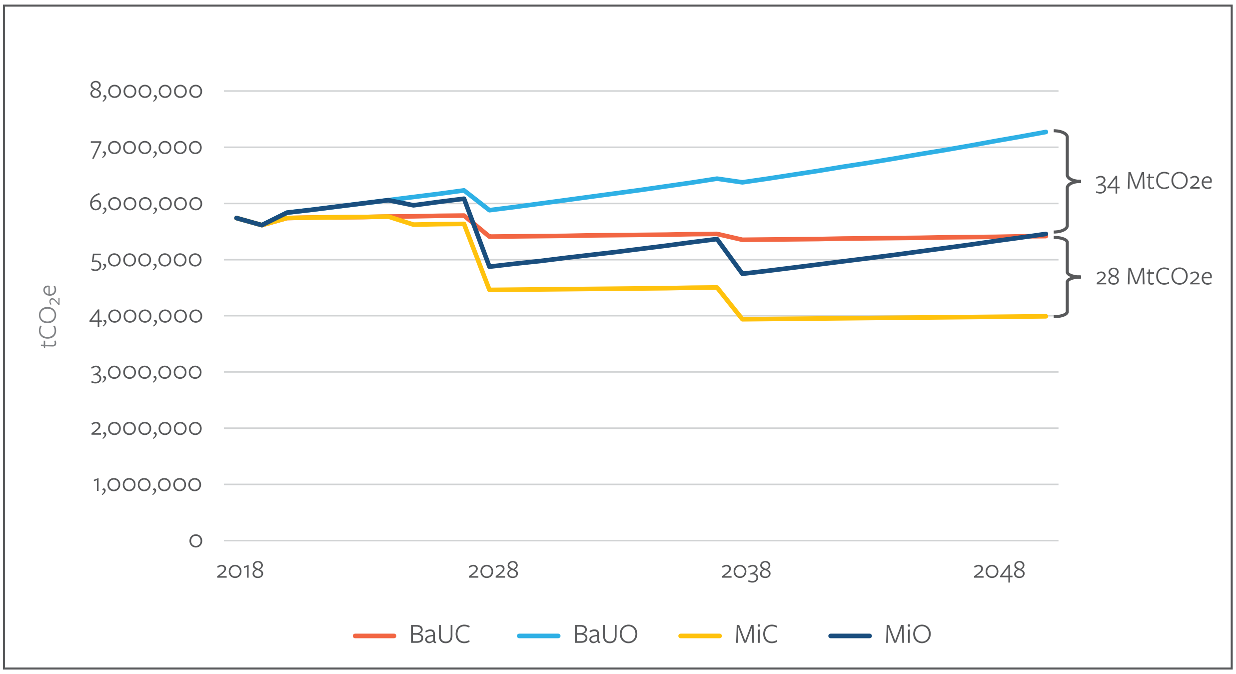


FIGURE 3.25 Projected emissions for the power generation sector by scenario

scenario. However, in this case, at the end of the projection period, the Conservative BaU scenario and the Optimistic Mitigation scenario would have a similar contribution due to the strong increase in renewable energies in the latter scenario.

Cumulative reductions during the period indicate that the Electrical Power Generation sector accounts for approximately 50 percent (44 MtCO2e) of the total reductions in the Conservative scenario and 44 percent (30 MtCO2e) in the Optimistic scenario.

TABLE 3.28 Comparison of the emissions of the electricity generation sector by scenario

Total (tCO_2e)	2018	2030	2040	2050	Δ 2018–2030	Δ 2018–2050
Conservative BaU (BaUC)	5,741,518	5,418,601	5,362,107	5,417,696	–6%	0%
Optimistic BaU (BaUO)	5,741,518	5,995,733	6,510,655	7,272,928	4%	27%
Conservative Mitigation (MiC)	5,741,518	4,469,064	3,947,679	3,991,643	–20%	–28%
Optimistic Mitigation (MiO)	5,741,518	4,976,291	4,856,064	5,458,946	–11%	–3%

TABLE 3.29 Comparison of the emissions of the industry sector by scenario

Total (tCO_2e)	2018	2030	2040	2050	Δ 2018–2030	Δ 2018–2050
Conservative BaU (BaUC)	32,899,574	33,123,125	33,351,404	33,598,190	1%	2%
Optimistic BaU (BaUO)	32,899,574	37,341,182	37,885,400	37,534,429	14%	14%
Conservative Mitigation (MiC)	32,899,574	32,923,380	31,191,909	31,438,678	0%	–4%
Optimistic Mitigation (MiO)	32,899,574	36,248,820	35,700,676	35,349,706	10%	7%

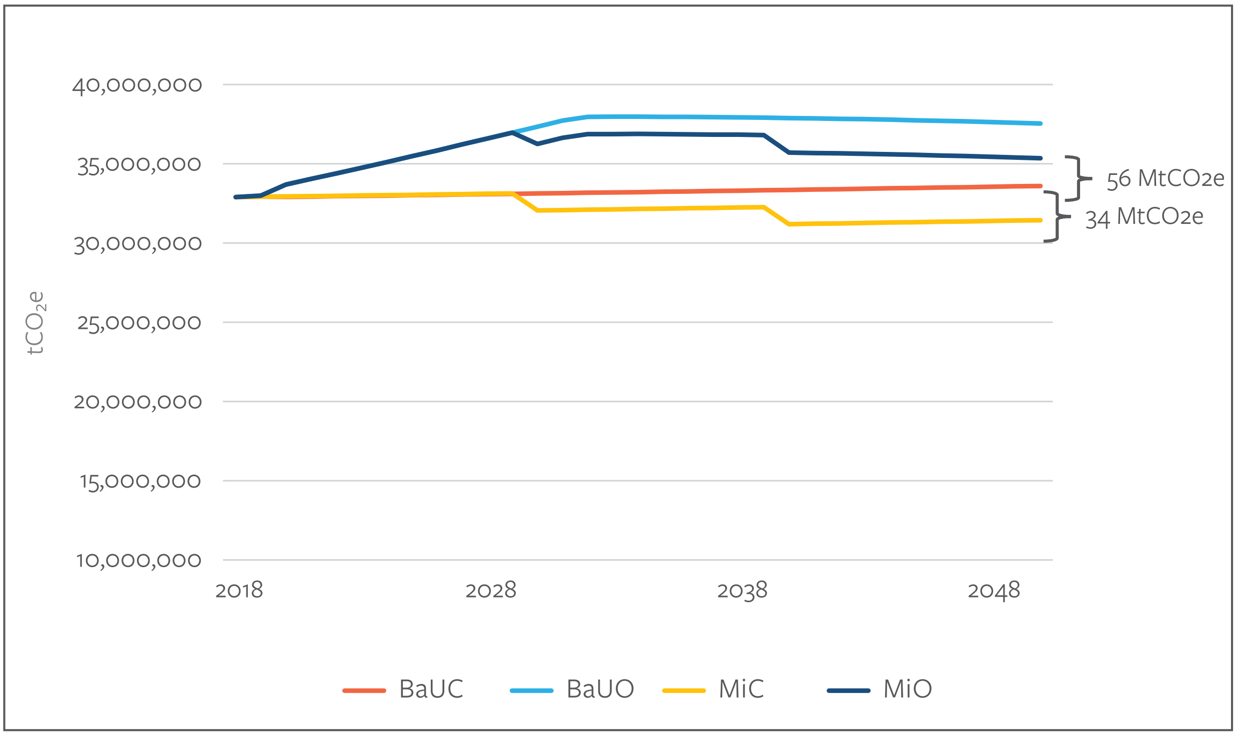


FIGURE 3.26 Projected emissions for the industry sector by scenario

The industry sector shows slightly different results, with the most important difference being that economic growth is not correlated with the increase in emissions, since the distribution of sectoral GDP also comes into account. The optimistic scenario projects 2050 being dominated by the service sector, as in the case of the most developed economies in the world. Therefore, despite a notable increase in GDP, the increase in emissions in this sector would be more moderate.

Nevertheless, the industrial sector would remain the largest emitter in the country. The cumulative GHG emissions reduction projected for this sector in the Conservative scenarios accounts for 32 percent (34 MtCO2e) and, in the Optimistic scenarios 56 percent (56 MtCO2e).

The projections for the industry sector are illustrated in **FIGURE 3.26**. This sector is not only the one with highest emissions, but also the sector in which the highest reductions are to be achieved. The decreasing projection in emissions in the mitigation scenarios is clear, as well as the reduction achieved in both scenarios. It must be acknowledged, however, that the mitigation potential would be mainly due to carbon sequestration measures.

The transport sector projects the highest growth in emission under optimistic scenarios (**TABLE 3.30**) compared to the power generation and the industry

TABLE 3.30 Comparison of the emissions of the transport sector by scenario

Total (tCO_2e)	2018	2030	2040	2050	∆ 2018–2030	∆ 2018–2050
Conservative BaU (BaUC)	2,687,832	2,891,386	2,944,446	2,998,930	8%	12%
Optimistic BaU (BaUO)	2,687,832	3,474,927	4,146,018	4,947,193	29%	84%
Conservative Mitigation (MiC)	2,687,832	2,524,681	2,577,740	2,632,224	–6%	–2%
Optimistic Mitigation (MiO)	2,687,832	3,108,222	3,779,312	4,580,487	16%	70%

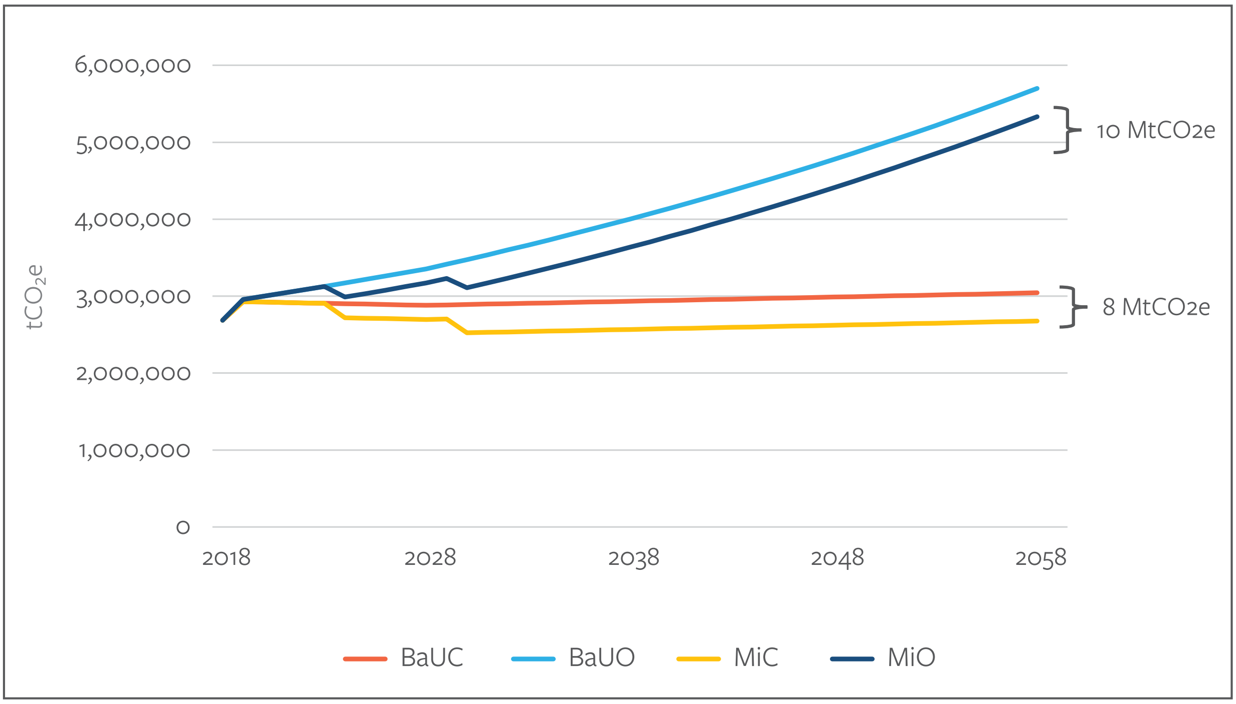


FIGURE 3.27 Projected emissions for the transport sector by scenario

sectors, largely due to assumptions for the transport sector based on a high correlation to GDP, and by the lack of adequate details on the GHG Inventory for a more detailed approach. There remains, therefore, some level of uncertainty.

Nevertheless, emissions reductions in the sector can be achieved by 2050. **FIGURE 3.27** provides an illustration of the emissions projections and cumulative reductions achieved in the transport sector.

Mitigation measures reduce 8 MtCO2e in the Conservative scenario and 10 MtCO2e in the Optimistic scenario or an average of eight percent of the total reductions in both scenarios.

The emissions projections in the waste and wastewater sector is mainly explained by the expected disposal of solid waste in landfills. Under BaU scenarios, emissions increase is linked to economic and demographic growth. However, emissions decrease in Mitigation scenarios because these scenarios consider the reduction of solid waste in landfills, which is the most influential variable (**TABLE 3.31**).

In almost all scenarios, the emissions decrease between 2018 and 2030 is characterised by the gradual reduction of methane generated in landfills by methane recovery measures and landfill improvements, but which in subsequent years is palliated by

TABLE 3.31 Comparison of the emissions of the waste and wastewater sector by scenario

Total (tCO_2e)	2018	2030	2040	2050	Δ 2018–2030	Δ 2018–2050
Conservative BaU (BaUC)	2,460,045	2,453,448	2,511,858	2,567,020	0%	4%
Optimistic BaU (BaUO)	2,460,045	2,617,612	2,977,326	3,416,296	6%	39%
Conservative Mitigation (MiC)	2,460,045	1,753,448	1,719,485	1,745,845	−29%	−29%
Optimistic Mitigation (MiO)	2,460,045	1,915,191	2,161,389	2,555,338	−22%	4%

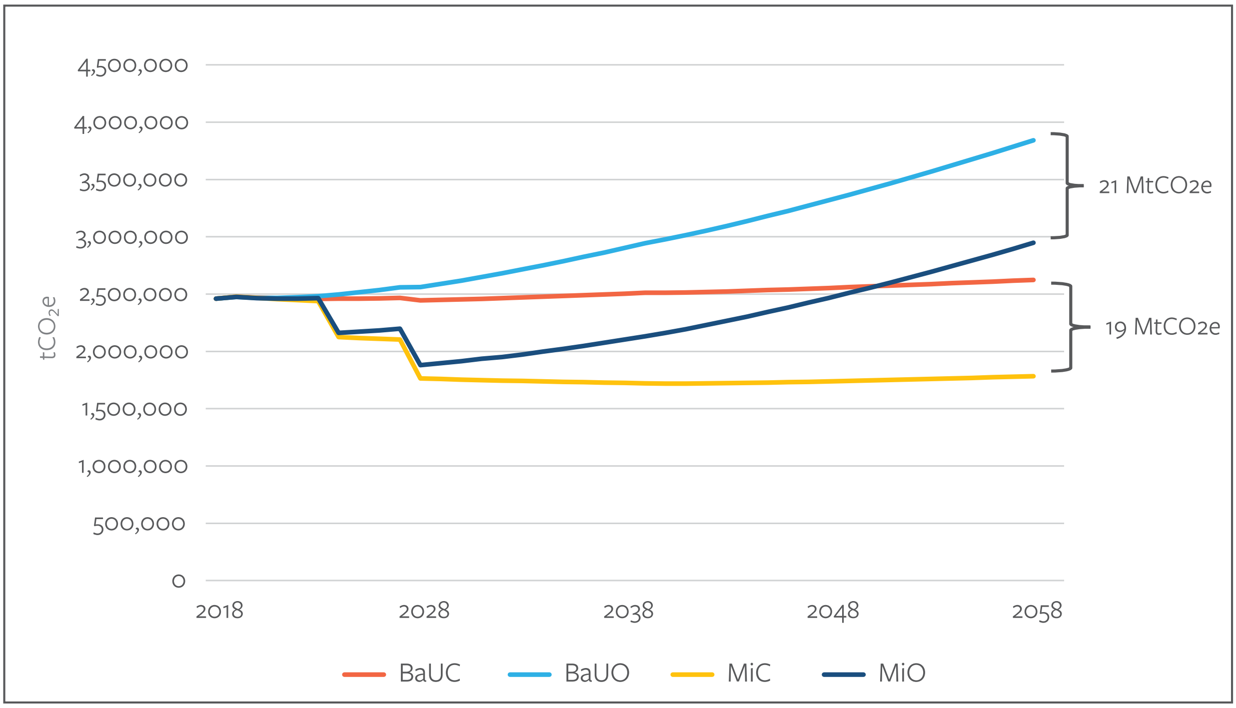


FIGURE 3.28 **Projected emissions for the waste and wastewater sector by scenario**

the increase in economic activity.

The cumulative GHG emissions reduction projected for this sector is 17 percent in the Conservative scenarios (19 MtCO2e) and 18 percent in the Optimistic scenarios (21 MtCO2e). (**FIGURE 3.28**).

The AFOLU sector contributes the least to the total emissions projections and total emissions reductions, mainly because the net balance of emissions and removals in the sector is negative. This means that more CO2 is absorbed than is generated.

The AFOLU sector projects a relatively high growth in terms of the net balance. Removals will continue

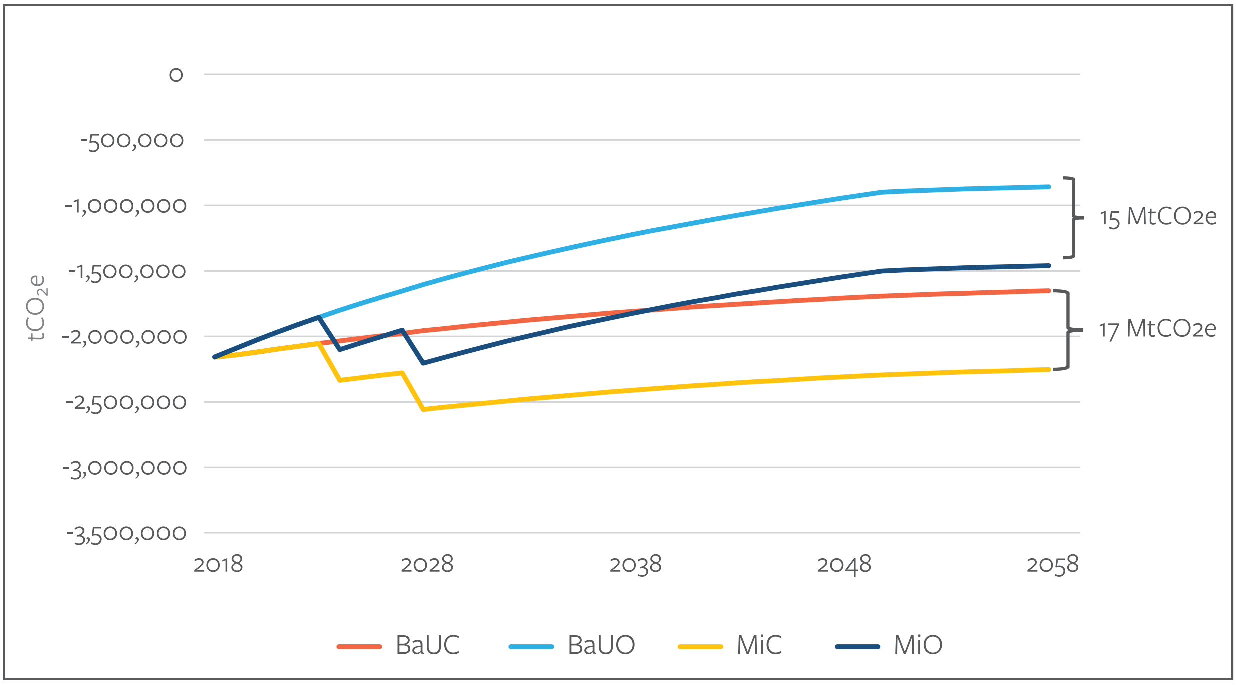


FIGURE 3.29 **Projected emissions for the AFOLU sector by scenario**

TABLE 3.32 Comparison of the emissions of the AFOLU sector by scenario

Total (tCO_2e)	2018	2030	2040	2050	Δ 2018–2030	Δ 2018–2050
Conservative BaU (BaUC)	–2,158,521	–1,923,426	–1,786,287	–1,693,524	11%	22%
Optimistic BaU (BaUO)	–2,158,521	–1,516,551	–1,162,360	–899,014	30%	58%
Conservative Mitigation (MiC)	–2,158,521	–2,525,007	–2,387,868	–2,295,105	–17%	–6%
Optimistic Mitigation (MiO)	–2,158,521	–2,118,132	–1,763,941	–1,500,595	2%	30%

to exceed emissions but negative balance will be reduced quite significantly (**TABLE 3.32**).

Cumulative emissions reductions during the period project 15 MtCO2e in the Conservative scenario and 17 MtCO2e in the Optimistic scenario.

3.6 Gender approach for identified measures

The importance of integrating gender into climate action is based on evidence that the empowerment of women and gender equality advancements can generate positive results in a variety of sectors, including food and economic security and health, while increasing resilience in vulnerable groups. It can also lead to more environmentally friendly decision-making at the domestic and national levels. The global consensus has also recognised that mainstreaming women's rights and gender equality into climate change mitigation and adaptation activities is not only essential, but maximises the effectiveness of interventions, programmes and resources (International Union for Conservation of Nature, 2015).

In order to assess how gender issues can be mainstreamed in the design of climate action, an overview of the main socio-economic issues focused on gender in the prioritised sectors, identified some key challenges faced by women in the context of climate change and climate change mitigation, and for which a gap analysis was conducted. Subsequently, guidelines were provided to integrate gender during the implementation of such measures including specific indicators.

The current approach therefore seeks to define mitigation measures that do not reinforce existing gender inequalities, but rather contribute to correcting existing gender inequalities and become gender-sensitive mitigation actions[9].

Gender gaps by sector

In all societies, women and men have different roles, responsibilities, needs and knowledge that are socially assigned. These differences must be fully understood to integrate them into effective measures to address climate change. **TABLE 3.33** analyses the roles of men and women and their relationship to climate change in each of the sectors prioritised for climate change mitigation.

For each sector, information was identified to understand the disparity between the status or position of men and women. As is recommended by UN Women, these differences have been identified in dimensions that cut across all sectors, such as economic participation and opportunity, access to education, health and life expectancy, and political empowerment (UN Women, n.d.).

For the gap analysis, priority was given to information of a local nature, where available. In the absence of such information, data from the Caribbean region were included as a proxy, and therefore represent

9 According to Trinidad and Tobago's National Policy on Gender and Development, gender sensitivity refers to being conscious of the different situations, needs, perceptions and priorities of women and men throughout the policy-making, planning and programme delivery process. It entails the ability to recognise the differences in women's and men's needs and interests arising from their different gender roles and social positions.

TABLE 3.33 Gender gaps

Sector	Main gaps
Power Generation	» Historically, energy policies and projects have not been designed with due consideration of the gender perspective (Snyder et al., 2018). » Women are under-represented in the energy industry workforce, in decision-making positions in the field of energy and are rarely considered as key stakeholders for energy initiatives. » Women and men have differentiated access to energy sources, consumption, and use. For men, energy consumption and production are mainly related to productive activities while for women, in addition to productive activities, it is related to the performance of household chores due to traditional gender roles (IDB, 2018). » The transversal between energy and gender means that the responsibilities of finding alternative energy sources and tackling energy poverty, particularly in rural areas, fall mainly on women (IDB, 2018). » The lack of safe cooking fuels and technologies poses serious health risks (acute respiratory diseases, lung cancer, pregnancy complications) to women and children who are the main procurers and users of household energy, especially in rural areas (UN Women, 2019). » Women rely on various electrical appliances and equipment to save time and reduce workload in the household (United Nations Development Programme NDC Support Programme, 2019).
Industry	» In the LAC region, men are far more likely than women to have formal employment in better paying industries such as high tech, construction, utilities, and transportation (The World Bank, 2020a). In T&T, women employed in industries represent only 12.5% of female employment in 2019 (The World Bank, 2020b). » There is a lack of representation of women in the industry sector and gender bias limits women's ability to reach decision-making positions (UNDP NDC Support Program, 2019). » Social and cultural perceptions of male and female roles perpetuate women's traditional activities in the domestic sphere. » Caribbean female entrepreneurs face many challenges related to their intra-household responsibilities in the care economy and to other obstacles linked to finance and education (Economic Commission for Latin America and the Caribbean [ECLAC], 2018) » Women are often excluded from the financial system, not having a bank account, and have less knowledge and awareness of financial products and services, including in rural areas (ECLAC, 2018).
Transport	» Women tend to rely on public transport more than men. However, women and girls have greater safety concerns about using public transportation, especially regarding sexual harassment (Ministry of Planning and Development, 2017). » Violence against women and girls in transport and public spaces related to transport has a negative impact on their access to education, economic opportunities and healthcare, leading to an increase in gender inequality (Granada et al., 2016). » LGBTQ+ commuters, particularly trans women or effeminate men, are at risk of assault and harassment when taking public transportation (UNDP NDC Support Program, 2019). » Transport and infrastructure sectors are predominantly male. At a regional level, women represent less than 15 percent of the total number of employees in the transport sector (IDB, 2020).
Waste, water and wastewater	» In communities where women and children still need to fetch water, water scarcity can affect school attendance, lead to absenteeism from work and leave them exposed to the risk of physical and sexual violence (Caribbean Development Bank [CDB], 2018) » Within the water sector in the Caribbean region, women have limited access to job opportunities in the water sector. There is a high proportion of males in jobs in management, construction, and maintenance. Women continue to be employed mainly in administrative functions within this sector (CDB, 2018). » In LAC, the integration of the gender perspective is very limited in waste management public policies (UN Environment, 2018) » In waste management sectors, there is a prevalence of men in prominent decision-making positions (UN Environment, 2018).

TABLE 3.33 (CONTINUED) Gender gaps

Sector	Main gaps
AFOLU	» Caribbean women have limited access to and control over the means of production, land, and credit. Women in agriculture thus face issues including limited land ownership, lack of security of tenure and poor access to financial assistance, agricultural incentives, and education and training (Office of the Prime Minister, 2018). » In the Caribbean, women lack legal titles to land and ownership of agricultural properties, and their contributions to family farming are often not recognised since the "principal farmers" are predominantly male (Food and Agriculture Organization [FAO] & CDB, 2019). Overall in T&T in 2004, 85.3 percent of all private landholders were male, while 14.7 percent were female (FAO, 2020). » In addition, women tend to receive fewer business loans than men, and smaller values, despite their stronger track record of loan repayment. Obstacles to accessing credit include the lack of access to collateral, such as land (FAO & CDB, 2019). » With limited access to and control of resources, women have more difficulties accessing training, improved technology, market information, and agricultural inputs, such as fertiliser and irrigation to improve production (FAO & CDB, 2019). » In T&T, women employed in agriculture represent 1.3 percent of female employment in 2019 (The World Bank, 2020b).

general descriptions which may or may not apply in the national context unless where specified (**TABLE 3.33**). It should be noted that one of the limitations observed for this analysis is that there is little or no local information disaggregated by gender. With more data, the gaps identified in **TABLE 3.33** are therefore generalisations and may change and be updated in future reports.

Suggested Gender Indicators for the Identified Measures

Based on the identified gaps, a series of indicators are proposed for consideration in each measure to mainstream gender and for closing identified gaps in the proposed measures. Although the gaps identified are general and may not be specific to Trinidad and Tobago, the indicators will be used in future reporting.

The Argyle ▶ Waterfall is the highest waterfall in Tobago, tumbling 54 metres into a deep pool, 2011

Photo Credit: Tobago House of Assembly

TABLE 3.34 Suggested gender indicators for the potential measures for all sectors (quantified)

Sector	Action line	Code	Purpose	Measure	Gender indicators
Power Generation	Education/ Awareness-raising	**P.G.1**	Awareness	Conservation Education through Curriculum and Culture	» Percentage of students enrolled and attending primary and secondary school, by gender
		P.G.8		Increased customer engagement	» Percentage of women and men participants at workshops » Number of specific knowledge material developed on gender » Number of gender references in information/knowledge material produced
	Renewable energies	**P.G.9**	Action	Use of solar power for water treatment plants	» Number of additional jobs for women and men in sustainable energy sector
		P.G.2		Renewable Energy and Direct Electricity Replacement (REDER) Campus Initiative	» Number of women and men with access to sustainable energy technologies » Number of additional jobs for women and men in sustainable energy sector » Percentage of women and men working in pilot facilities » Equal opportunities for women-owned business
		P.G.5		Cooperative RE	» Number of additional jobs for women and men in sustainable energy sector » Number of women and men with access to sustainable energy technologies » Number of new/improved sustainable energy technologies for women and men
		P.G.6		Increased penetration of Utility Scale RE	» Number of additional jobs for women and men in sustainable energy sector » Number of women and men with access to sustainable energy technologies » Number of new/improved sustainable energy technologies for women and men
	Green Building	**P.G.3**	Awareness	Green Building Awareness and Incentive Programme	» Percentage of women and men participants at training sessions » Percentage of women and men trained on new technologies » Number of workshops that include dedicated gender sessions » Percentage of time dedicated to gender aspects of RE and EE potentials and benefits for each awareness-raising effort » Number of gender-specific recommendations concluded from research
	Energy efficiency	**P.G.4**	Action	Supply Side Management Generation Dispatch	» Percentage of female and male professionals, engineers, or technicians for targeted sectors » Percentage of women and men trained in new technologies

TABLE 3.34 (CONTINUED) Suggested gender indicators for the potential measures for all sectors (quantified)

Sector	Action line	Code	Purpose	Measure	Gender indicators
Power Generation	Energy efficiency	**P.G.7**	Action	Energy Efficient Appliance Programme	» Percentage of female and male participants at workshops » Percentage of time dedicated to gender aspects of EE potentials and benefits for each awareness-raising effort » Number of events that include dedicated gender sessions
Industry	Renewable energies	**I.1**	Action	Renewable fuels	» Number of additional jobs for women and men in sustainable energy sector » Number of new enterprises owned and/or managed by women and men using sustainable energy » Percentage of women-owned and men-owned businesses newly engaged in RE and EE
		I.2		Captured Carbon Industry	» Number of additional jobs for women and men in captured carbon sector » Number of new enterprises owned and/or managed by women and men using captured carbon technologies » Percentage of women-owned and men-owned businesses newly engaged in captured carbon technologies » Percentage of women and men professionals, engineers, technicians in targeted sectors
Transport	Public transport and road network	**T.3**	Action	Introduction of park-and-ride system pilot	» Number of passengers in public transport during peak and off-peak hours, gender-disaggregated
		T.5		Transit Service Improvements	» Public transport accessibility assessment, according to sex and number of children » Number of training sessions on gender and transport, including gender sensitive planning; facilitation of stakeholder consultation; participation for implementing agencies and/or community organisations » Percentage of increased work opportunities for women within a transport project » Number of passengers in public transport during peak and off-peak hours, gender-disaggregated » Percentage of increased use of public transport services by women in terms of number of trips made » Percentage of increased (perception of) security using public transport

TABLE 3.34 (CONTINUED) Suggested gender indicators for the potential measures for all sectors (quantified)

Sector	Action line	Code	Purpose	Measure	Gender indicators
Transport	Incentives and disincentives for private modes of transport	**T.1**	Policy	Compact land use policies and mixing of land uses	» Percentage of land committee members who are women » Percentage of reduced transport-related expenses by gender » Average travel time to formal and informal places of work, by gender and by mode of transport » Percentage of reduction in traveling time to access health services
		T.2		Pay-as-you-drive auto insurance	» Changes in women's travel patterns and transport mode use as a result of project
		T.4		Parking pricing and parking supply management	» Number of meetings using participatory concepts and methodologies to ensure that the planning, implementation, supervision and monitoring of the project will involve and benefit women and men equally
Waste and wastewater	Solid Waste	**W.W.1**	Action and Awareness	Waste Reduction and Diversion	» Number of gender impact assessments » Percentage of women in policymaking organs/structures » Percentage of female and male professionals, engineers, or technicians for targeted sectors
		W.W.2	Action	Segregation of solid organic waste for material recovery in composting plants	» Percentage of female representation among multi-stakeholders » Number of female participants in research projects » Percentage of female and male professionals, engineers, or technicians for targeted sectors
	Wastewater	**W.W.3**		Installation of anaerobic sludge digesters at Water Treatment Plants to capture and burn methane	» Percentage of female representation among multi-stakeholders » Percentage of female and male professionals, engineers, or technicians for targeted sectors
		W.W.4		Use of treated wastewater	» Number of female participants in research projects » Percentage of project beneficiaries who are female
Waste and wastewater	Agricultural residues	**W.W.5**		Urgent development of responsible disposal of end-of-life wood products	» Percentage of female and male participants at workshops

TABLE 3.34 (CONTINUED) Suggested gender indicators for the potential measures for all sectors (quantified)

Sector	Action line	Code	Purpose	Measure	Gender indicators
AFOLU	Urban Greening	**A.1**	Action	Urban Greening Activities	» Percentage of project beneficiaries who are female
	Forest	**A.2**	Action	Reforestation, Rehabilitation of degraded forested lands and Improved Catchment Management	» Percentage of project beneficiaries who are female
		A.5		Forest Management and Protection	» Number of measures to mainstream gender in interventions » Percentage of female representation among multi-stakeholders
		A.3	Knowledge	Reduction, control and monitoring of Agri-chemical application by farmers	» Percentage of women trained in correct agri-chemicals application
		A.4	Action	Halting of Biomass burning—especially agricultural burning	» Percentage of trained women on recycling or processing of agricultural waste
		A.6	Knowledge	Biochar production and application	» Percentage of trained women in biochar production and application » Percentage of project beneficiaries who are female

TABLE 3.35 Suggested gender indicators for the potential measures for all sectors (non-quantified)

Code	Purpose	Measure	Gender indicators
N.Q.1	Knowledge	Electricity Usage Behavioural Research	» Number of women and men participants in the surveys » Number of specific knowledge material developed on gender » Number of gender references in information/ knowledge material produced
N.Q.2	Policy	Economic instruments to foster carbon reductions	» Percentage of policy decisions in which associations focusing on gender equality and women's empowerment have been consulted » Number of impact assessments » Number of gender-specific recommendations for mitigating impact of policy decisions on women » Number of gender-specific targets included in energy policy
N.Q.3	Knowledge	Agriculture and Technology—Vertical Farming	» Percentage of project beneficiaries who are female
N.Q.4		Land Use Planning & Anticipatory Action to bolster Adaptation and Resilience	» Number of measures to mainstream gender in interventions » Percentage of female representation among multi-stakeholders
N.Q.5		Development of a National Climate Smart Agricultural (CSA) approach	» Number of gender impact assessments » Percentage of policy decisions in which female workers have been consulted » Number of gender specific goals/ targets included in policy » Percentage of women trained in new technologies and practices » Number of technical guidelines on gender mainstreaming » Number of specific measures undertaken to support women entrepreneurs and women-owned or managed businesses » Percentage of women and men trained in CSA approach
N.Q.6		Livestock—feeding and long-term management, breeding	» Percentage of women trained in livestock best practices

Based on the analysis, the proposed indicators to be incorporated into the implementation of the measures will be improved once the measures are more precisely defined. This would then facilitate a more detailed analysis of relevant gender aspects and be updated in future reports.

3.7 Financing opportunities

Introduction

Climate finance is required for funding climate action. While there is no universally accepted definition of climate finance, the Standing Committee on Finance (SCF) of the United Nations Framework Convention on Climate Change (UNFCCC) defines climate finance as "local, national or transnational financing—drawn from public, private and alternative sources of financing—that seeks to support mitigation and adaptation actions that will address climate change" (United Nations Climate Change, n.d.).

According to Article 4.3 of the UNFCCC, developed countries (Annex II parties) shall provide the financial resources to cover the costs incurred by developing countries (non-Annex I parties) in implementing the Convention (United Nations, 1992). Therefore, the Convention founded a financial mechanism

TABLE 3.36 Global public and private climate finance flows averaged across 2017 and 2018 | *Source: Based on Climate Policy Initiative, 2019b*[1]

Source	Examples	Channel	Amount (billion USD)
Private sector ▼			**325 (56%)**
Corporations		Debt, equity	183 (31.5%)
Households		Debt	55 (9.5%)
Commercial financial institutions		Debt	73 (12.5%)
Institutional investors		Debt, equity	9(1.5%)
Private equity		Debt, equity	5 (1%)
Public sector ▼			**252 (44%)**
Multilateral DFI	IDB, CDB, CAF, IFAD, EIB, WBG	Debt	57 (10%)
Bilateral DFI	KfW (Germany), AFD, CDC, DFID, JICA	Debt	23 (4%)
National DFI	(there is none in Trinidad and Tobago)	Debt	132 (23%)
Governments and their agencies	AECID, BMZ/GIZ	Grants	37 (6%)
National and multilateral climate funds	**UNFCCC:** GEF, GCF, AF, SCCF, LCDF **UN agencies:** UN REDD **Non-UNFCCC:** CDF, EDF, GCCA+, IKI, FCPF, Biocarbon Fund, PMR, CIF, Nama Facility, REM, GCPF, ICF, NICFI **National funds:** Green Fund	Grants	3 (1%)
(1 billion unknown) **Total**			**578**

1 **Private sector:** Investment in renewable energy, solar water heating systems, electric vehicles and infrastructure projects in water, waste, municipal infrastructure and low-carbon transport from IJ Global and Climate Bonds Initiative datasets.
Institutional investors: Insurance companies, asset management firms, pension funds etc.
Public sector: Finance carried out by central, state or local governments and their agencies.
Multilateral DFI: Institution has multiple shareholder countries.
Bilateral DFI: Single country owns the institution and it directs finance flows internationally.
National DFI: Single country owns the institution and finance is directed domestically.
Governments and their agencies: Bilateral development finance.
National and multilateral climate funds: Commitments from a DFI's own resources.

(Article 11) which is put into practice by five funds[10], the biggest two of them (accounting for over 80% of the finance [Climate Policy Initiative, 2019a]) being the Global Environmental Facility (GEF) established in 1992, and the Green Climate Fund (GCF) established in 2010. According to the Cancun Agreement (2010), developed countries will pledge 100 billion USD of climate finance per year by 2020. In 2025, a new collective, more ambitious goal will be set (United Nations Climate Change, n.d.).

Yet, these funds are not enough to finance the transition towards low-carbon climate-resilient economies. In fact, national investments by national Development Finance Institutions (DFI) and private sector involvement contribute much more to reaching the goals of the Paris Agreement (**TABLE 3.36**).

- Total global climate finance in 2017/2018 amounted to almost 600 billion USD.
- Public climate finance, mostly from national

10 GEF, GCF, Adaptation Fund (AF), Least Developed Country Fund (LDCF), Special Climate Change Fund (SCCF)

DFIs, was spent on low-carbon transport (37% of the public total) and renewable energy (23%), whereas, private climate finance predominantly benefitted renewable energies (85% of the private total) and low-carbon transport (14%). Therefore, 93% of all climate finance contributed to mitigation.
- Adaptation climate finance increased to 30 billion USD in 2017/2018, just 5 percent of the global overall spending. Thirty percent of adaptation finance benefitted water and sanitation, 23 percent agriculture, forestry, land-use, and 23 percent disaster risk management.
- Market-rate debt channelled most climate finance in 2017/2018 (316 billion USD).
- East Asia and the Pacific remained the largest receiver region of climate finance, accounting for 41 percent of the total. Sixty-one percent of climate finance was destined to countries which were not part of the Organisation for Economic Cooperation and Development.

Yet, current public and private climate finance is not enough to mobilise resources to undertake measures to maintain global temperature rise below 1.5 °C by the end of the century (Climate Policy Initiative, 2019a). The IPCC estimates of required investments in the energy sector alone are in the order of trillions annually between 2016 and 2050 (de Coninck et al., 2018). Therefore,

- governments should continue to allocate resources to their national climate action plans;
- governments, financial institutions and capital markets should align loan portfolios and investments with the aims of the Paris Agreement and shift toward green finance;
- all actors should increasingly invest in adaptation;
- the end purpose of finance must diversify and reach sectors other than renewable energy, particularly energy efficiency, adaptation and land use; and
- all actors involved should provide more, and uniform data on climate finance, also to avoid double-counting (UNFCCC Standing Committee on Finance, 2018).

Outlook

Trinidad and Tobago is eligible for several sources of climate finance and is already taking advantage of some of these. Trinidad and Tobago's main challenge in accessing climate finance is its high GNI. Therefore, the country is not classified as a developing country according to the OECD, which limits its eligibility for financial products from multilateral DFIs such as the World Bank, and for ODA, as with most non-UN climate funds, funding from bilateral DFIs, governments and their agencies are disbursed. The climate finance sources the country currently does make use of cover mostly the energy sector for mitigation, and the transport, water and sanitation, agriculture and fisheries sectors and disaster risk management for adaptation.

Below are the main specifications of the financing opportunities available to the country.

Multilateral DFI

- With regard to loans from DFIs, one of the country's most important lenders is the Inter-American Development Bank (IDB). In fact, for 2020, five percent of the PSIP (about 39 million USD) was targeted to be financed from IDB loans, particularly in the water and sanitation sector.
- Another important DFI is the Development Bank of Latin America (CAF), which recently lent 200 million USD for transport infrastructure.
- A third DFI active in Trinidad and Tobago is the Caribbean Development Bank (CDB), which will support the country's efforts on infrastructure and transport according to the PSIP, although the scale of investment is unknown.
- Moreover, the three DFIs provide expertise on partnerships with the private sector—the largest climate finance source—in the infrastructure sector and others such as tourism, agriculture/fishery, housing and finance.

- The only DFI that Trinidad and Tobago is not taking advantage of (according to public record) is the International Fund for Agricultural Development (IFAD). If adaptation in agriculture is to be a priority of the country's climate action, accessing its grants and concessional loans should be considered.

National and multilateral climate funds (UN)
Trinidad and Tobago has access to all of the UN funds and programmes mentioned in previous chapters. The country is already taking advantage of most of these.

- The Ministry of Planning and Development has been designated the country's National Designated Authority (NDA) and is receiving readiness support to assist a number of initiatives including the strengthening of the NDA, improving the monitoring system for climate change impacts on the agriculture sector, and building climate resilience into the healthcare system. Assistance is also being received to support the accreditation of the Environmental Management Authority (EMA).
- Whereas the GCF supports adaptation as well as mitigation measures, the GEF Trust Fund is more focused on mitigation and is one of few multilateral climate funds which explicitly support projects in the waste sector. Trinidad and Tobago has a long-standing record implementing regional and national GEF projects and small grants from the SGP. The last GEF Trust Fund project on climate change in Trinidad and Tobago was from the energy sector. The country's designated Operational Focal Point (OFP) for liaising with the GEF is the EMA.
- An additional, yet so far untapped, opportunity to enhance the country's mitigation efforts is the UN REDD programme. If mitigation in the forestry sector were to be a priority of the country's climate action, accessing the programme's support would be an important consideration.
- Regarding adaptation, there is one project on record for the SIDS-focused SCCF, namely on fisheries.
- A funding project proposal is being developed for the Adaptation Fund (AF) to address flooding in a vulnerable part of the country.
- Funding is being sought under the CBIT to enhance the existing MRV system to incorporate the transparency provisions of the Paris Agreement, which will also consider:
  - monitoring the relationship between input (investment) and output (impact) which contributes to increasing the effectiveness and efficiency of climate finance;
  - monitoring emissions and thereby laying the founding stone for emissions trading and access to carbon markets, which in turn provide additional climate finance.

National and multilateral climate funds (non-UN)

- Largely because of the classification by the OECD of Trinidad and Tobago as a developed country, it is not eligible for ODA and thus, not eligible for most multilateral non-UN climate funds.
- An exception is the CDF, which during its current second cycle also funds projects in more developed countries e.g. on sustainable energy and infrastructure. In order to receive funding from the CDF, Trinidad and Tobago would have to design a Country Assistance Programme (CAP). This process would have to be initiated by Trinidad and Tobago's CARICOM National Focal Point (NFP), the Ministry of Foreign and CARICOM Affairs.
- Along with the IDB and the CDB, the EDF is one of three external financial sources mentioned in Trinidad and Tobago's PSIP. Over 2020–2022, the EDF will contribute 9 million EUR to climate action.
- Unfortunately, public information on climate finance sources, spending and eligibility criteria

Photo Credit: Tobago House of Assembly

▲ A young hawksbill sea turtle (*Eretmochelys imbricata*) at rest among coral and sponges, Tobago, 2010

▼ Wetlands , Lowlands, Tobago, 2017

Photo Credit: Tobago House of Assembly

is neither complete nor coherent. The EDF, IKI and GCCA+ generally prescribe ODA-eligibility; nevertheless, there are 13 EDF projects, four IKI projects and one GCCA+ project on record for Trinidad and Tobago (with similar results for Barbados, Bahamas and St. Kitts and Nevis). The findings demonstrate how important inter-governmental relationships and Trinidad and Tobago's participation in the UNFCCC negotiations are for the country's access to climate finance (see also GCCA+'s project eligibility criteria).

In-house Public Climate Finance

The Government of the Republic of Trinidad and Tobago also takes on a leading role when it comes to climate finance. In 2020, the country will spend 5.3 billion TTD, equivalent to 800 million USD, on public programmes and projects, many of which have the potential to benefit mitigation and adaptation efforts.

- Funding Theme V of Vision 2030 (Placing the Environment at the Centre of Social and Economic Development) will augment national climate finance.
- Mainstreaming climate change across sectoral plans and strategies beyond Theme V will benefit climate action without assigning additional resources or necessitating significant capital injection. A financial investment plan is being developed to strategise the integration of climate risks into sectoral plans and strategies.
- Climate-proofing public investments right from the pre-investment phase guarantees the sustainability of goods and services in the long run and reduces the country's loss and damage record which consumes precious public (climate) finance resources.
- The national Green Fund, aimed at financing environmental projects of eligible entities (non-governmental organisations and statutory agencies), which is capitalised by a 0.3 percent levy from all business profits is also a domestic source of financing for climate-related projects.

On the global level, over half of climate finance is mobilised by the private sector, i.e. corporations, households, commercial financial institutions, investors and equity. The public sector takes on a leading role in engaging the private sector to provide and receive climate finance, from promoting PPPs, to collaborating with commercial banks, to reducing legal and financial barriers for private investments. Good examples are Trinidad and Tobago Electricity Commission (T&TEC) and Regulated Industries Commission (RIC) Acts which are targeted for amendment in order to promote the deployment and uptake of renewable energies.

Ways of leveraging support for private sector involvement include the following:

- Engaging IDB Invest and IDB Lab, which are institutions focused on the private sector.
- Engaging CAF, CDB and the GCF which can act as guarantees for public sector loans from private institutions. One of the GCF's explicit aims is to mobilise additional resources from the private sector and reduce market barriers.
- The CDF's CAPs, which are elaborated between the public and private sector and thereby explicitly engage the private sector.
- Scotiabank and Citigroup, which finance public sector projects and are working on green bonds.
- IRENA and SEforALL which specialise in facilitating project development, match-making between investors and the public sector, and attracting funding in the energy sector.

A summary of the used and unused public sector climate finance sources available to the country and their prioritised sectors with reference to recent projects is provided in **TABLE 3.37**. Untapped sources (IFAD, REDD, CDF) are marked in grey. The letters in the cells make reference to active/very recent activities explained in the notes at the bottom of the table.

TABLE 3.37 Summary of available public sector climate finance sources and their prioritised sectors with reference to active/very recent activities

Source	Energy	Coastal Infrastruc.	Transport	Buildings	Water	Information	Mainstreaming	Ecosystem, biodiversity	Agro/ fishery	Tourism	DRM	Waste	Forestry	Private sector
Multilateral DFI														
IDB					A						B			C
CAF			D											E
CDB			F											G
IFAD														
EIB														
National and multilateral climate funds (UN)														
GCFH														
GEF	I													
REDD														
SCCF									J					
AF		B			B				B					
CBIT						B								
National and multilateral climate funds (non-UN)														
CDF														
EDF	K								L					
GCCA+	M													
IKI	N										O			
Green Fund														
Other public sector climate finance sources														
CCRIF											O			
PSIP														P
Market mec.	Q													
Com. banks														
IRENA														
SEforALL														
IICA									R					

KEY FOR TABLE 3.37

A. According to the PSIP, IDB will finance the Multi Phase Wastewater Rehabilitation Programme and the Wastewater Network Expansion Seamless Education System Project.

B. "Preparing You!"

C. Tourism, fisheries, infrastructure, housing, agriculture, water, finance.

D. A USD 200 million loan for developing transport infrastructure was disbursed in 2019.

E. Infrastructure, agriculture, finance.

F. CDB supports Theme III of Vision 2030 "Improving Productivity through Quality Infrastructure and Transportation" in 2020.

G. Training of public sector staff on PPP is foreseen, including on screening the project pipeline and identifying next steps in the development of higher priority projects.
Training on PPP for infrastructure projects was provided before. SME development in agriculture and tourism was supported according to the PSIP.

H. Trinidad and Tobago received readiness support to later apply for full-scale projects.

I. "Energy Efficiency through the Development of Low-carbon RAC Technologies in Trinidad and Tobago".

J. "Climate Change Adaptation in the Eastern Caribbean Fisheries Sector".

K. "Technical Assistance Programme for Sustainable Energy in the Caribbean" (TAPSEC); PSIP: Renewable energy laboratory (2020, 5 million EUR).

L. Enhancing regional food security—Fisheries, Caribbean Natural Resources Institute (CANARI).

M. "Support to the implementation of Trinidad and Tobago's Nationally Determined Contribution".

N. "Support for IRENA's SIDS Lighthouses Initiative".

O. "Climate Risk Adaptation and Insurance in the Caribbean (CRAIC)"; CCRIF: Payouts were made in 2017, 2018 and 2019 worth nearly USD 10 million in total.

P. PPPs for infrastructure, sanitation, waste management, energy, housing.

Q. Petrotrin Oil Fields Associated Gas Recovery and Utilization PoA; CarbonSoft Open Source PoA, LED Lighting Distribution.

R. "Technical Cooperation for Replicable and Scalable Climate Resilient Agriculture in Trinidad and Tobago: Building on the Matelot Experience".

Photo Credit: Institute of Marine Affairs

▲ Fort King George, Scarborough, Tobago

Matching measures with most likely potential climate finance sources

Measures were proposed across sectors which were matched with potential climate finance sources (**TABLE 3.38**):

1. Power generation
2. Industry
3. Transport
4. Waste and wastewater
5. Agriculture, forestry and other land use (AFOLU)

The two DFI, IDB and EIB, as well as the four funds—GCF, GEF, IKI and the Green Fund—are the most likely potential sources as, in theory, they support a range of topics. In contrast, the UN-REDD programme, IICA and IFAD are more specific in their portfolios for potential climate finance sources, as they focus exclusively on forestry and agriculture, respectively. The CBIT was not included in the analysis as it supports the establishment of transparency frameworks for reporting the outcomes of measures.

TABLE 3.38 Measures and most likely potential climate finance sources

Measure			IDB	CAF	CDB	IFAD IICA	EIB	GCF	GEF	REDD	AF	CDF	EDF	GCCA+	IKI	Green Fund
Power generation	P.G.1 Conservation Education through Curriculum and Culture	Introduce conservation across the curriculum in Early Childhood Care and Education (ECCE), primary and secondary school systems.										■	■		■	■
Power generation	P.G.2 REDER campus Initiative	Renewable Energy and Direct Electricity Replacement (REDER) installations at ECCE, Primary and Secondary Schools	■	■	■		■	■	■			■	■		■	
Power generation	P.G.3. Green building awareness and incentive programme	Raise awareness on green building construction and Direct Electricity Replacement (DER) technologies such as solar water heating and daylighting systems and night air cooling systems.	■		■		■	■	■			■	■		■	■
Power generation	P.G.4. Supply side management: Generation dispatch	Supply side management refers to optimising the efficiency of electric power generation, transmission and distribution.	■		■		■	■	■			■	■		■	
Power generation	P.G.5. Cooperative renewable energy	Small to medium scale renewable energy installations with private investment from localised communities	■	■	■		■	■	■			■	■		■	
Power generation	P.G.6. Increased penetration of grid- scale renewable energy	Designing and implementing utility scale renewable energy installations with appropriate storage capabilities	■	■	■		■	■	■			■	■		■	
Power generation	P.G.7. Energy Efficient Appliance Programme	Incentive programmes to encourage switching to higher efficiency appliances and devices	■		■		■	■	■			■	■		■	
Power generation	P.G.8. Increased customer engagement	Making electricity usage more transparent by increasing consumer interaction and increasing visual awareness around usage										■	■		■	■
Power generation	P.G.9. Use of solar power for water treatment plants	Use of solar power for water treatment plants e.g. use of floating solar panels in dams/reservoirs	■	■	■		■	■	■		■	■		■	■	

TABLE 3.38 (CONTINUED) Measures and most likely potential climate finance sources

Measure			IDB	CAF	CDB	IFAD IICA	EIB	GCF	GEF	REDD	AF	CDF	EDF	GCCA+	IKI	Green Fund
Industry/ Power gen.	I.1 Renewable fuels	Increase the usage of renewable fuels which have lower life cycle greenhouse gas (GHG) costs than their fossil fuel counterparts.	✓	✓	✓		✓	✓	✓			✓	✓		✓	
Industry	I.2. Captured carbon industry	Development of downstream industries for captured carbon to make carbon capture feasible		✓				✓							✓	
Transport	T.1 Compact land use policies and mixing of land uses	Reducing vehicle miles (kilometres) travelled by adopting planning policies towards the decentralisation of public offices mainly from the capital					✓	✓	✓				✓		✓	
Transport	T.2 Pay-as-you-drive auto insurance						✓	✓	✓				✓		✓	
Transport	T.3 Introduction of park-and-ride system pilot	Park remotely and safely, and travel by bus on priority lanes to Port of Spain from the East and South, and back	✓		✓		✓	✓	✓				✓		✓	✓
Transport	T.4 Parking pricing and parking supply management						✓	✓	✓				✓		✓	
Transport	T.5 Transit Service Improvements	To improve public transit services, and encourage transit use, including increased service area and frequency, increased transit speed and reliability	✓				✓	✓	✓				✓		✓	
Waste and Water	W.W.1 Waste Reduction and Diversion	Reduce the volume of waste that reaches the country's landfills.	✓	✓	✓		✓	✓	✓		✓			✓	✓	
Waste and Water	W.W.2 Segregation of solid organic waste for material recovery in composting plants	This measure consists of building composting plants for the recovery of solid organic waste.	✓	✓	✓		✓	✓	✓		✓			✓	✓	

TABLE 3.38 (CONTINUED) Measures and most likely potential climate finance sources

Sector	Measure	Description	IDB	CAF	CDB	IFAD IICA	EIB	GCF	GEF	REDD	AF	CDF	EDF	GCCA+	IKI	Green Fund
Waste and Wastewater	W.W.3 Installation of anaerobic sludge digesters at Water Treatment Plants to capture and burn methane	Installation of bio-digesters to treat the sludge so that the large amounts of methane generated by the sludge volumes can be reduced.	■	■	■		■	■	■		■			■	■	
Waste and Wastewater	W.W.4 Use of treated wastewater	This measure proposes the reuse of treated wastewater for irrigation of green areas or for agriculture or industrial use as process water.	■	■	■		■		■		■			■	■	
Waste and Wastewater	W.W.5 Urgent development of responsible disposal of end-of-life wood products						■	■	■					■	■	
AFOLU	A.1 Urban greening activities							■						■	■	
AFOLU	A.2 Rehabilitation of degraded forested land	Reforestation, improved catchment management and rehabilitation of degraded forested lands					■	■	■	■				■	■	■
AFOLU	A.3 Reduction, control and monitoring of agrichemical application by farmers					■		■	■					■	■	
AFOLU	A.4 Halting of biomass burning—especially agricultural burning					■		■						■	■	
AFOLU	A.5 Forest management and protection						■	■		■	■			■	■	■
AFOLU	A.6 Biochar production and application					■		■			■			■	■	

The following section accompanies the information in TABLE 3.38 and offers more detail on which strategies and priority areas of the climate finance sources relate to the measures outlined for the five sectors.

1. Power Generation

The measures related to power generation refer to four broad areas:

1. Education/Public awareness
2. Renewable energies
3. Green buildings
4. Energy efficiency

Four DFI and six funds appear to be particularly suitable to support these (TABLE 3.39).

2. Industry

The measures related to industry refer to three broad areas:

1. Fiscal incentives/ disincentives
2. Carbon capture industries
3. Renewable fuels

Two DFI and four funds appear to be particularly suitable to support these (TABLE 3.40).

3. Transport

The measures related to transport refer to two broad areas:

1. Public transport and road network
2. Incentives and disincentives for private modes of transport

Three DFI and five funds appear to be particularly suitable to support these (TABLE 3.41).

4. Waste and Wastewater

The measures related to waste and wastewater refer to three broad areas:

1. Wastewater
2. Solid waste
3. Education/public awareness/research/capacity development

Four DFI and six funds appear to be particularly suitable to support these (TABLE 3.42).

5. Agriculture, Forestry and Other Land Use (AFOLU)

The measures related to AFOLU refer to four broad areas:

1. Urban greening
2. Forests
3. Adaptation in agriculture
4. Mitigation in agriculture

Three DFI and seven funds appear to be particularly suitable to support these (TABLE 3.43).

TABLE 3.39 Link between most likely potential climate finance sources and power generation measures

Climate finance source	Strategy and/or priority area relating to power generation measures
IDB	**First and second strategic area of the Country Strategy 2016–2020:** Strengthen public sector institutions and governance: » Adjust fiscal policies which discourage energy efficiency, energy conservation and renewable energies. » Encourage energy-efficient technologies and infrastructure. **Promoting private sector development:** » Promote the development of renewable energy sources.
CAF	**Third strategic line of the Latin American Climate Change Program** a) Diversify the energy matrix and promote renewable energies
CDB	**Fifth development outcome of the Country Strategy 2017–2021:** b) Support renewable energy/ energy efficiency investments and infrastructure. c) Support the energy sector in becoming efficient and secure.
EIB	The **ELM Climate Strategy** prioritises renewable energies and energy efficiency.
GCF	**Third results area:** Energy (renewables, low-emission sources, smart technologies)
GEF	» **Second focal area:** Climate change mitigation » **Impact programme on sustainable cities:** Supports integrated solutions also concerning energy
CDF	**One of five priorities in the second funding cycle:** Sustainable energy
EDF	» **Priorities of the eleventh EDF 2014–2020:** Sustainable energy » **Fifth strategic objective of the National Indicative Programme 2014–2020:** Supporting the implementation of the NDC
IKI	**One of four priority areas:** Mitigation
Green Fund	**One of four sectors:** Public awareness activities/education

TABLE 3.40 Link between most likely potential climate finance sources and industry measures

Climate finance source	Strategy and/or priority area relating to industry measures
IDB	**First strategic area of the Country Strategy 2016–2020:** Strengthening public sector institutions and governance: » Improve efficiency of public expenditure, including assessing and redesigning subsidies etc. » Policy reforms to mainstream climate change across sectors and thematic areas » IDB Invest and IDB Lab support private sector development
CAF	**One of three priorities in Trinidad and Tobago** » Private sector in productive transformation
GCF	**Second results area:** Buildings, cities, industries and appliances
GEF	**Second focal area:** Climate change mitigation
GCCA+	**Priority area:** Mainstreaming in budgetary systems
IKI	**One of four priority areas:** Mitigation

Photo Credit: curtis boodoo

▲ Electric bus at UTT Campus, Trinidad, 2017

TABLE 3.41 Link between most likely potential climate finance sources and transportation measures

Climate finance source	Strategy and/or priority area relating to transport measures
IDB	**Second strategic area of the Country Strategy 2016–2020:** Promoting private sector development: » Traffic management and public transportation
CDB	**Fifth development outcome of the Country Strategy 2017–2021:** a) Support road infrastructure, building resilience and promoting safety. b) Support public bus transportation and ancillary facilities. c) Support transportation in Tobago.
EIB	The **ELM Climate Strategy** prioritises transportation.
GCF	**Fourth results area:** Transport (Compact, connected urban transport, new technologies, modal shifts, infrastructure planning)
GEF	» **Second focal area:** Climate change mitigation » **Impact programme on sustainable cities:** Supports integrated solutions also concerning transport.
EDF	**Second strategic objective of the National Indicative Programme 2014–2020:** Fighting climate change through CO_2 reductions in the transport sector, amongst others.
IKI	**One of four priority areas:** Mitigation
Green Fund	**One of four sectors:** Public awareness activities, education

TABLE 3.42 Link between most likely potential climate finance sources and waste and wastewater measures

Climate finance source	Strategy and/or priority area relating to waste and wastewater measures
IDB	**Third strategic area of the Country Strategy 2016–2020:** Fostering human development: » Improve water and sanitation services and infrastructure.
CAF	**Third strategic line of the Latin American Climate Change Program** » Assure access to water for human consumption.
CDB	**Fifth development outcome of the Country Strategy 2017–2021:** » Support water and sanitation infrastructure and systems.
EIB	The **ELM Climate Strategy** prioritises water and sanitation and municipal solid waste management.
GCF	» **Sixth results area:** Health, food and water security » **Seventh results area:** Infrastructure (water supply)
GEF	» **Second focal area:** Climate change mitigation » **Impact programme on sustainable cities:** Supports integrated solutions also concerning solid waste.
AF	**One of nine sectors:** Water management
GCCA+	**Focuses on the sectors** water and sanitation, and waste management
IKI	**Two of four priority areas:** Mitigation and adaptation
Green Fund	**One of four sectors:** Public awareness activities/education

TABLE 3.43 Link between most likely potential climate finance sources and AFOLU measures

Climate finance source	Strategy and/or priority area relating to AFOLU measures
IDB	» Supports climate-smart agriculture (**IDB Lab**)
IFAD	**The Adaptation for Smallholder Agriculture Programme's (ASAP) first and fifth objective:** 1) Improved land management and climate-resilient agricultural practices 5) Knowledge on climate-smart smallholder agriculture documented and disseminated
EIB	The **ELM Climate Strategy** prioritises forestry and land use.
GCF	» **First results area:** Agriculture, forestry and other land use » **Second results area:** (Green) buildings
GEF	» **Second focal area:** Climate change mitigation » **Impact programme on food, land use and restoration:** Supports deforestation-free agri-culture and restoration of degraded ecosystems.
REDD	**Deforestation and forest degradation**
AF	**Two of nine sectors:** Agriculture and forests
GCCA+	**Focuses on the sectors** agriculture and food security, and environment and natural resources (including forestry).
IKI	**Two of four priority areas:** Mitigation and adaptation
Green Fund	**Two of four sectors:** Public awareness activities/ education and reforestation

4

ASSESSMENT OF VULNERABILITY AND ADAPTATION

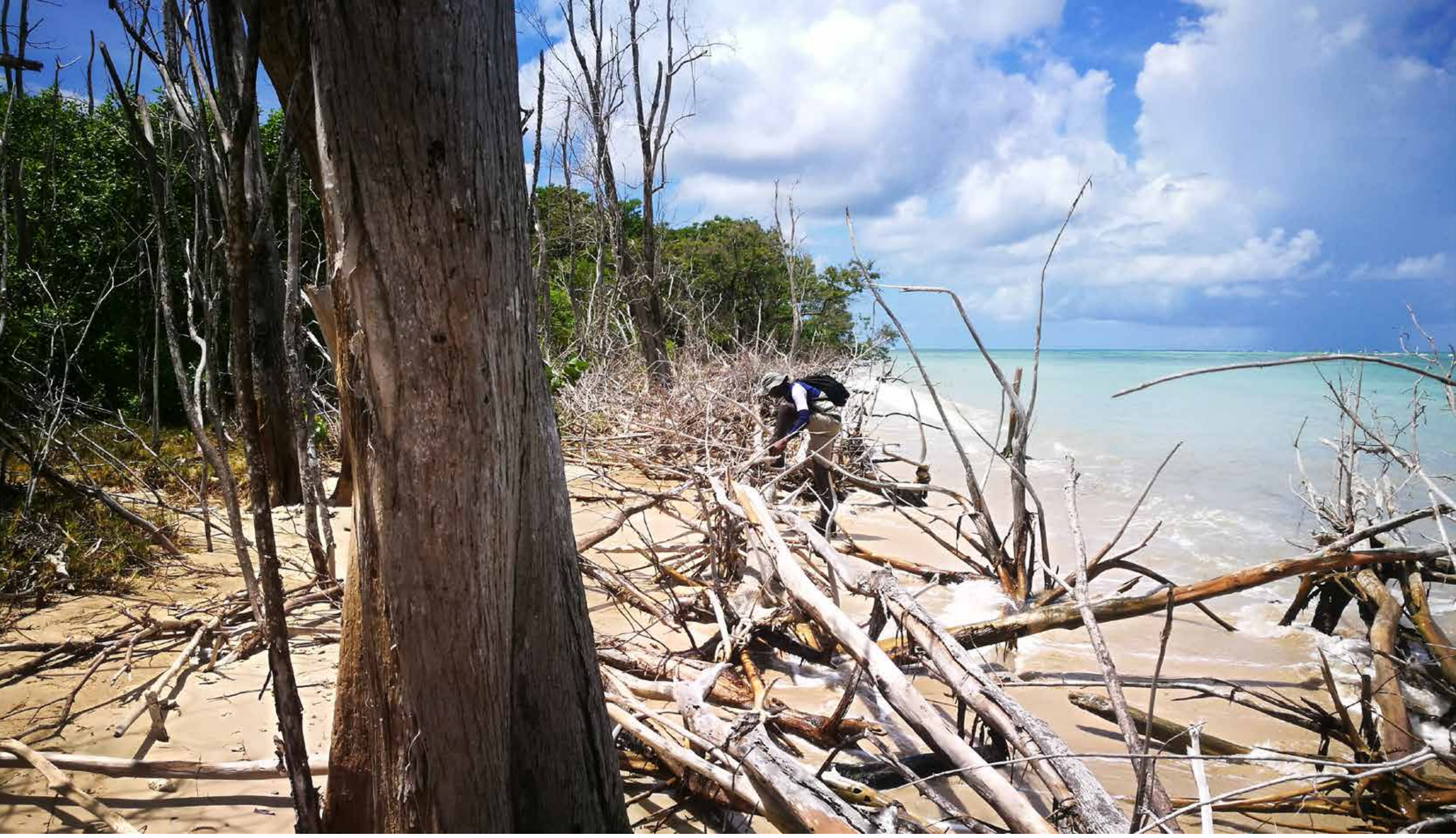


Photo Credit: Howard Robin

▲ Mangrove dieback in a coastal area, Tobago, 2018

4.1 Introduction

Background and Context

This chapter details a climate change Vulnerability and Adaptation (V&A) assessment of the coastal zone of Trinidad and Tobago and the sectors within it, using Regional Climate Models and national vulnerability Geographic Information Systems (GIS) maps.

It presents the results of analyses of current climate and future climate projections within Trinidad and Tobago. For future climate projections, the potential impacts on the priority development sectors in the coastal zone of both islands and the Main Ridge Forest Reserve in Tobago are discussed. Sectors operating in the coastal zone include marine ecosystems; biodiversity (including fisheries resources); agriculture and food security; water resources and human health; and human settlements and infrastructure.

For the purposes of the assessment, the operational definition of the coastal zone proposed in the 2014 Draft Integrated Coastal Zone Management (ICZM) Policy Framework was used which sets out three classifications covering the terrestrial and sea areas (Institute of Marine Affairs [IMA], 2014):

1. **Zone T1**—Immediate and direct impact area: This area is delineated on the seaward side as the line of low-water at mean low-water spring tides and on the landward side as the 5-metre contour. The 5m contour represents the limit of immediate and direct impact of sea level rise and storm surges.
2. **Zone T2**—**Area of influence:** The area between the 5-metre contour and 90-metre contour. This area and Zone T1 contain most of the urban, industrial and agricultural areas of the country and influence the marine and coastal areas through direct and indirect impacts.
3. **Sea Zone S1**—Immediate and direct impact area **(3 nautical miles):** This zone (S1) will be delineated on the landward side from the low-water at mean low-water spring tides and shall extend to a distance of three nautical miles offshore parallel with the mean high-water mark, consistent with the outer limit defined for the coastal nearshore in the Water Pollution Rules, 2001.

A predecessor activity of direct relevance to this assessment was conducted from 2016 to 2018 whereby the Government of the Republic of Trinidad and Tobago (GoRTT) received support from the European Union (EU) under the Technical Assistance to the Environment Programme to provide an assessment of the impacts of climate change, climate variability and projected climate change impacts on the country in all key sectors, and to facilitate decision-making on climate change risk management by key agencies.

The resulting Vulnerability and Capacity Assessment (VCA) undertook:

1. a preliminary climate change vulnerability assessment at the sectoral level;
2. a climate change risk assessment at the sectoral level; and
3. a climate change adaptive capacity assessment of key ministries and agencies involved in climate change adaptation.

The GoRTT is establishing "a whole of government approach" to manage climate change risks and mobilise the necessary resources (human, technical and financial) for effective implementation. This will enable a strategic approach to the management of climate change risks which clearly defines the roles and responsibilities of various relevant government agencies.

Accordingly, a Strategic Framework and Programme for Climate Change Risk Management was developed in consultation with the relevant key stakeholders. The Strategic Framework proposes to address priority climate-related risks and capacity needs and identifies roles and responsibilities of stakeholders to manage the risks and is being used to inform and guide the revision of the National Climate Change Policy.

"Pathways Approach" to long term adaptation and climate resilience

The approach taken by Trinidad and Tobago to address climate change risk and implement adaptation measures is a "Pathways Approach" to resilience. The approach, also referred to as "Climate-resilient pathways", is supported by the Intergovernmental Panel on Climate Change (Denton et al., 2014) and addresses one of the main barriers to adaptation identified by stakeholders. This involves the unwillingness of policymakers to prioritise adaptation decisions that contain inherent uncertainties regarding the development and implementation of adaptation options to address long-term impacts. Their unwillingness is based on the inherent uncertainty of climate models, potential change in the rate of future climate change and its impacts, and evolving scientific evidence which could incur the risk of significant and costly maladaptation. As such, the short and medium-term measures recommended in this chapter, once implemented, are expected to pave the way for the longer-term adaptation decisions through the incremental building of climate resilience

The Pathways Approach is the preferred approach by the GoRTT because it is often difficult to differentiate between the impacts of climate-related stimuli and non-climate impacts in a small island state like Trinidad and Tobago due to the complex interactions between climate, social, ecological and economic systems, including impacts arising from development. To overcome this challenge, at least to some extent, climate impact assessments are being integrated into environmental impact assessments for development activities.

The Pathways Approach also supports "no-regrets" and "low-regrets" adaptation which:

- maximises the return on investment when certainty of the associated climate change risk is high; and
- delivers net socio-economic benefits regardless of the climate change outcome.

An example of this type of adaptation might be measures to reduce the loss of potable water in transmission due to leakage in a country where the quantity of available potable water is projected to decline as a result of climate change, as is the case for Trinidad and Tobago.

The recommended adaptation measures are proposed at the national level as well as the sectoral level where many ministries and private sector interests in the disaster risk reduction, tourism and oil and gas sectors are already engaged in activities and initiatives to support adaptation and provide socioeconomic benefits. Whilst these initiatives are commendable, more is needed, and efforts to mainstream climate change into sectoral planning and action are of paramount importance in order for the country to chart a path towards adaptation to the longer-term impacts of climate change.

Scope and Objectives of the Vulnerability and Adaptation Assessment

The objectives of the assessment are:

1. to assess the impacts of climate change, climate variability and projected climate change impacts in the coastal zone in Trinidad and the Main Ridge Forest Reserve in Tobago. The coastal zone encompasses key bio-physical and socio-economic impacts on marine ecosystems, biodiversity (including fishery resources), agriculture, water resources, human health, human settlements and infrastructure, and food security;
2. to identify policy gaps and potential opportunities that will enable the Government to formulate plans and strategies for adaptation in these sectors.

Methods and Data

A complete literature review was undertaken including reports from sectors that currently operate in the coastal zone. Climate change and sea level rise projection modelling was conducted for 2030 and 2050 and stakeholder meetings were held to validate results and analyses.

The following subsections outline the main methods and data as they relate to the overall approach, and how the climate and sea level rise projection modelling was conducted.

Overall Risk Management Approach

Global and Regional Climate models provide projections that are, at best, approximations. In such an environment of uncertainty, a risk management approach is considered suitable for bringing some precision to the decision-making process involved in developing climate change adaptation options for implementation. (Caribbean Community Secretariat, 2003) In fact, risk assessment is considered an essential early step in the adaptation planning and management process of the policy cycle because it provides a systematic, informative and science-based approach to help decision-makers analyse the risks and benefits of climate variability and change and select optimal courses of action.

The approach to conducting this vulnerability assessment therefore had risk assessment as its overarching approach and followed on from the work in the Vulnerability and Capacity Assessment completed in 2018. In the VCA report, the framing of main climate risks, impacts and adaptation options was based on a socially-inclusive, broad-based consultative process within the country. This ensured that any proposed adaptation actions would build upon local experiences and reflect the views and needs of a range of stakeholders, including vulnerable groups and sectors such as small farmers, women, youth, indigenous peoples and local communities.

The key steps in the process were based on the CARICOM Risk Management Guidelines for Climate Change Adaptation Decision Making[1] outlined in **FIGURE 4.1**.

It is important to note that risks which cannot be completely controlled or accommodated by adaptation strategies will entail some economic loss.

1 Developed under the "Adapting to Climate Change in the Caribbean" and "Mainstreaming Adaptation to Climate Change" project funded by the Global Environment Facility (GEF)/World Bank/Canadian International Development Agency (CIDA), 2003. A copy of the Guide can be found at the following link: http://dms.caribbeanclimate.bz/M-Files/openfile.aspx?objtype=0&docid=2879

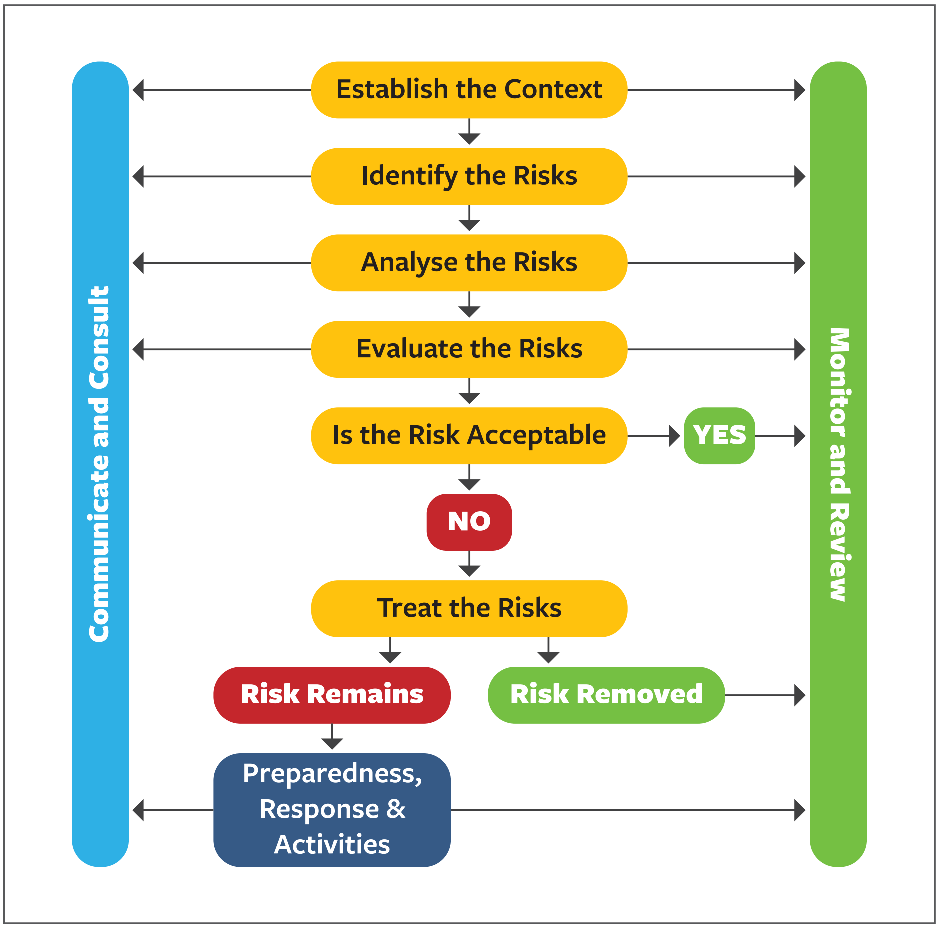


FIGURE 4.1 Climate Change Risk Management Process

Climate Change Projections

This chapter presents the results of analyses of current climate and future climate projections within Trinidad and Tobago. For future climate projections, the potential impacts on the priority development sectors in the coastal zone are discussed. These sectors include marine ecosystems, biodiversity (including fisheries resources), agriculture, water resources, human health, human settlements and infrastructure, food security, and the Main Ridge Forest Reserve in Tobago.

The projections used to inform the assessment utilised scenario predictions developed by the Caribbean Community Climate Change Centre (CCCCC) and the Instituto de Meteorología de Cuba (INSMET) which is Cuba's Institute of Meteorology, and the Climate Research Unit (CRU)/Universities of East Anglia and Oxford, UK. The data provided were PRECIS-downscaled scenarios of a version of the HadCM3 and ECHAM5 climate models forced by the SRES A1B forcing scenario and recast on a 25 x 25 km grid spacing. The SRES (Special Report Emissions Scenario; Intergovernmental Panel on Climate Change [IPCC], 2007) AIB scenario that projects a global temperature of < 3 °C by 2100 lies between the RCP (Representative Concentration Pathways) scenarios that project global temperature increases of 2.2 °C (RCP 6.0) and 3.7 °C (RCP 8.5) by the end of the century (IPCC, 2013).

In order to assess the correspondence between the PRECIS-downscaled HadCM3 and ECHAM5 climate data and observed data, data from previous research were presented to support how well the modelled data correlate with the observed data.

Additionally, several reports from the IPCC were also drawn upon, as well as other scientific and technical information.

The selected climate variables, namely mean, maximum and minimum temperatures, precipitation and water excess (positive P-E) and water deficits (negative P-E) were mapped for the dry season which occurs roughly from January to May and the wet season which occurs roughly from June to December, for a current decadal time slice, namely 2000–2010, and their anomalies centred on the decade 2025–2035 to represent 2030 and on the decade 2045–2055 to represent 2050 for both the downscaled HadCM3 and ECHAM5 global climate models.

Climate anomalies (*deviation* of temperature and rainfall from the normal value in the time slices being considered) and quantiles (*variation* of the ranges of temperature and rainfall over the time slices being considered) will change over Trinidad and Tobago in the future time periods, namely 2030 (2025–2035) and 2050 (2045–2055) and these changes were more or less similar for the downscaled climate models (HadCM3 and ECHAM5).

Sea Level Rise and Storm Surge

The coastal zone of Trinidad and Tobago is highly vulnerable to future changes in sea levels and extreme weather conditions that produce severe storm surges. Further, ocean encroachment and inundation on sensitive ecosystems, infrastructure facilities and settlements which are already occurring in some areas may lead to significant and irreversible damage to natural habitats, agricultural lands, built infrastructure and settlements, and people.

Future sea level and hurricane-driven projections (2030 and 2050) of sea level and storm surges for the coastal zone of Trinidad and Tobago and the Main Ridge Forest Reserve in Tobago were assessed, in particular, for the priority development sectors within the three coastal zones T1, T2 and S1. The development sectors include marine ecosystems, biodiversity (including fisheries resources), agriculture, water resources, human health, human settlements and infrastructure, and food security.

Empirical values of storm surge heights for Category 2 (moderate) and Category 5 (extreme) storms were derived from studies for areas similar to the study area based on the TAOS (Total Arbiter of Storms[2]) model for the Caribbean (Caribbean Development Bank & Caribbean Community Secretariat, 2004).

Sea level rise values of the IPCC (2013) are rather conservative when compared to other recent studies that integrate feedback effects and land ice contribution to sea level rise. As such, the extreme values of the IPCC (Olsson et al., 2014) were selected. They were based on the Representative Concentration Pathway (RCP) forcing scenarios 0.15 m for the 2030 period (RCP 8.5) and 0.25 m for the 2050 period for both Trinidad and Tobago (RCP 8.5).

Thereafter, the different categories of storm surges as generated by a Category 2 and a Category 5 hurricane were superimposed on a Digital Terrain Model (DTM).

Selecting Adaptation Measures

Validation of short-term adaptation measures previously identified in the VCA exercise was necessary and based on the climate change and sea level rise projections for 2030 and 2050. Adaptation measures were developed through national consultations and expert guidance. These measures also took the following into consideration:

- The "resilience" objective or goal of the sector. Some sectors such as water resources already had a policy that included directives related to resilience to climate change.
- Current/ongoing activities to achieve that objective or goal
- Barriers to implementing adaptation measures
- The stakeholders involved and their roles

Measures also included those to address non-climate change issues such as poor storm water management and poor land use.

2 The TAOS model simulates the effects of selected hazards (waves, wind, storm surge, coastal erosion, flooding) as well as the impact on both physical and built environments, including damage and economic loss estimates. It was developed by Charles C. Watson and tailored for the Caribbean under the United States Agency for International Development (USAID)/ Organization of American States (OAS) Caribbean Disaster Mitigation Project.

Photo Credit: Sean McCoon, Environment Tobago

▲ Iguana Bay, Charlotteville, Tobago

▼ In the Main Ridge Rainforest

Photo Credit: Tobago House of Assembly

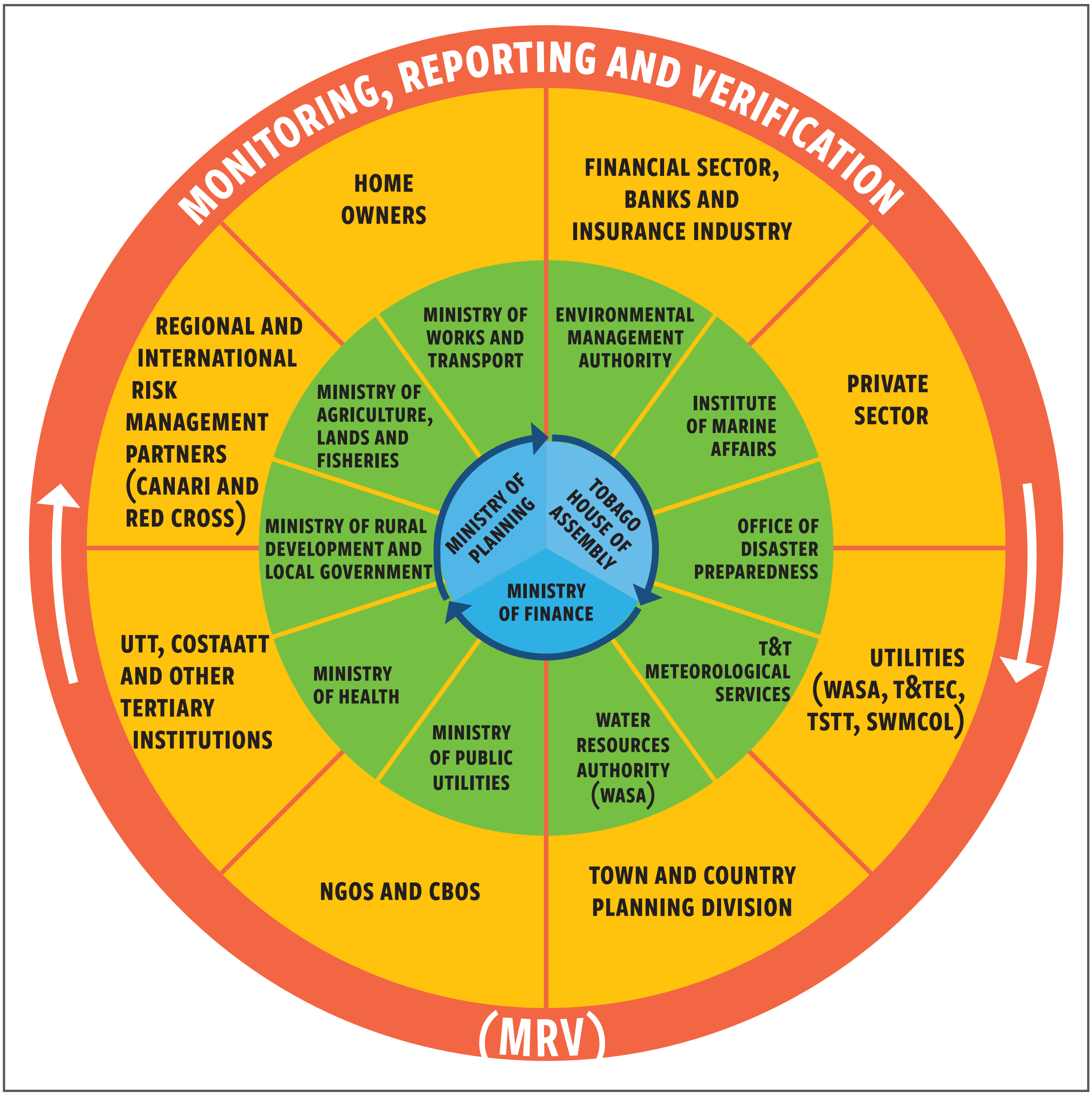


FIGURE 4.2 Strategic Framework and Programme for Climate Change Risk Management

In keeping with the Pathways Approach, "No regrets" and "Low regrets" options were strongly considered, particularly at the national level, since they also support national development goals and several other obligations under various multilateral environmental agreements. "No regrets" and "Low regrets" options are characterised by the following:

1. **Benefits across a wide range of future uncertainties:** Options which provide an acceptable level of benefit across a range of future climate and development scenarios. They build resilience to future climate shocks while also delivering near-term benefits.
2. **Bringing co-benefits across sectors and stakeholders:** Options which minimise trade-offs and maximise benefits to all stakeholders and with other related development priorities.
3. **Flexibility to future change:** Options which can be adjusted in future and avoid locking-in investment for long periods of time.

No regrets options provide benefits in the absence of climate change and also for a wide range of future uncertainty. This includes measures aimed at:

1. addressing institutional and regulatory barriers that may inhibit timely and efficient adaptation which are captured in **FIGURE 4.2,** *Strategic Framework and Programme for Climate Change Risk Management*; and
2. increasing the resilience of key socio-economic sectors by better understanding what is at risk. These would be in response to the highest risks over the next 5–10 years which are ranked at 1 and 2 in **TABLE 4.5**.

Most of the recommended interventions at the sector level are not capital investments for direct protection but rather the development of capacity, data and information to implement future capital-intensive projects that would alleviate potential damage. This is a necessary step in being able to implement specific cost and life-saving measures which were not specified in the VCA project. As such, any expenditure on these initial measures should be seen as an investment in cost savings on future interventions since the selection of such interventions would have a greater probability of relevance once the capacity and knowledge of decision-makers and technocrats were enhanced. Where possible, avoided losses and damages, as well as adaptation measures to address the greatest risks, were quantified.

4.2 Socioeconomic Context of the Vulnerable Sectors in Trinidad and Tobago

Zones T1 and T2 which together define the impact area and area of influence, constitute the region which characterises the economic contribution of the coastal zone. This is because the coastal ecosystems and the economy are inter-related. It is anticipated that the most likely sectors/areas to be heavily impacted by future climate change would include agriculture (e.g. increased aridity of soils leading to decreased crop yields), human health (e.g. increased incidences of water borne diseases), human settlements (e.g. disruption from an increased incidence of flooding), coastal zones (e.g. loss of natural coastal defences) and water resources (e.g. reduced availability of surface water and potable water). Further, the marine environment and coastal ecosystems which contribute oil and gas reserves and are the mainstay of the economy were also projected to be impacted.

Agriculture

Trinidad and Tobago's agricultural sector has shifted from an export-oriented industry to one geared towards meeting domestic demands and which is therefore important to food security. Currently, only 10.53 percent of the total land area is categorised as agricultural land (Trading Economics, n.d.). The country is highly dependent on imports for as much as 85 percent of its food supply (Inter-American Development Bank [IDB], 2018).

Agriculture, including forestry and fisheries, contributed 0.5 percent to GDP in 2018 (Shik et al., 2018) and 3.40 percent to overall employment in 2015 (Shik et al., 2018). The decline of the agriculture sector, especially in terms of real contribution to GDP, threatens the seeming relevance of the sector to the national economy and thus puts it at a disadvantage in terms of investments. Crop production is affected biophysically by meteorological variables, including rising temperatures, changing precipitation patterns, increased atmospheric carbon dioxide (CO_2) levels, the availability of water resources and the anomalous presence of extreme events.

Key climate-related impacts already being observed include increased aridity of soils and decreased crop yields due to an increase in air temperature, salinisation of soils and ground water due to coastal inundation, and the reduced availability of fresh water due to lower precipitation. Studies conducted by the International Center for Tropical Agriculture (CIAT) in the cocoa and tomato-growing regions of Trinidad and Tobago showed that farmers are also experiencing the changes in local agroecological conditions. Results indicated that the majority of farmers believe that the climate is changing, specifically as it relates to rainfall (Eitzinger et al., 2015).

Water Resources

There are 55 watersheds in Trinidad and 15 in Tobago. Large-scale development of surface water has been limited to four rivers in Trinidad and Tobago. These are the Caroni and Oropouche Rivers in Trinidad's Northern Basin; the Navet River in Trinidad's Central Range; and the Hillsborough River in Tobago, which is the principal source of supply for Scarborough and south-west Tobago.

Before 1981, 60 percent of the total municipal water supply was provided by groundwater. After large surface water plants were constructed, such as the Caroni-Arena Pump Storage Complex and the North Oropouche Scheme, groundwater has accounted for only about 25 percent of the total water supply of Trinidad.

Whilst the Trinidad and Tobago Water and Sewerage Authority (WASA) is the major abstractor of water resources, other users include industrial and agricultural facilities. Approximately 94.7 percent of the population in Trinidad and 84.8 percent in Tobago are connected to the piped water supply network. However, a 24-hour supply is provided only to 16.6 percent and 39.6 percent of the population on the islands of Trinidad and Tobago, respectively.

The quality of the surface water is deteriorating in many locations, as evidenced by high levels of biological oxygen demand, bacterial content, turbidity and the presence of chemical pollutants in rivers (Food and Agriculture Organization of the United Nations [FAO], 2015). The main threats are uncontrolled point waste discharges, in particular from industries and domestic sources, as well as the high level of erosion in the upper reaches of watercourses. Pollution of surface water not only affects the production of drinking water, but also the ability of the rivers to provide productive habitats for terrestrial and aquatic species. Reduced freshwater supply has also been reported due to decreased rainfall and subsequent reduction in stream flow.

Human Health

Human health is of paramount importance to the socio-economic well-being of the people of Trinidad and Tobago with health-care being provided through both public and private health facilities across the country. The Caribbean, including Trinidad and Tobago, has been plagued recently by mosquito-borne diseases with outbreaks of chikungunya in 2015 and zika in 2016. The Social Sector Investment Programme 2017 report (Government of the Republic of Trinidad and Tobago, 2017) indicated that the number of laboratory-confirmed cases for chikungunya and dengue fever was 38 and 23, respectively, as at July 2015, and 335 cases of zika as at August 2016. There have been zero recent cases of malaria which is not endemic to Trinidad and Tobago. However, every year the country records several imported cases of malaria as well as cases involving residents who had travelled to malaria-endemic countries.

A recent study conducted on the delayed impacts of climate change on dengue risk in Barbados confirmed that the risk of dengue outbreaks increased with increasing minimum temperatures of up to 25 °C and

Photo Credit: Sunil Ramnath, Institute of Marine Affairs

▲ Sharing the mudflats: Scarlet Ibises (*Eudocimus ruber*), Snowy Egrets (*Egretta thula*), and a lone Greater Yellowlegs (*Tringa melanoleuca*) wade on exposed mudflats searching for small fish, crustaceans, and insects. The Caroni Swamp was declared a Ramsar Site, a wetland of international importance, in 2005

that disease outbreaks were more likely to occur four to five months after periods of drought and one month after periods of excess rainfall (Lowe et al., 2018).

Infrastructure and Human Settlements

For administrative purposes, Trinidad is now typically divided into 14 regions and municipalities and Tobago into seven parishes. In Trinidad and Tobago areas are classified as urban or rural, based primarily on the population density per square kilometre. Areas with a population density of 200 or more persons per square kilometre are classified as urban, whereas areas with a density less than 200 persons are classified as rural. Based on this classification, 71 percent of the population live in urban areas while the remaining 29 percent reside in smaller rural villages and towns. Settlement pattern shows marked concentration of urban settlements in the western half of Trinidad, and in the south-west of Tobago. A large proportion of Trinidad's population is concentrated in urbanised regions of the East/West and North/South Corridors. This is in contrast to eastern Trinidad and the south-west peninsula which are relatively sparsely populated. On Tobago, the lowest population density is found in the north-east.

The Office of Disaster Preparedness and Management (ODPM) reported in its 2014 Preliminary Vulnerability Assessment of Trinidad and Tobago that no formal critical facilities inventories were readily available and that the unavailability of information does not allow for any conclusions to be made regarding the vulnerability of critical facilities and infrastructure. A Critical Facilities Protection Programme has been developed and will include the assessment, ranking and mapping of critical facilities across Trinidad and Tobago. It is a national programme for the identification and management of critical facilities in Trinidad and Tobago.

TABLE 4.1 Value of Infrastructures by coastal zone and as a Percent of Total Value for Trinidad and Tobago
Source: Adapted from IDB, 2013, as cited in Clarke et al., 2018

Land Use	Value USD $ Million					Percent of Total		
	T1 Impact Zone	T2 Influence Zone	Combined Zone	Total	'Total' Equivalent in 2019[1]	T1 Impact Zone	T2 Influence Zone	Combined Zone
Residential	$312	$3,196	$3,508	$4,271	$5,317	7%	75%	82%
Commercial	$139	$1,381	$1,520	$1,870	$2,328	7%	74%	81%
Industrial	$103	$1,009	$1,112	$1,300	$1,619	8%	78%	86%
Private and Public Services (Health, Education and Government)	$43	$450	$493	$602	$750	7%	75%	82%
Urban Infrastructure (Substations, Plants and Tanks, Dams, Aqueducts, Sewage Systems, Gas, Networks, Airports, Wharves, Urban Bridges)	$63	$202	$265	$304	$379	21%	66%	87%
National Infrastructure (Roads, Bridges, Hydroelectricity facilities, Power Plants, Electricity distribution, Hydrocarbon, Communications)	$820	$7,861	$8,682	$10,912	$13,584	8%	72%	80%
All Infrastructure	$1,481	$14,099	$15,580	$19,259	$23,977	8%	73%	81%

1 Inflation calculator on www.worlddata.info was used to calculate 2019 values. These values were rounded up to the nearest '000. See https://www.worlddata.info/america/trinidad-and-tobago/inflation-rates.php

Contribution of the Coastal Zone to the Economy of Trinidad and Tobago

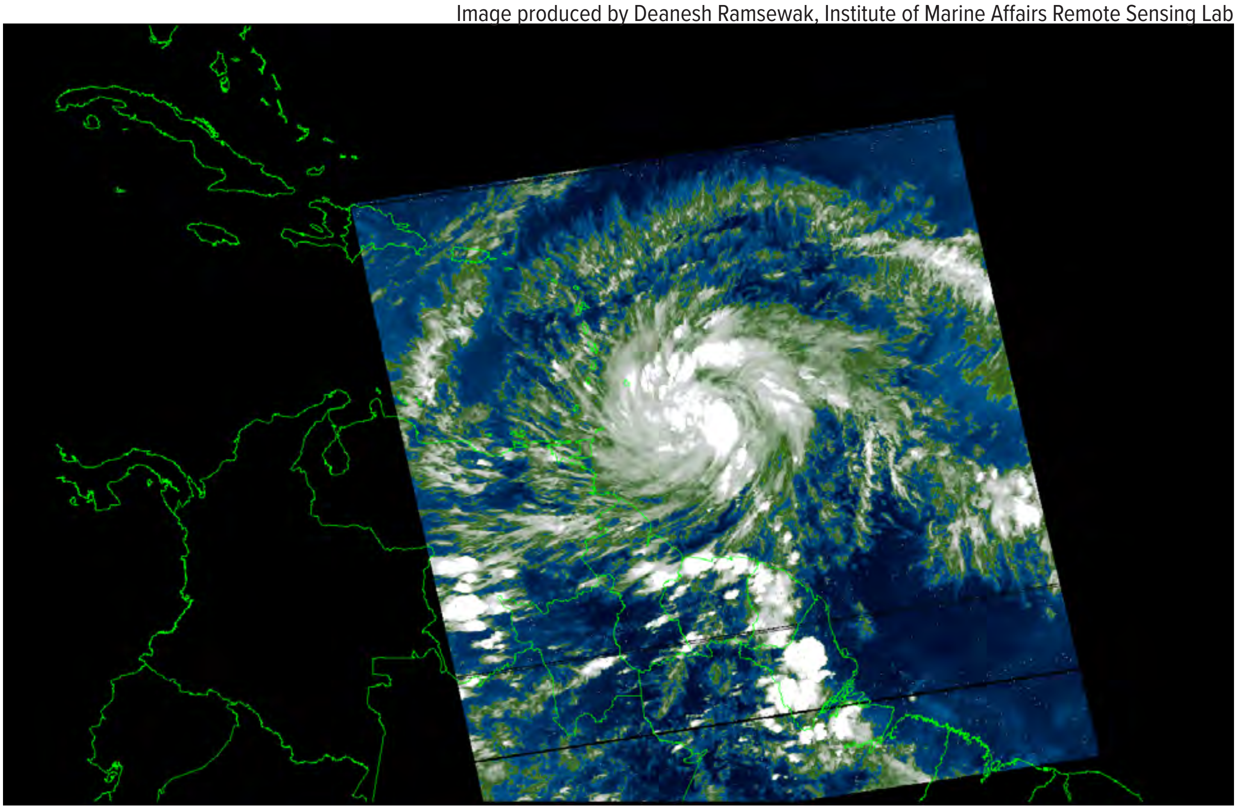
Almost 80 percent of all socio-economic activities and 70 percent of Trinidad and Tobago's population are located along the coast (Central Statistical Office, 2010). The contribution of the coastal zone to the economy or GDP is based on the share of Trinidad and Tobago's infrastructure which lies within the coastal zone and where coastal and marine resources have long supported the country's important productive sectors, including oil and gas, tourism and fisheries.

A comprehensive assessment by the IDB of the value of structures and infrastructure in Trinidad and Tobago through 2012 produced sufficient data for an estimate of the economic value of the country's assets, as well as the relative share of that value within the coastal zone (IDB, 2013, as cited in Clarke et al., 2018).

As shown in **TABLE 4.1**, approximately eight percent of the value of all infrastructure is within Zone T1 which is the area of immediate impact, while 81 percent of the total value of physical assets lies within the combined zones of T1 and T2. These percentages are roughly indicative of the share of GDP from the economic activity which depends on assets located in the combined zones of impact and influence (IDB, 2013, as cited in Clarke et al., 2018).

In dollar terms, the value of combined T1 and T2 share of GDP is approximately 22.50 billion USD. A

Image produced by Deanesh Ramsewak, Institute of Marine Affairs Remote Sensing Lab



▲ Tracking Tropical Storm Tomas: NOAA-15 Infrared Satellite Image of Tropical Storm Tomas approaching Trinidad and Tobago and the Lesser Antilles captured at 4:00 p.m. local time on 29 October, 2010

similar calculation shows that 2.14 billion USD of GDP comes from the economic activity within the immediate impact area (T1). It is noteworthy that the population statistics follow the same pattern as the infrastructure with 81 percent of the population residing within the combined areas of T1 and T2, and seven percent living within the T1 impact zone. (IDB, 2013, as cited in Clarke et al., 2018)

The tourism sector is especially important to the economic value of the coast, especially in Tobago. This industry was the direct source of employment for 27,700 workers and indirectly employed another 46,000 in industries which supply goods and services to the tourism sector and sold goods and services to households employed in tourism within Trinidad and Tobago. However, this is only part of the economic value of tourism. Business travel aside, nature-based leisure tourism could generate additional value in the form of consumer surpluses above and beyond what people pay out of pocket and is accounted for in the GDP (IDB, 2013, as cited in Clarke et al., 2018).

4.3 Assessment of Climate Change Risks: Current and Future Climate

General and Baseline Climatology and Current Trends

Trinidad and Tobago's overall climate is shaped by several interacting and counter-acting forces but its geographical position is a predominant factor. The country is very close to the equator and its location places it within the zones of influence of the Intertropical Convergence Zone, the North Atlantic Sub-Tropical High-pressure cell and the Tropical Atlantic Cyclone or Hurricane Belt which collectively contribute to the temperature, rainfall and wind regimes that are experienced on the twin-island republic (Clarke et al., 2018).

The selected climate variables, namely maximum and minimum temperatures, precipitation and water excess (positive P-E) and water deficits (negative P-E) were mapped for the dry and wet seasons for a current decadal time slice, 2000–2010 for both the downscaled HadCM3 and ECHAM5 global climate models.

Photo Credit: Ministry of Planning and Development

▲ Coastal erosion, Trinidad, 2012

▲ Historical (1916–2015) Tropical Storm and Hurricane Tracks passing over or near to Trinidad and Tobago. | *Source: https://coast.noaa.gov/hurricanes*

Temperature

HadCM3 climate model

The spatial distribution of maximum daily temperatures for Trinidad and Tobago during the dry season (**FIGURE 4.3**) for the decade 2000–2010 shows that for Trinidad, except for the north-eastern tip of the island near Toco where the marine influence leads to cooler temperatures, maximum daily temperatures

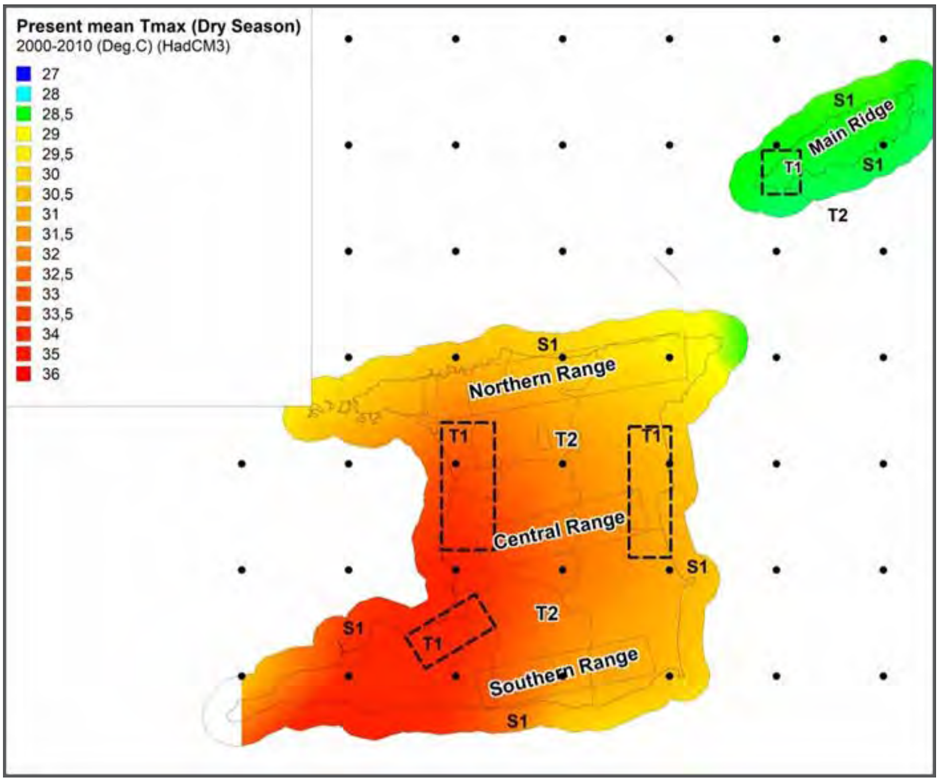


FIGURE 4.3 Spatial distribution of maximum daily temperatures for Trinidad and Tobago during the Dry season for the decade 2000–2010 according to the downscaled HadCM3 climate model

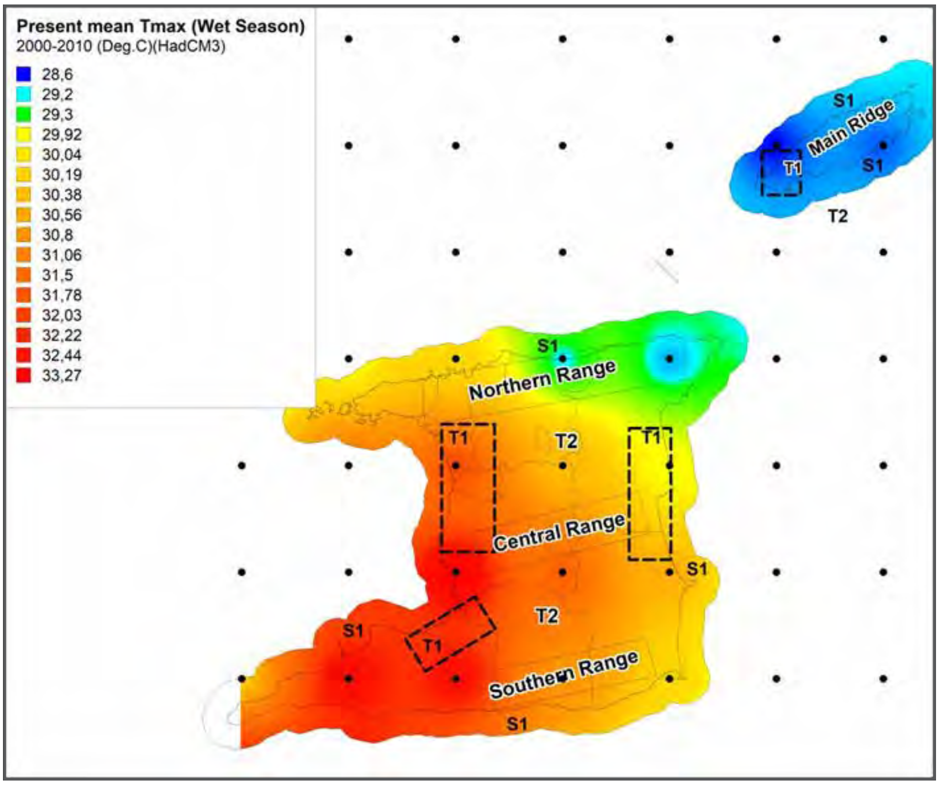


FIGURE 4.4 Spatial distribution of maximum daily temperatures for Trinidad and Tobago during the Wet season for the decade 2000–2010 according to the downscaled HadCM3 climate model

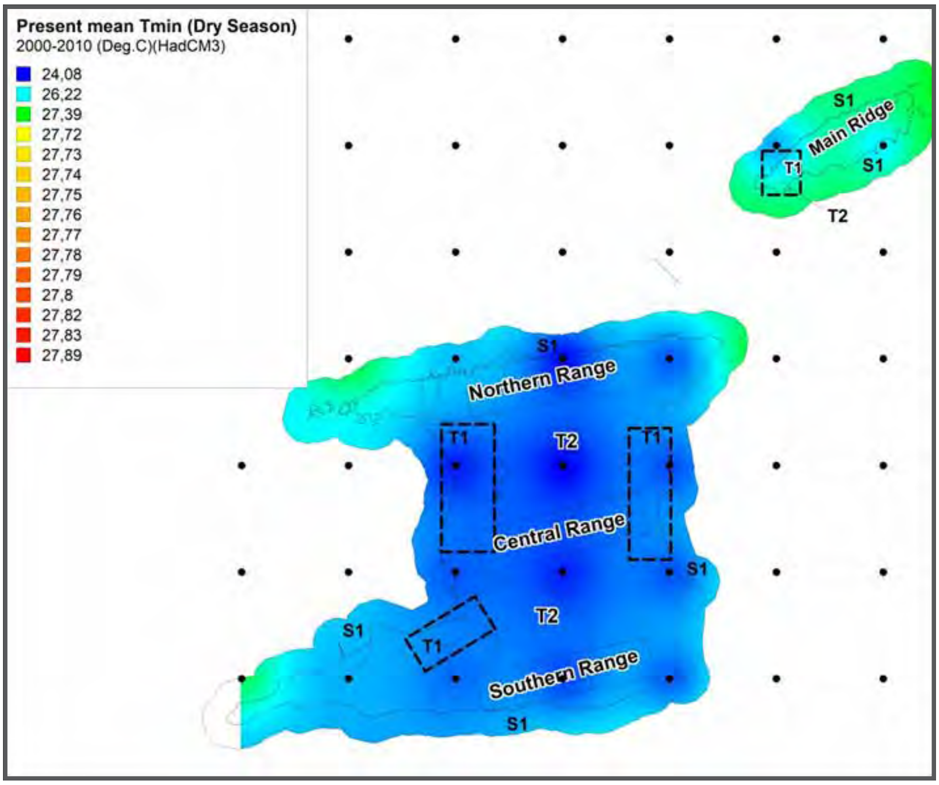


FIGURE 4.5 Spatial distribution of minimum daily temperatures for Trinidad and Tobago during the Dry season for the decade 2000–2010 according to the downscaled HadCM3 climate model

vary between ~29 °C and ~33 °C. Temperatures may even rise to ~33 °C over local microclimates along the west coast (Zones T1, T2 and S1) due to a combination of dry conditions and less forest cover (**FIGURE 4.3**).

In terms of Tobago, the average daily maximum temperature during the dry season is ~28.5 °C throughout the island (T1, T2 and S1) due to its small size and strong marine influence (**FIGURE 4.3**).

The spatial distribution of maximum daily temperatures for Trinidad during the wet season (**FIGURE 4.4**) for the decade 2000–2010, shows that, except for the north-eastern tip of the island between Toco and Blanchisseuse where the elevation of the Northern Range and marine influence combine to produce cooler temperatures of ~29 °C, maximum daily temperatures again vary between ~29 °C and ~32 °C over the island (Zones T1, T2 and S1), while rising to ~33 °C over local microclimates along the west coast (**FIGURE 4.4**).

As for Tobago, the average daily maximum temperature during the wet season is ~28.6 °C throughout the island (T1, T2 and S1) due to its small size and strong marine influence (**FIGURE 4.4**).

Several observations could be made from the spatial distribution of minimum daily temperatures for Trinidad and Tobago during the dry season (**FIGURE 4.5**) for the decade 2000–2010. In Trinidad, except for the north-eastern tip of the island near Toco and the north-western peninsula near Diego Martin where the elevation of the Northern Range and marine influence combine to produce cooler temperatures, and the south-western peninsula near Point Fortin, the minimum temperatures are ~24 °C. However, minimum daily temperatures for the rest of the island are steady at ~27 °C (Zones T1, T2 and S1) (**FIGURE 4.5**).

As for Tobago, the average daily minimum temperature during the dry season is also steady at ~27.0 °C throughout the island, except for pockets of slightly warmer temperatures near Plymouth and Roxborough. (Zones T1, T2 and S1) This is due to its small size and strong marine influence (**FIGURE 4.5**).

Several observations can be made from the spatial distribution of minimum daily temperatures for Trinidad and Tobago during the wet season (**FIGURE 4.6**) for the decade 2000–2010. For Trinidad, except for the north-eastern tip of the island near Toco, the

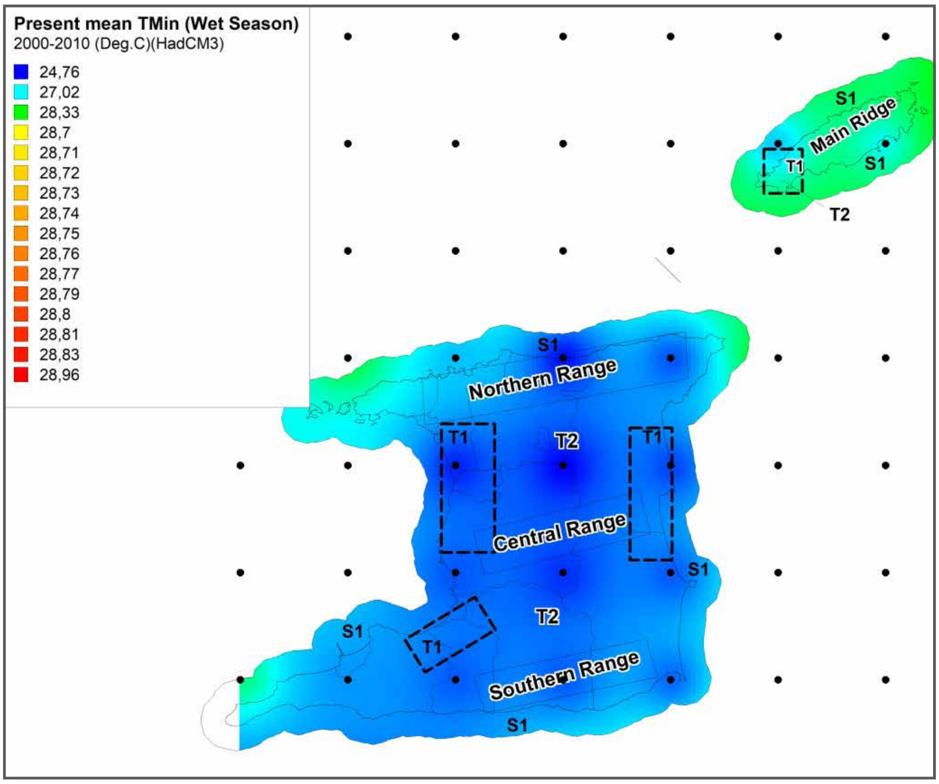


FIGURE 4.6 Spatial distribution of minimum daily temperatures for Trinidad and Tobago during the Wet season for the decade 2000–2010 according to the downscaled HadCM3 climate model

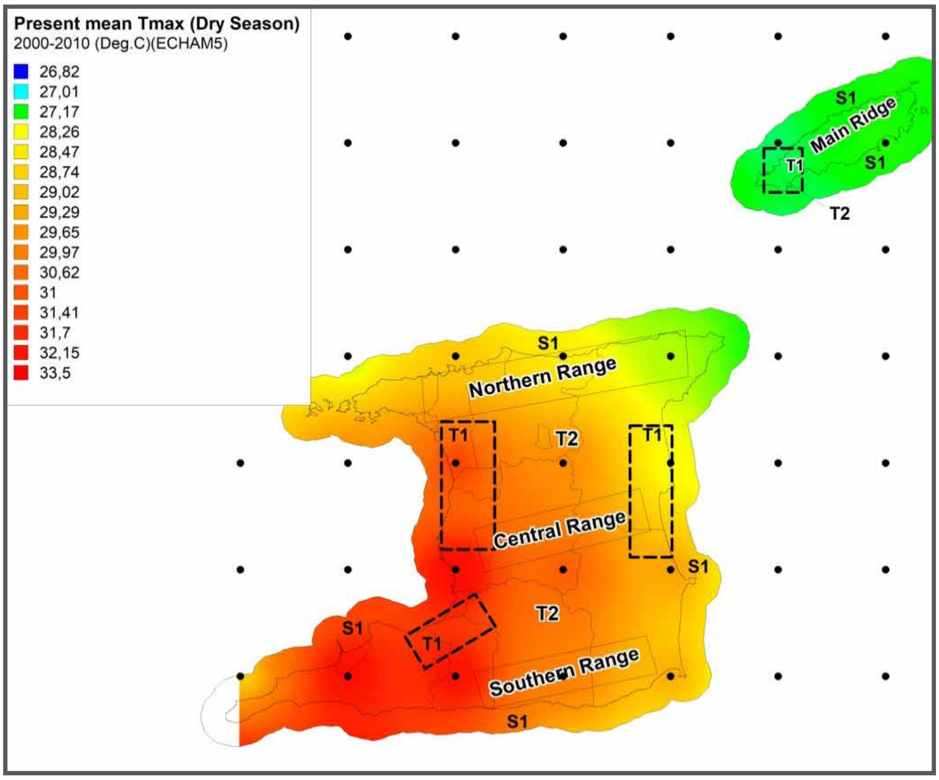


FIGURE 4.7 Spatial distribution of maximum daily temperatures for Trinidad and Tobago during the Dry season for the decade 2000–2010 according to the downscaled ECHAM5 climate model

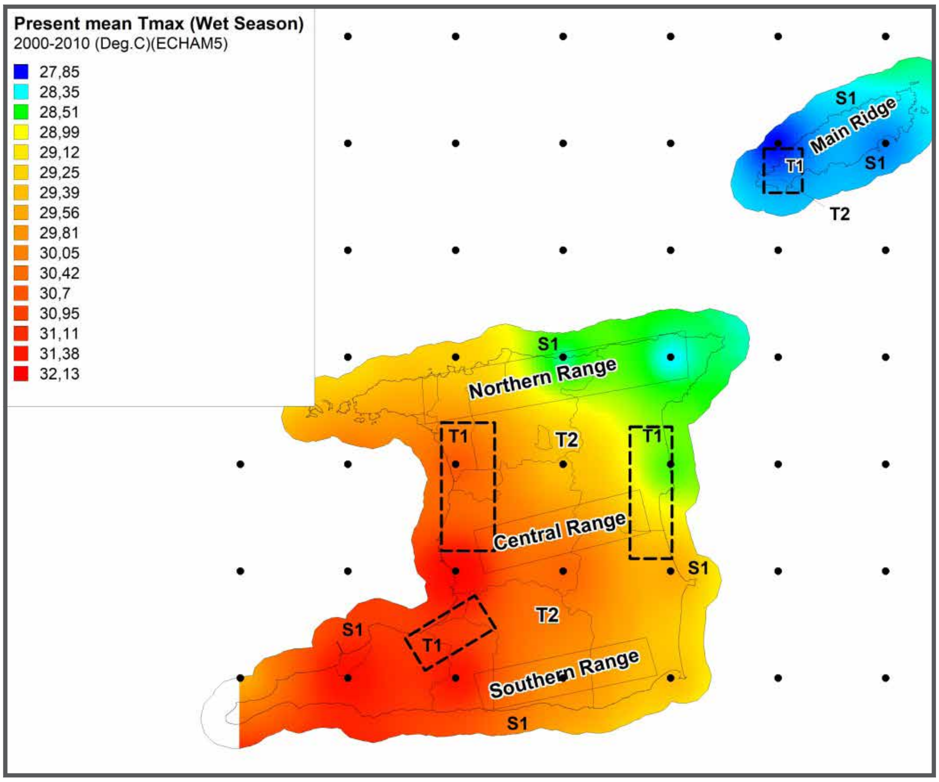


FIGURE 4.8 Spatial distribution of maximum daily temperatures for Trinidad and Tobago during the Wet season for the decade 2000–2010 according to the downscaled ECHAM5 climate model

north-western peninsula near Diego Martin, and the south-western peninsula near Point Fortin, the minimum temperatures are ~26.3 °C. However, for the rest of the island, minimum daily temperature anomalies are generally ~24.7 °C (Zones T1, T2 and S1) (**FIGURE 4.6**).

For Tobago, the average daily minimum temperature anomaly during the wet season is also steady at ~28.0 °C throughout the island, except for pockets of slightly cooler temperatures near Plymouth and Roxborough (Zones T1, T2 and S1). This is due to its small size and strong marine influence (**FIGURE 4.6**).

ECHAM5 climate model

The spatial distribution of maximum daily temperatures for Trinidad and Tobago during the dry season (**FIGURE 4.7**) for the decade 2000–2010 shows that for Trinidad, except for the north-eastern tip of the island near Toco where the marine influence leads to cooler temperatures of ~27 °C, maximum daily temperatures for the eastern half of the island vary between ~28 °C and ~29 °C and even up to ~33 °C over local microclimates along the west coast of the island (Zones T1, T2 and S1). This is due to a combination of dry conditions and less forest cover (**FIGURE 4.7**).

For Tobago, the average daily maximum temperature during the dry season is uniformly ~27.0 °C throughout the island (Zones T1, T2 and S1) due to its small size and strong marine influence (**FIGURE 4.7**).

The spatial distribution of maximum daily temperatures for Trinidad and Tobago during the wet season (**FIGURE 4.8**) for the decade 2000–2010 shows that for Trinidad, except for the north-eastern tip of the island covering parts of Saint George, Saint David and Saint Andrew counties where the combination of elevation of the Northern Range and marine influence produces cooler temperatures of ~28.5 °C, maximum daily temperatures again vary between ~29 °C and ~32 °C over most of the island (Zones T1, T2 and S1) (**FIGURE 4.8**).

For Tobago, the average daily maximum temperature during the wet season is ~27.8 °C throughout most of the island due to its small size and strong marine influence, except the north-east tip of the island near Charlotteville where the maximum temperature anomaly is ~28.5 °C due to the marine influence (Zones T1, T2 and S1) (**FIGURE 4.8**).

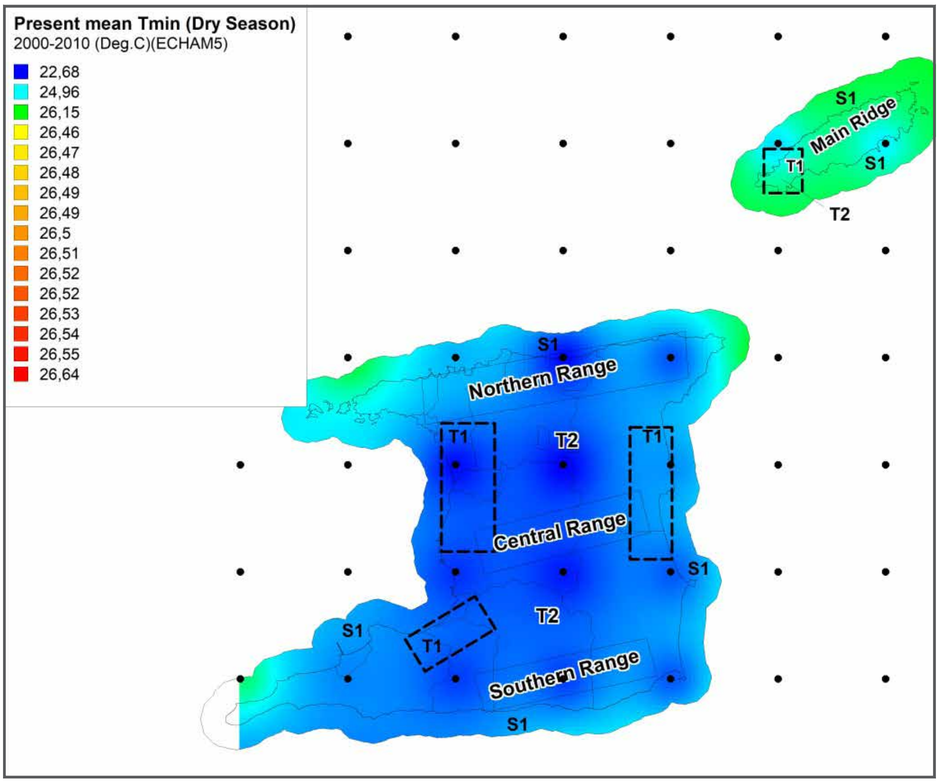


FIGURE 4.9 Spatial distribution of minimum daily temperatures for Trinidad and Tobago during the Dry season for the decade 2000–2010 according to the downscaled ECHAM5 climate model

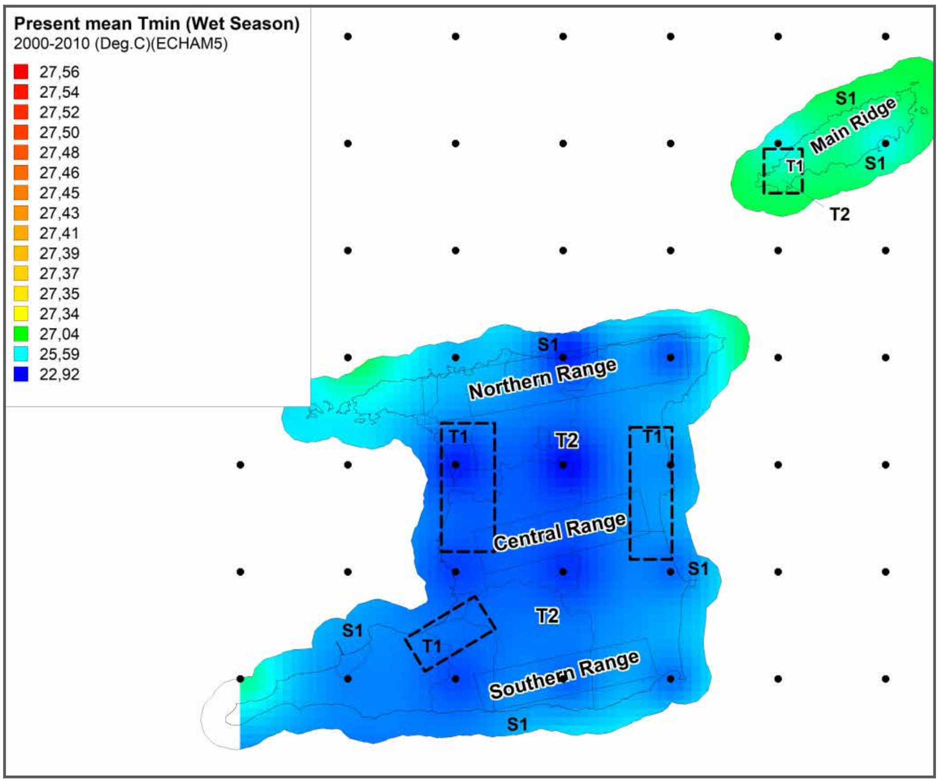


FIGURE 4.10 Spatial distribution of minimum daily temperatures for Trinidad and Tobago during the Wet season for the decade 2000–2010 according to the downscaled ECHAM5 climate model

The spatial distribution of minimum daily temperatures for Trinidad and Tobago during the dry season (**FIGURE 4.9**) for the decade 2000–2010 shows that for Trinidad, except for the north-eastern tip of the island near Toco, the north-western peninsula near Diego Martin and the south-western peninsula near Cedros, the minimum temperatures are generally ~23 °C to ~24 °C (Zones T1, T2 and S1) (**FIGURE 4.9**).

For Tobago, the average daily minimum temperature during the dry season is also steady at ~26.0 °C throughout the island, except for pockets of slightly warmer temperatures near Plymouth and Roxborough (Zones T1, T2 and S1). This is due to its small size and strong marine influence (**FIGURE 4.9**).

The spatial distribution of minimum daily temperatures for Trinidad and Tobago during the wet season (**FIGURE 4.10**) for the decade 2000–2010 shows that for Trinidad, except for the north-eastern tip of the island near Toco, the north-western peninsula near Diego Martin and the south-western peninsula near Cedros, the minimum temperatures are ~23 °C to ~ 25.5 °C (Zones T1, T2 and S1) (**FIGURE 4.10**).

For Tobago, the average daily minimum temperature anomaly during the wet season is also steady at ~25.5 °C throughout the island, except for pockets of slightly cooler temperatures near Plymouth and Roxborough (Zones T1, T2 and S1). This is due to its small size and strong marine influence (**FIGURE 4.10**).

Rainfall

HadCM3 climate model

The spatial distribution of seasonal rainfall for Trinidad and Tobago during the dry season (**FIGURE 4.11**) for the decade 2000–2010, shows that for Trinidad, the eastern half of the island generally receives rainfall of ~250 mm, except for the south-eastern tip of the island where dry season rainfall reaches ~300 mm. This is most likely due to the marine influence advected by the Trade Winds. On the other hand, the western sheltered half of the island receives ~189 mm of rainfall per dry season and certain areas near the north-western and south-western peninsulas receive lesser amounts of <189 mm of dry season rainfall (Zones T1, T2 and S1) (**FIGURE 4.11**).

In Tobago, the average seasonal rainfall during the Dry season is generally ~250 mm throughout the island, except for a pocket of slightly higher seasonal rainfall

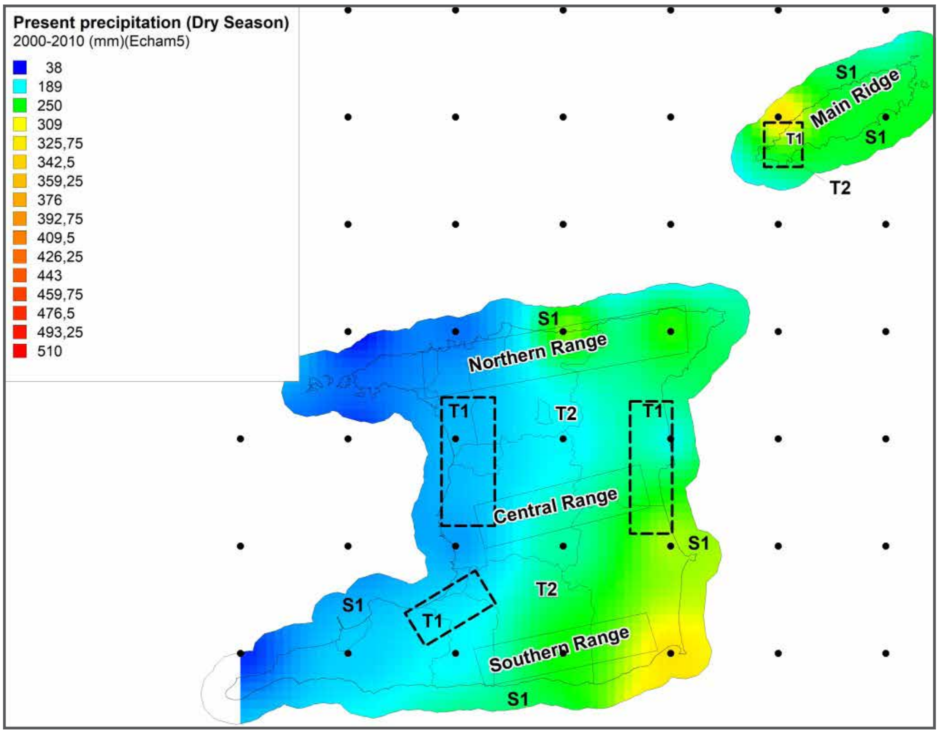


FIGURE 4.11 Spatial distribution of seasonal rainfall for Trinidad and Tobago during the Dry season for the decade 2000–2010 according to the downscaled HadCM3 climate model

of ~309 mm near Plymouth (Zones T1, T2 and S1). This is due to its small size and strong marine influence, according to the downscaled HadCM3 climate model (**FIGURE 4.11**).

ECHAM5 climate model

Alternatively, according to the downscaled ECHAM5 climate model, the spatial distribution of mean daily temperatures for Trinidad and Tobago during the dry season (**FIGURE 4.12**) for the decade 2000–2010 shows that for Trinidad, mean daily temperatures vary between ~ 27 °C and ~ 28 °C. The cooler temperatures (~ 27 °C) are found in the eastern quadrant of the island in the County of Saint David and in parts of the counties of Saint George and Victoria as well as the counties of Saint Andrew, Nariva and Mayaro (zones T1, T2 and S1). This is due to a combination of elevation (Northern Range) and the marine influences advected by the prevailing north-east trade winds. For the western half of the island, covering the counties of Caroni, Victoria, Saint Patrick and parts of the County of Saint George, temperatures are warmer (~28 °C) (zones T1, T2 and S1) due to a combination of lower elevation and shelter from the cooling north-east trade winds. In between there is a transition zone (green) stretching from the County of Saint George all the way to the County of Mayaro where the average daily temperature is ~ 26.5 °C (**FIGURE 4.12**).

As for Tobago, the average daily temperature during the dry season is ~ 26 °C throughout (T1, T2 and S1) according to the ECHAM5 climate model, due to its small size and strong marine influence (**FIGURE 4.12**).

Summary of Future Extremes

The selected climate variables, namely maximum and minimum temperatures, precipitation and water excess (positive P-E) and water deficits (negative P-E) were mapped for the dry and the wet seasons and their anomalies centred on the decade 2025–2035 to represent 2030 and on the decade 2045–2055 to represent 2050 for both the downscaled HadCM3 and ECHAM5 global climate models.

Temperature

From an analysis of the models, mean, maximum and minimum temperatures are projected to increase by ~0.5 °C to ~1.0 °C by 2030 and by ~1.0 °C to ~1.5 °C by 2050 in Trinidad and Tobago.

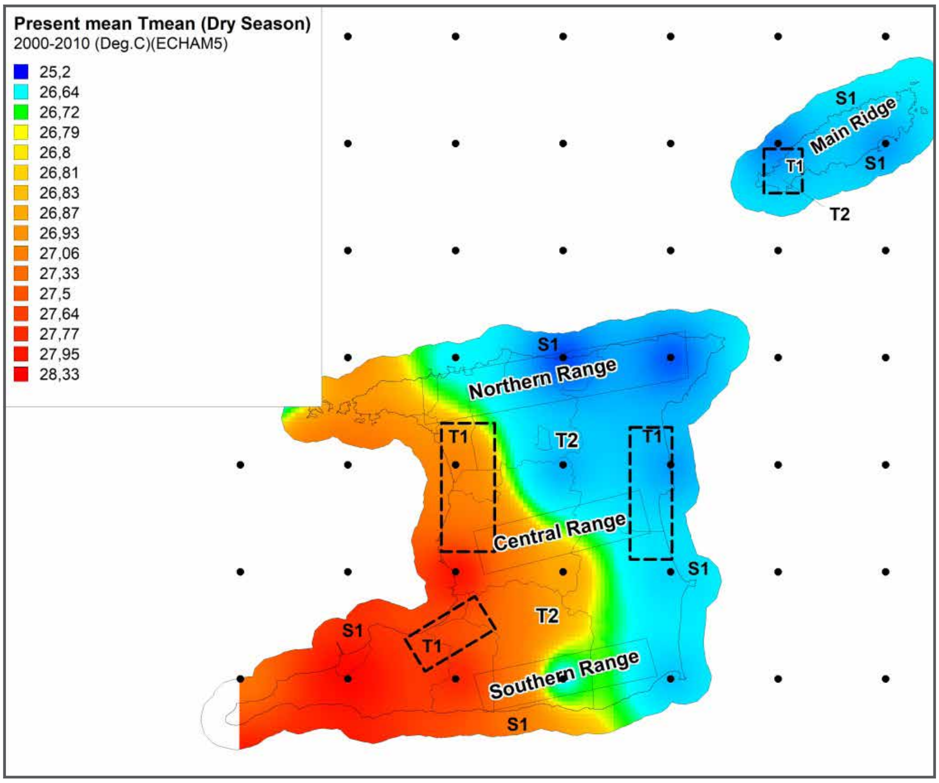


FIGURE 4.12 Spatial distribution of mean daily temperatures for Trinidad and Tobago during the Dry season for the decade 2000–2010 according to the downscaled ECHAM5 climate model

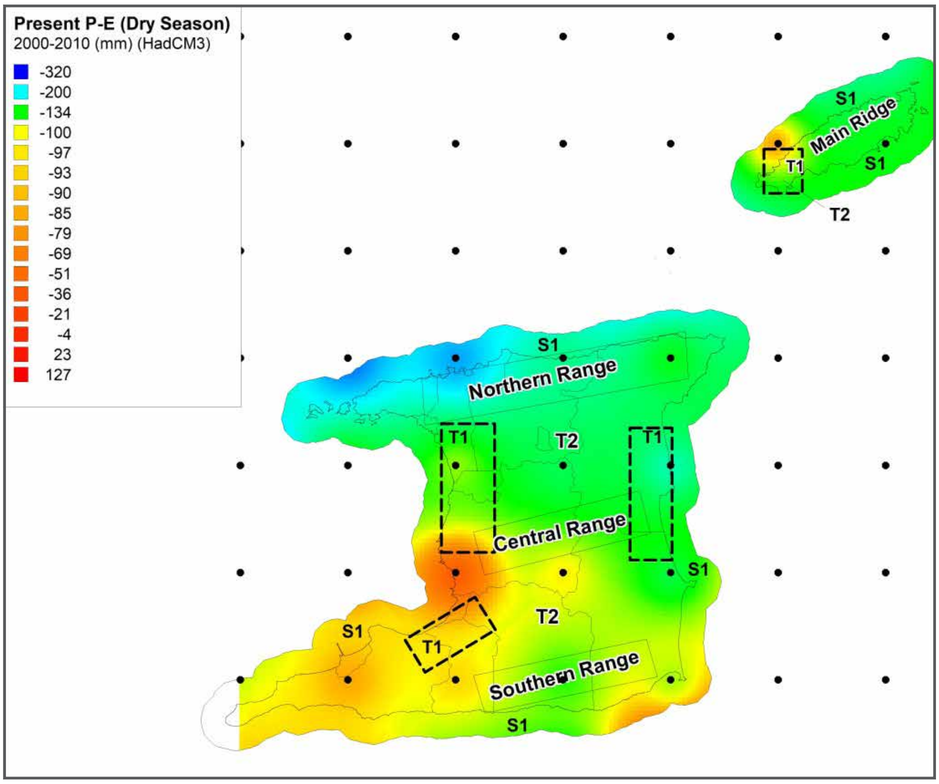


FIGURE 4.13 Spatial distribution of seasonal water excess (positive P-E) and water deficits (negative P-E) for Trinidad and Tobago during the Dry season for the decade 2000–2010 according to the downscaled HadCM3 climate model

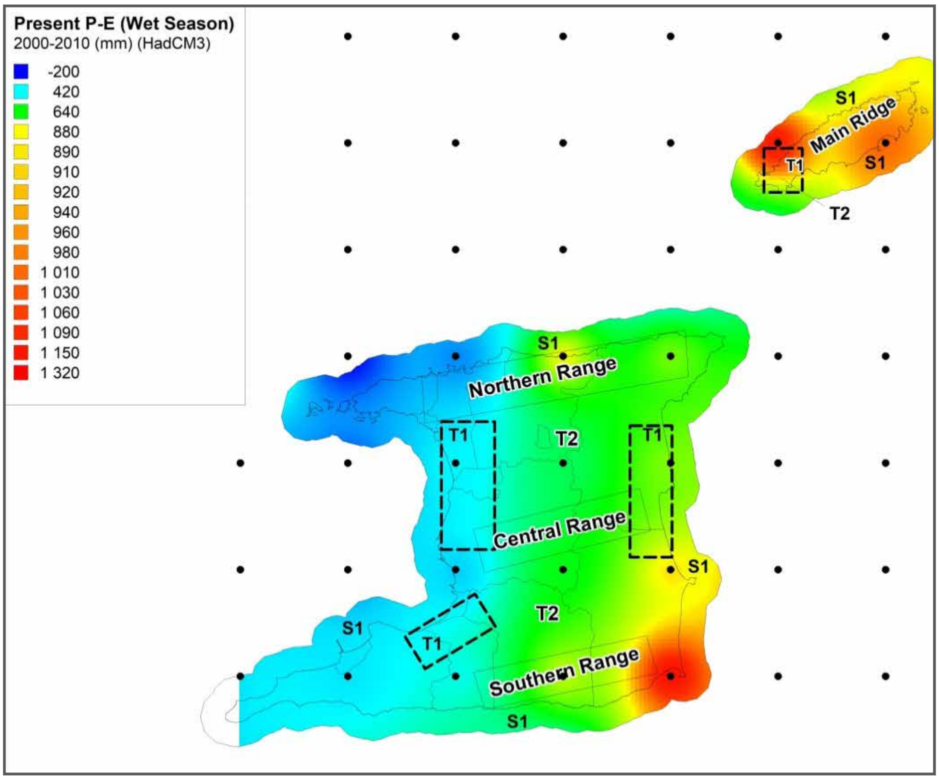


FIGURE 4.14 Spatial distribution of seasonal water excess (positive P-E) and water deficits (negative P-E) for Trinidad and Tobago during the Wet season for the decade 2000–2010 according to the downscaled HadCM3 climate model

Rainfall

HadCM3 climate model

The spatial distribution of seasonal water excess (positive P-E) and water deficit (negative P-E) for Trinidad and Tobago during the dry season (**FIGURE 4.13**) for the decade 2000–2010, shows that for both Trinidad and Tobago the dry season is characterised by water deficit (negative P-E) and hence the risk of drought conditions. For Trinidad, most of the island experiences a water deficit (negative P-E) of –134 mm during the dry season. An area along the north-western peninsula (Zones T1 and S1) experiences a water deficit (negative P-E) of –200 mm. Further, areas in the southern part of the counties of Caroni as well as Victoria and Saint Patrick as well as south-eastern Mayaro experience water deficits (negative P-E) that range from –69 mm to –100 mm during the dry season (**FIGURE 4.13**).

In Tobago, the whole of the island experiences a water deficit (negative P-E) of –134 mm, except for a localised point near Plymouth where the water deficit is (negative P-E) –90 mm during the dry season (T1, T2 and S1) (**FIGURE 4.13**).

The spatial distribution of seasonal water excess (positive P-E) and water deficit (negative P-E) for Trinidad and Tobago during the wet season (**FIGURE 4.14**) for the decade 2000–2010, shows that for both Trinidad and Tobago the season is characterised by water excess (positive P-E) resulting in the risk of flooding conditions. In Trinidad, the eastern half of the island covering the counties of Saint David, Saint Andrew, Nariva and parts of Saint George experiences a water excess (positive P-E) hovering around ~640 mm during the wet season. In Mayaro, however, there is a water excess (positive P-E) of > 1100 mm during the wet season (Zones T1, T2 and S1). Over the western half of the island, including the counties of Caroni and Saint Patrick and in parts of Saint George and Victoria, a water excess (positive P-E) of around ~420 mm can occur during the wet season (**FIGURE 4.14**).

In Tobago, the entire island experiences a water excess (positive P-E). Along the south-west coast the water excess (positive P-E) hovers around ~640 mm during the wet season. However, for the rest of the island the water excess (positive P-E) ranges from

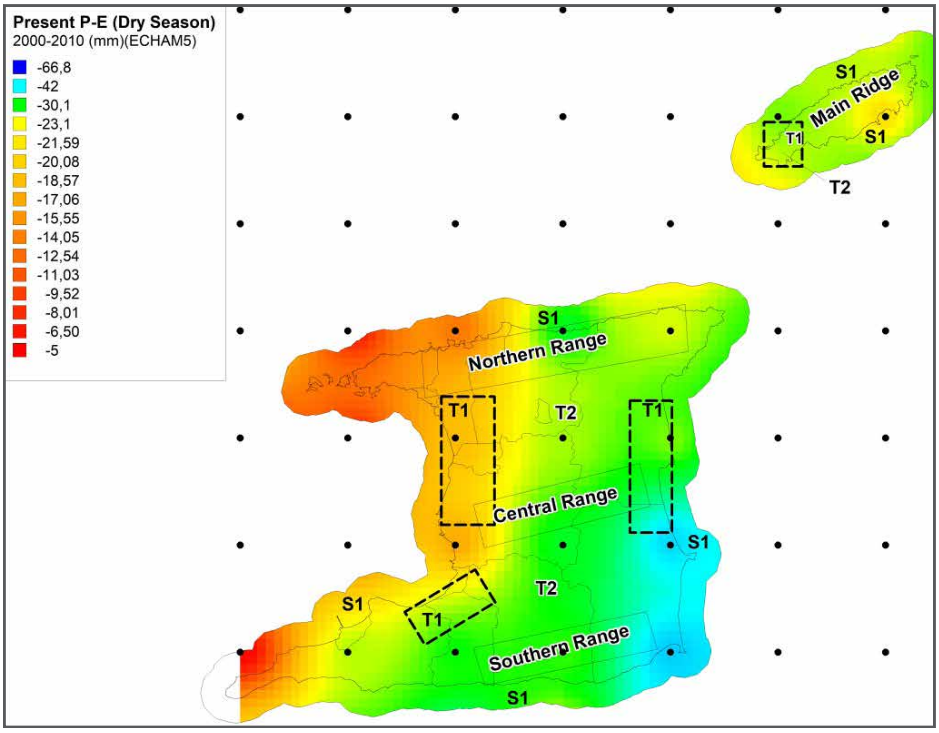


FIGURE 4.15 Spatial distribution of seasonal water excess (positive P-E) and water deficits (negative P-E) for Trinidad and Tobago during the Dry season for the decade 2000–2010 according to the downscaled ECHAM5 climate model

~940 mm to ~1060 mm during the wet season (Zones T1, T2 and S1). An area of extreme water deficit is also observed on the extreme north-west peninsula (**FIGURE 4.14**).

ECHAM5 climate model

The spatial distribution of seasonal water excess (positive P-E) and water deficit (negative P-E) for Trinidad and Tobago during the dry season (**FIGURE 4.15**) for the decade 2000–2010 shows that for both islands the dry season is characterised by water deficit (negative P-E) resulting in the risk of drought conditions. For Trinidad, most of the eastern part of the island experiences a water deficit (negative P-E) of –30 mm during the dry season but an area along the south-east coast in Mayaro experiences a water deficit (negative P-E) of –42 mm. Further, areas in the western part of the island encompassing parts of Saint George and Caroni, Victoria and Saint Patrick experiences water deficits (negative P-E) that range from –8 mm to –23 mm during the dry season (Zones T1, T2 and S1) (**FIGURE 4.15**).

For Tobago, the entire island experiences a water deficit (negative P-E) that ranges from –23 mm to –30 mm during the dry season (Zones T1, T2 and S1) (**FIGURE 4.15**).

The spatial distribution of seasonal water excess (positive P-E) and water deficit (negative P-E) for Trinidad and Tobago during the wet season (**FIGURE 4.16**) for the decade 2000–2010 shows that for both islands the wet season is characterised by water excess (positive P-E) with the risk of flooding conditions. For Trinidad, the eastern half of the island, including the counties of Saint David, Saint Andrew, Nariva and parts of Saint George and Mayaro, experiences a water excess (positive P-E) that is around 670 mm during the wet season. However, a water excess (positive P-E) of about 1,480 mm covers most of Mayaro during the wet season (Zones T1, T2 and S1). However, the western half of the island, including the counties of Caroni and Saint Patrick and parts of Saint George and Victoria, experiences a water excess (positive P-E) of around 450 mm during the wet season (**FIGURE 4.16**).

In Tobago, the entire island experiences a water excess (positive P-E) of approximately more than 1,000 mm, except for the north-western and south-eastern tips of the island where rainfall excess is about 670 mm (T1, T2 and S1) (**FIGURE 4.16**).

From the foregoing analyses, it was evident that the climate anomalies and quantiles would change

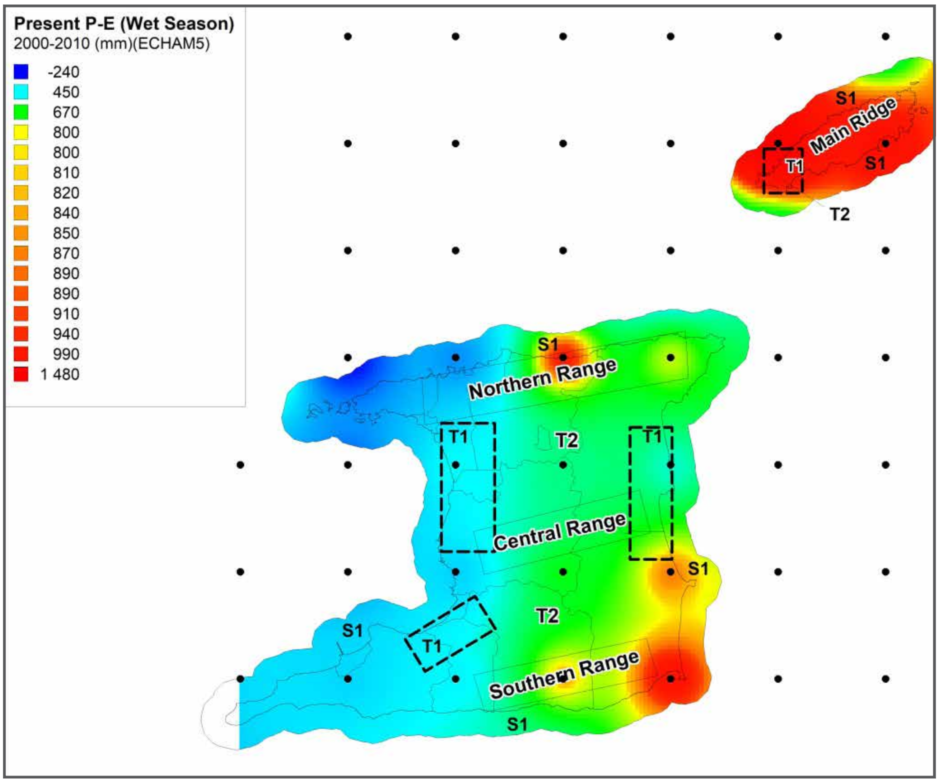


FIGURE 4.16 Spatial distribution of seasonal water excess (positive P-E) and water deficits (negative P-E) for Trinidad and Tobago during the Wet season for the decade 2000–2010 according to the downscaled ECHAM5 climate model

over Trinidad and Tobago in the future time periods, namely 2030 (2025–2035) and 2050 (2045–2055) and that these changes are more or less similar for the downscaled climate models (HadCM3 and ECHAM5).

By 2030, mean air temperature (Tmean) is expected to rise by ~0.5 °C, depending on climate model and location. On the other hand, by 2050 mean air temperature (Tmean) is expected to rise by ~1.0 °C, depending on climate model and location.

By 2030, maximum air temperature (Tmax) is expected to rise by ~1.0 °C to ~1.5 °C, depending on climate model and location. On the other hand, by 2050 maximum air temperature (Tmax) is expected to rise by ~1.5 °C to ~2.0 °C, depending on climate model and location.

By 2030, minimum air temperature (Tmin) is expected to rise by > 1.0 °C to > 1.5 °C, depending on climate model and location. On the other hand, by 2050 minimum air temperature (Tmin) is expected to rise by > 1.5 °C to > 2.0 °C, depending on climate model and location. This means that minimum temperatures that occur mainly at night in Trinidad and Tobago will rise slightly higher than maximum temperature (Singh, 1997b).

As for seasonal rainfall, it is expected to generally decrease slightly, especially in the dry season and more so by 2050 than 2030. Also, rainfall will become more variable with drier conditions in the dry season and slightly wetter conditions in the Wet season, especially by 2050. Lighter rainfall events are expected to decrease and heavier rainfall to increase, both by 2030 and 2050.

Insofar as water excess (+) and water deficits (–) are concerned, the slight decrease of stable rainfall amounts when combined with higher evaporation rates driven by higher temperature, water deficits (–) and more drought-like conditions are expected to be more common.

These changes in climate variables will have far-reaching impacts on several key sectors in the coastal zones (T1, T2 and S1) of Trinidad and Tobago, including water resources, agriculture and forestry, livestock and poultry, marine ecosystems and fisheries, coastal infrastructure and tourism in Tobago.

Future Climate (2030 and 2050)

According to the downscaled HadCM3 model for the 2025–2035 decadal period when compared to

TABLE 4.2 Projections for climate variables in 2030 and 2050

Climate variable	2030	2050
Mean air temperature	Expected to increase by ~0.5 °C	Expected to increase by ~1.0 °C
Maximum air temperature	Expected to rise between ~1.0 °C and ~1.5 °C	Expected to rise by between ~1.5 °C and ~2.0 °C
Minimum air temperature	Expected to rise by between > 1.0 °C and > 1.5 °C	Expected to rise by between > 1.5 °C and > 2.0 °C
Seasonal rainfall	Expected to decrease slightly, especially in the dry season	Expected to decrease slightly more than for 2030, especially in the dry season

the current decadal period, 2000–2010, the number of days with maximum temperatures in the range of 26 °C to 29 °C decreases significantly, especially those in the temperature range 27 °C to 28 °C which decrease by 179 days. On the other hand, the number of days with maximum temperatures in the range of 29 °C to 33 °C increases significantly especially in the temperature range 29 °C to 30 °C which increases by 924 days.

Similarly, according to the downscaled HadCM3 model for the 2045–2055 decadal period when compared to the current decadal period, 2000–2010, there is again a significant decrease in the number of days with maximum temperatures in the range of 29 °C to 30 °C (–1,363 days) and in the range 28 °C to 29 °C (–1,382 days). On the other hand, the number of days with maximum temperatures in the range of 30 °C to 31 °C (963 days) and 28 °C to 29 °C (1,382 days) increases significantly.

It is evident then that there is definitely a shift towards higher maximum air temperatures for the grid point near the Piarco station (observed data) in the future (2030 and 2050) according to the data simulated by the HadCM3 model.

TABLE 4.2 summarises the results of the analyses for the climate variables. The ranges and approximation of the results are dependent on climate model and location within Trinidad and Tobago.

The slight decrease of stable rainfall amounts, when combined with higher evaporation rates driven by higher temperature, suggests that water deficits and more drought-like conditions will be more common.

These changes in climate variables will have far-reaching impacts on several key sectors in the coastal zones (T1, T2 and S1) of Trinidad and Tobago, including water resources, agriculture and forestry, livestock and poultry, marine ecosystems and fisheries, coastal infrastructure and tourism in Tobago.

Temperature

According to the downscaled HadCM3 model for the 2025–2035 decadal period when compared to the current decadal period, 2000–2010, the number of days with minimum temperatures in the range of 25 °C to 26 °C (–454 days) and 26 °C to 27 °C (–156 days) decreases significantly, whereas the number of days with minimum temperatures in the range of 27 °C to 29 °C increases significantly, especially for the temperature range 27 °C to 28 °C (1,119 days).

Similarly, according to the downscaled HadCM3 model for the 2045–2055 decadal period when compared to the current decadal period, 2000–2010, there is again a significant decrease in the number of days with minimum temperatures in the range of 24 °C to 27 °C, especially for the temperature ranges 25 °C to 26 °C (–487 days) and 26 °C to 27 °C (–856 days), whereas the number of days with minimum temperatures in the range of 27 °C to 30 °C increases significantly, especially for the temperature range 28 °C to 29 °C (1,834 days).

It is again evident then that there appears to be a highly likely shift towards higher minimum air temperatures for the grid point near the Piarco station in the future (2030 and 2050) according to the HadCM3 model.

According to the downscaled HadCM3 model for the 2025–2035 decadal period when compared to the current decadal period, 2000–2010, the number of days with minimum temperatures in the range of 25 °C to 28 °C decreases significantly, especially for the temperature ranges 26 °C to 27 °C (−473 days), and 27 °C to 28.0 °C (−889 days) while the number of days with minimum temperatures in the range of 28 °C to 30 °C increases significantly.

Similarly, according to the downscaled HadCM3 model for the 2045–2055 decadal period when compared to the current decadal period, 2000–2010, there is again a significant decrease in the number of days with maximum temperatures in the range of 25.5 °C to 28.5 °C, especially for the temperature ranges 26.5 °C to 27 °C (−377 days), 27 °C to 27.5 °C (−653 days) and 27.5 °C to 28.0 °C (−582 days). On the other hand, the number of days with minimum temperatures in the range of 28 °C to 30 °C increases significantly, especially for the temperature ranges 28.5 °C to 29 °C (742 days), 29 °C to 29.5 °C (817 days) and 29.5 °C to 30.0 °C (132 days).

Again, there appears to be a highly likely shift towards higher minimum air temperatures in the future (2030 and 2050) mostly occurring at night, near the Crown Point station, according to the HadCM3 model.

Rainfall

According to the downscaled HadCM3 model for the 2025–2035 decadal period when compared to the current decadal period, 2000–2010, the number of days with little or no rainfall (0.00 mm/day) increases (55 days) and rainfall in the range of 0 to 10 mm/day decreases (−66 days), both of which are indicative of drier and more drought-like conditions. On the other hand, the number of days with more intense rainfall in the range of 10.00 to 20 mm/day increases (11 days). Both of these conditions demonstrate more extreme rainfall conditions in 2025 to 2035, drier on the one hand and more intense rainfalls on the other.

Similarly, according to the downscaled HadCM3 model for the 2045–2055 decadal period when compared to the current decadal period, 2000–2010, the number of days with little or no rainfall (0.00 mm/day) increases (101 days) and rainfall in the range of 0 to 10 mm/day decreases (−105 days), both of which are again indicative of drier and more drought-like conditions. On the other hand, the number of days with more intense rainfall in the range of 10.00 to 20 mm/day increases (5 days), though now to a lesser extent. Again, both of these conditions also demonstrate more extreme rainfall conditions in 2045 to 2055, drier on the one hand and more intense rainfalls on the other. These projections are likely to have implications for water management and water security as well as flooding and associated impacts.

According to the downscaled ECHAM5 model for the 2025–2035 decadal period when compared to the current decadal period, 2000–2010, the number of days of rainfall generally decreases with the largest decreases affecting days with more intense rainfalls in the range of 0.00 to 20 mm/day increases (−25 days) and 20–40 mm/day (−8 days).

Similarly, according to the downscaled ECHAM5 model for the 2045–2055 decadal period when compared to the current decadal period, 2000–2010, the number of days of rainfall again generally decreases with the largest decreases affecting the days with more intense rainfalls in the range of 0.00 to 20 mm/day increases (−130 days) and 20–40 mm/day (−7 days).

For both of these time slices (2025–2035 and 2045–2055) it shows that there will be a general decrease in rainfall and that this decrease in rainfall affects the more intense rainfall classes.

4.4 Assessment of Risks from Coastal Erosion, Sea Level Rise and Storm Surges

Coastal systems behave non-linearly and may not respond incrementally or proportionally to a rising sea level or related changes, or show any decline or migration until an intrinsic threshold triggering a response is reached. This non-linear behaviour of the coast and non-linearity of coastal retreat add to the uncertainty associated with adaptation to climate-driven sea level rise. Whereas episodes of rapid shoreline change and wetland losses during recent decades have been reported, there are still difficulties in attributing the proportional contributions from human activity as opposed to sea-level rise in the 20th century (Olsson et al., 2014; Singh, 1997b).

Photo Credit: Lori Lee Lum, Institute of Marine Affairs

▲ Coastal erosion can be exacerbated by sea level rise and storm surge, 2011

Coastal Erosion

Historic Erosion or Accretion Rates: Trinidad

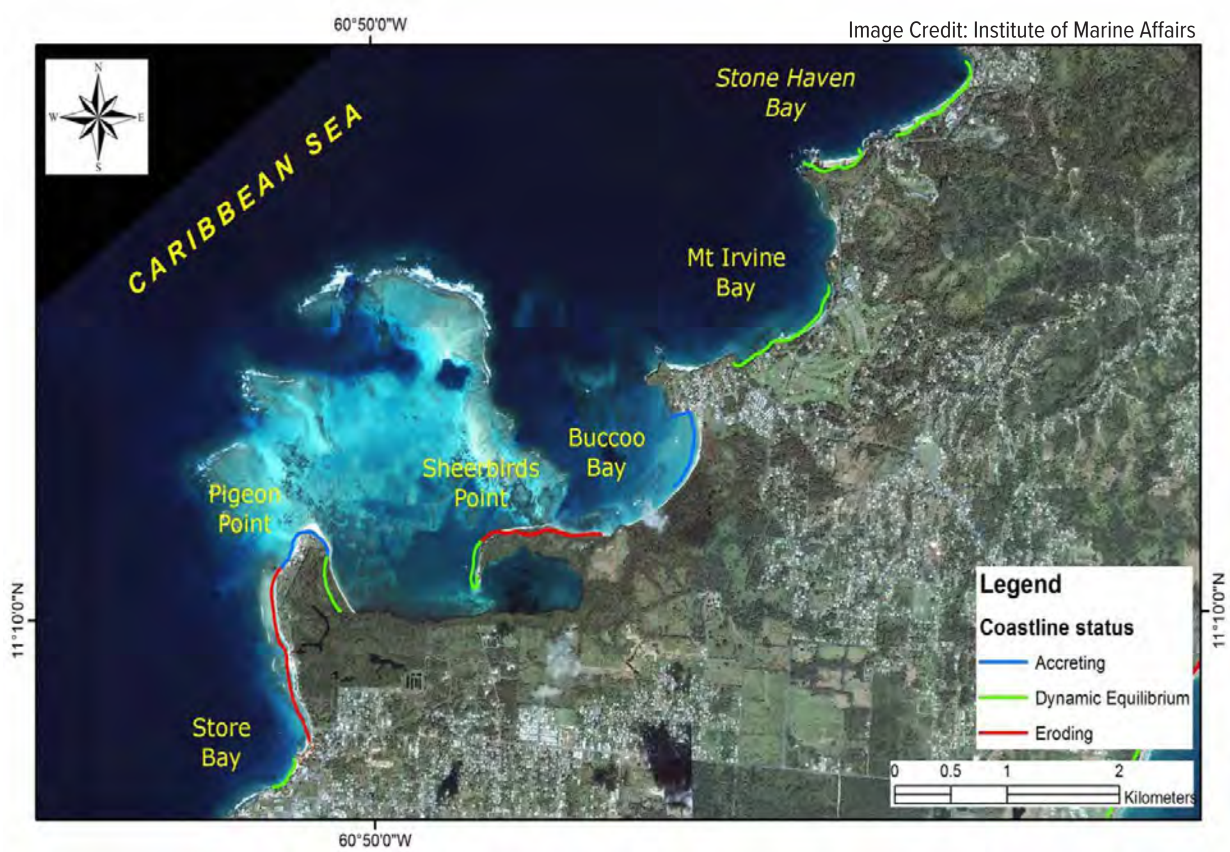
Beaches and dynamic coastal headlands respond differently to wind, waves, currents, tides and the occasional storm, depending on their geology. Where the coastal geology is resistant to wave attack, erosion may occur at a reduced rate and where the geology is less resistant, it would likely erode at a faster rate. In the case of Trinidad, the north coast consists mainly of rocky cliffs, while the west coast is rocky to the north, consists of wetlands (Caroni and Oropouche) and mudflats at its central region, and alluvium material toward the south end. On the other hand, the south coast consists mainly of sandstone cliffs while the east coast is variable and consists of cliffs to the north, wetlands (Nariva) and cliffs towards the central and southern regions (IMA, 2016).

Photo Credit: Institute of Marine Affairs

Coastal erosion, Trinidad, 2007 ▲

In Trinidad, most of the beaches on the north coast, including Macqueripe, Maracas, Tyrico, Grande Riviere and Salybia are in dynamic equilibrium (DE), meaning that erosion is counterbalanced by accretion and net erosion rates were near zero during the period 2004–2008. It is only at Las Cuevas (–3.5m to –4.0 m in 2005) and Blanchisseuse (–1.35 m in 2005) that erosion was observed.

In the case of Trinidad's east coast, all of the beaches, including Guayamara, Saline, north and



▲ South West Region of Tobago showing Coastal Stability, 2017

central Cocos and Mayaro are in Dynamic Equilibrium (DE). It is only at south Cocos that erosion was observed (rates –3.20m in 2005 and –4.80m in 2008). Also, the south and western coasts of Trinidad have been experiencing severe erosion in recent years. For instance, Los Gallos Point in the south-west peninsula has been facing the highest levels of erosion for the past 37 years (Theodore, 2013).

Along the south coast of Trinidad, all beaches, including Guayaguayare East and Central, Quinam, Los Iros, Erin and Punta del Arenal are in dynamic equilibrium (DE), except for West Guayaguayare where erosion was consistently prevalent from 2005–2008 (–2.20m in 2006). On the other hand, Punta del Arenal showed a slight amount of accretion (+0.16m in 2005).

On the west coast of Trinidad, most of the beaches, including Columbus Bay, Granville, Irois, Guapo, La Brea, Dhein's Bay and Chagville are in dynamic equilibrium (DE). Only the beaches at Irois (North Chatham: –1.70m in 2007) and Guapo (S: –0.71 and SA: –2.95 m in 2007) are experiencing erosion.

Field studies conducted by Singh (1997) using beach profiles between 1990 and 1996 found significant erosion rates (2 to 4m per year) at some beaches in Trinidad, including South Cocos, Guayaguayare, Los Iros, Blanchisseuse, Saline and Icacos. It was only at Punta de Arenal that accretion was observed.

Current Erosion or Accretion Rates: Tobago

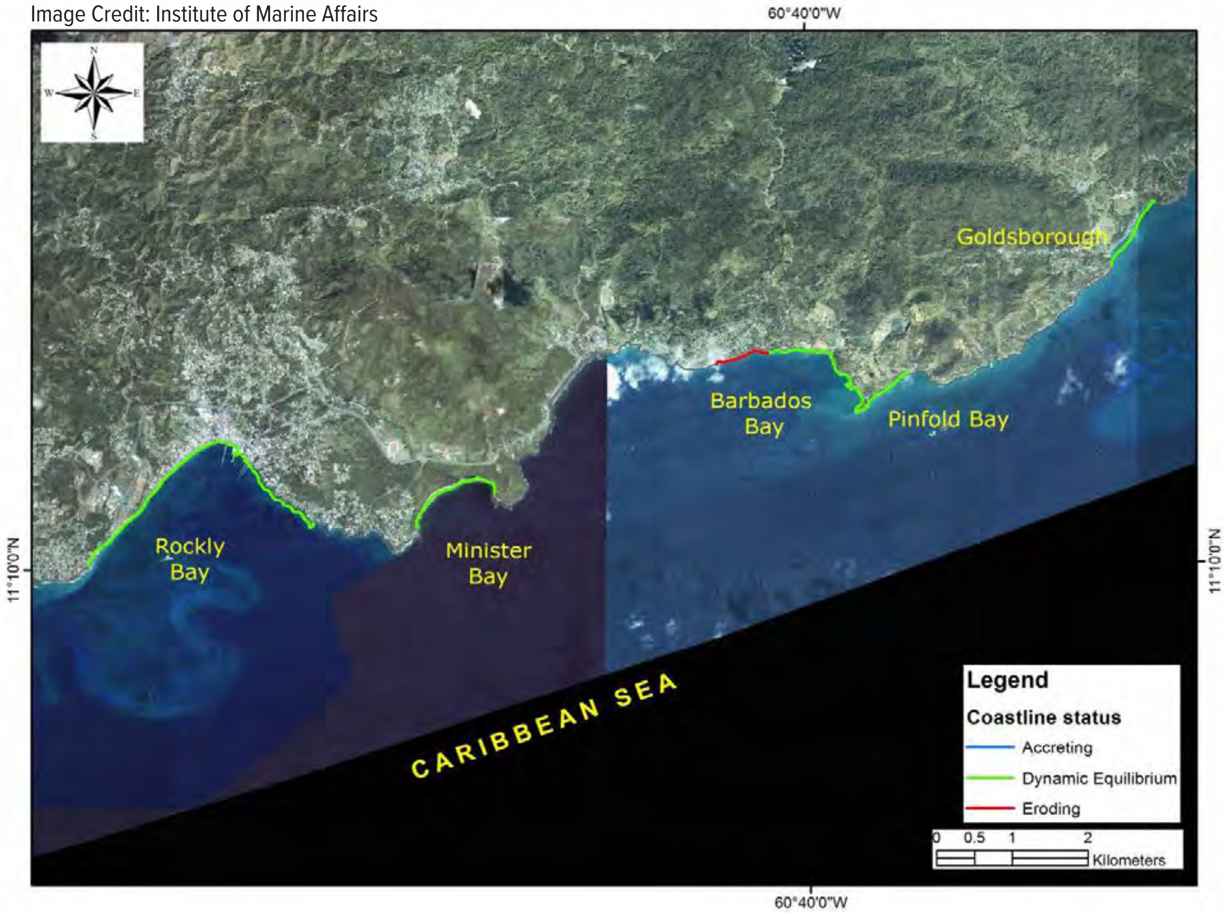
For Tobago, the coastline consists mainly of rocky cliffs at the central and north-eastern section of the island. The south-west of the island consists mainly of coral limestone and this results in a lesser degree of coastal erosion (Darsan et al., 2013).

For the Leeward Shoreline of Tobago, most of the beaches, including Store Bay, Sheebird's Point Mt. Irvine, Stone Haven, Great Courland, Arnos Vale, Culloden Bay, Castara Bay, Englishman's Bay, Parlatuvier, Bloody Bay and Man of War Bay are in dynamic equilibrium. However, there is net annual erosion at parts of Pigeon Point (3), Sheebird's Point (2), Buccoo Bay (2) and Parlatuvier. On the other hand, there is net annual accretion at Buccoo Bay (1).

Photo Credit: Ministry of Planning and Development

▲ Coastal erosion, Trinidad, 2013

Image Credit: Institute of Marine Affairs



▲ Eastern End of Goldsborough Bay shows Coastal Erosion, 2017

Most of the beaches on the Windward Shoreline of Tobago, including Anse Bateau, King's Bay, Goldsborough (1), Pinfold, Barbados Bay (1 and 2), Minister Bay, Rockly, Little Rockly, Canoe Bay and La Guira Bay are in dynamic equilibrium. Only Richmond Bay, Goldsborough (2) and Barbados Bay (3) show evidence of Net Annual Erosion.

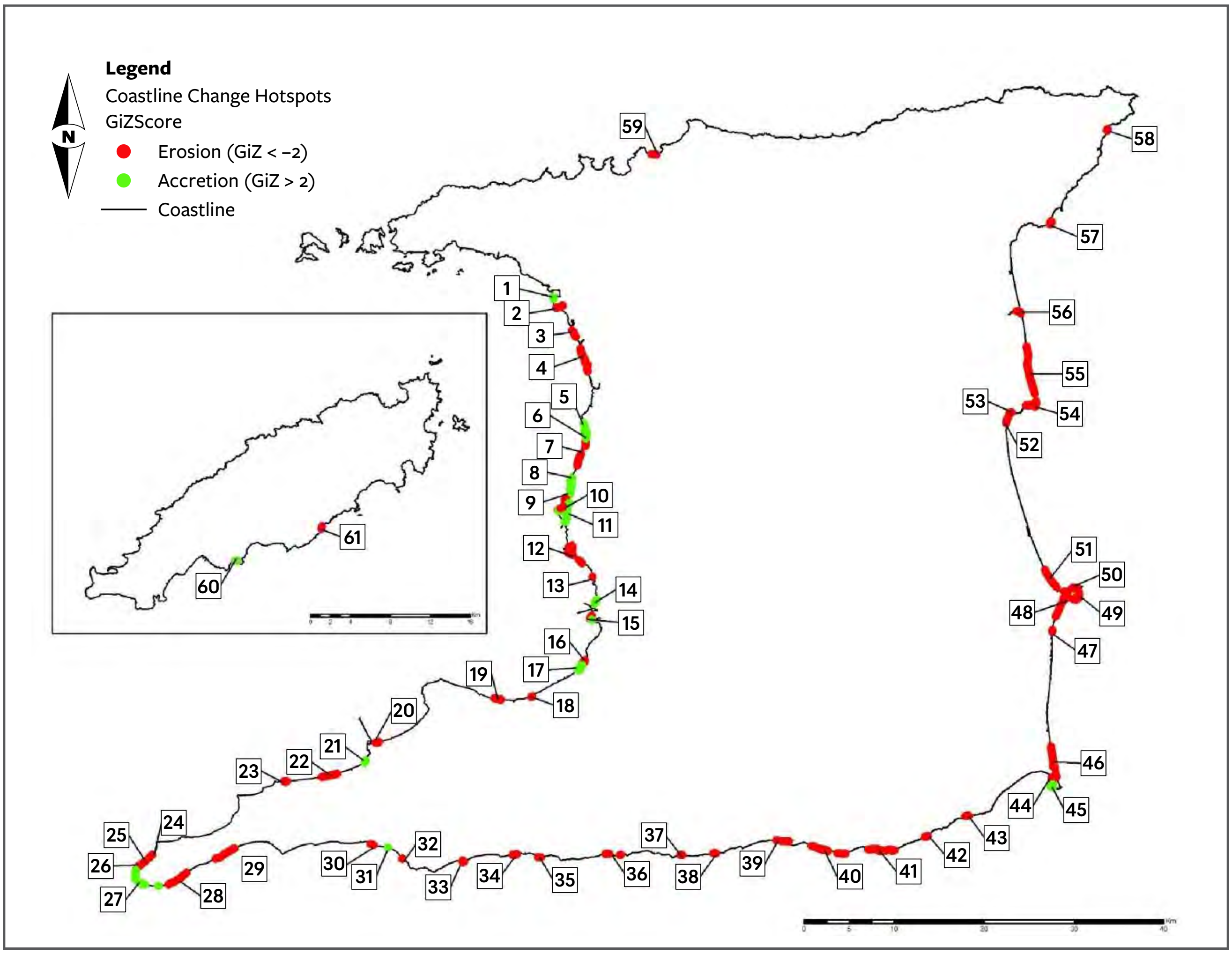
FIGURE 4.17 shows the coastline change erosion hotspots for Trinidad and Tobago. For Trinidad, most of the erosion hotspots are found along the Gulf of Paria and the Southern Atlantic coasts. The coastline change erosion hotspots along the Atlantic coast are fewer in number while along the north coast, the cliffed nature of the Northern Range limits erosion (Jehu & Ramsewak, 2012).

For Tobago, the erosion hotspots are limited to Windward Coastline at Minister Bay and Goldsborough Bay (Jehu & Ramsewak, 2012). Work conducted by the IMA also identified Canoe Bay, La Guira Bay, Pigeon Point, Sheebird's Point and Buccoo Bay as erosion hotspots in Tobago.

Sea level rise and storm surges

The different categories of storm surges as generated by a Category 2 and a Category 5 hurricane were superimposed on a Digital Terrain Model (DTM) of Trinidad and Tobago as shown in Figures 4.18–4.25.

These storms are usually accompanied by heavy rainfalls that can exacerbate the level of flooding. Also, the storm surge flooding by a Category 2 and a Category 5 hurricane may not be the result of a single event but the flooding maps are meant to show how the different coastlines and coastal zones (T1 and T2) of Trinidad and Tobago will be flooded, depending on the angle of attack of the storm surges.



Key = ID **Region** Description of change

WEST COAST

1 **Caroni Swamp (Northern End)** Accretion 1.2km north from the river mouth

2 **Caroni River** Erosion within the river, extending for 840m inland—attributed to dredging (Ramroop, 2005)

3 **Caroni Swamp (Blue River Region)** Erosion of seaward mangrove forests 440m south of the river

4 **Caroni Swamp (Aripo Point)** Erosion extending on both sides of the Guayama River mouth, mainly northward for 2.5km

5 **Barranconnes Bay** Accretion 780m south of Barranconnes Point

6 **La Cuesa River** Erosion extending from river mouth northwards for 610m

7 **Barranconnes River** Erosion extending from river mouth northwards for 1.5km—485m south of the Temple in the Sea

8 **Orange Valley** Accretion 1.2km south of Fisherman's Pier

9 **Cascajal Point** Erosion on both sides of the point mainly focused southward towards Carli Bay

10 **Carli Bay (Southern region)** Erosion from Cangrejos Point, extending northward for 750m

11 **Cangrejos/Couva Bay** Accretion of much of the Bay from the Couva River to the Point Lisas Industrial Port

12 **Point Lisas** Erosion on both sides of the point, extending southward to Claxton Bay

13 **Claxton Bay** Erosion 420m north of the Trinidad Cement Limited port facility

14 **Pointe-a-Pierre** Accretion 530m northward from the point

15 **Guaracara River Mouth** Small area of accretion at the river mouth with areas of erosion northward for 850m

16 **Cipero River Mouth** Erosion 260m northward from the river mouth

17 **Ally's Creek** Accretion on both sides of the river mouth at the creek

18 **Godineau River Mouth** Erosion 270m south-west of the river mouth

19 **Otaheite Bay** Erosion on the eastern end of the Roussillac Swamp

20 **Point Fortin** Erosion 180m west of the Point Fortin Jetty

FIGURE 4.17 Map illustrating the coastline change hotspots for Trinidad and Tobago (Source: Jehu & Ramsewak, 2012) ▲

21 **Point Ligoure** Accretion 480m south from the point
22 **Irois Bay (central region)** Erosion for 1.7km within the central area of the bay
23 **Irois Bay (Western region)** Erosion 1km from Point Rouge
24 **Columbus Bay (Central Region)** Erosion at the central region of the bay adjacent to the mangrove/swamp area
25 **Columbus Bay (Southern Region)** Erosion 290m north-east from the Estate extending towards the southem end of the mangrove swamp
26 **Corral Point** Erosion with complete removal of the point

SOUTH COAST

27 **Punta del Arenal** Accretion extending on both sides of Icacos Point—1km northward and south-west for 1.5km
28 **Icacos** Erosion along the seaward mangrove boundary 2km west of Icacos
29 **Galfa Point** Erosion extending westward but mainly eastward into Islote Bay
30 **Quoin Cliff** Erosion west of point
31 **Puerto Grande** Accretion 1.3km east from Quoin Cliff
32 **Frank Bay** Erosion at west point near outflow of Erin River
33 **Anglais Point** Vegetation cleared east of point
34 **Between Chagonaray Point and Palmiste Point** Erosion 1.5km east of Chagonaray Point
35 **Palmiste Point** Erosion to the east and west of point
36 **Between Siparia Point and Negra Point** Erosion in central areas, 2.6km & 4.1km east of Siparia Point
37 **Point Negra** Erosion 1km east of point
38 **Point Curao** Erosion 1.1km west of point
39 **Moriquite Point** Erosion to the east and west of point
40 **Alcatras Point** Erosion intermittent westward from the point for 4km
41 **Between Canari Point and C. Casa Cruz** Erosion almost continuous between both points
42 **Tablas Point** Erosion from the Point extending westward
43 **Casse Cou Point** Erosion 480m east of point
44 **Guayaguayare Bay** Erosion along eastern end of bay
45 **Guayaguayare Bay** Accretion on northern end of port facility

EAST COAST

46 **Mayaro Bay (Southern End)** Erosion starts 1.4km from Galeota Point to south of Navet River
47 **Mayaro Bay (Plaisance)** Erosion for approximately 300m of shoreline
48 **Mayaro Bay (Northern End)** Erosion along coast of St. Joseph district intermittently for 3.8km southward from Mayaro Point
49 **Mayaro Point** Erosion both westward and eastward extending towards Guatauro Point
50 **Guatauro Point** Erosion eastward 900m from point towards the Ortoire River outflow
51 **Cocos Bay (Southern End)** Erosion for approximately 2.5km of shoreline starting 400m from Ortoire River outflow
52 **Cocos Bay (Northern End)** Erosion present for several areas towards the north and south of Recreation Facility
53 **Cocos Bay (L'Ebranche River Outflow)** Erosion in the northern corner of Cocos Bay on both sides of the river mouth
54 **Manzanilla Bay/Manzanilla Point** Erosion towards the eastern end of the bay—extending towards Manzanilla Point
55 **Mathura Bay (Southern End)** Erosion 650m from Manzanilla Point extending past Point Paloma
56 **Mathura Bay (Central Region)** Erosion at the mouth of the Oropouche River, including along its bank 250m from the mouth
57 **La Palie** Erosion at the cape extending towards the southern tip of Balandra Bay
58 **Cumana Bay** Erosion at the southern extent of the bay within the proximity of Dopsion Point

NORTH COAST

59 **Las Cuevas Bay** Erosion from the central to portions of the western end mainly associated with change at the mouth of the Curaguate River

TOBAGO

60 **Minister Bay** Accretion on the north-eastern end of the bay
61 **Goldborough Bay** Erosion on the south-western region of the bay area 90m south-west from the river mouth

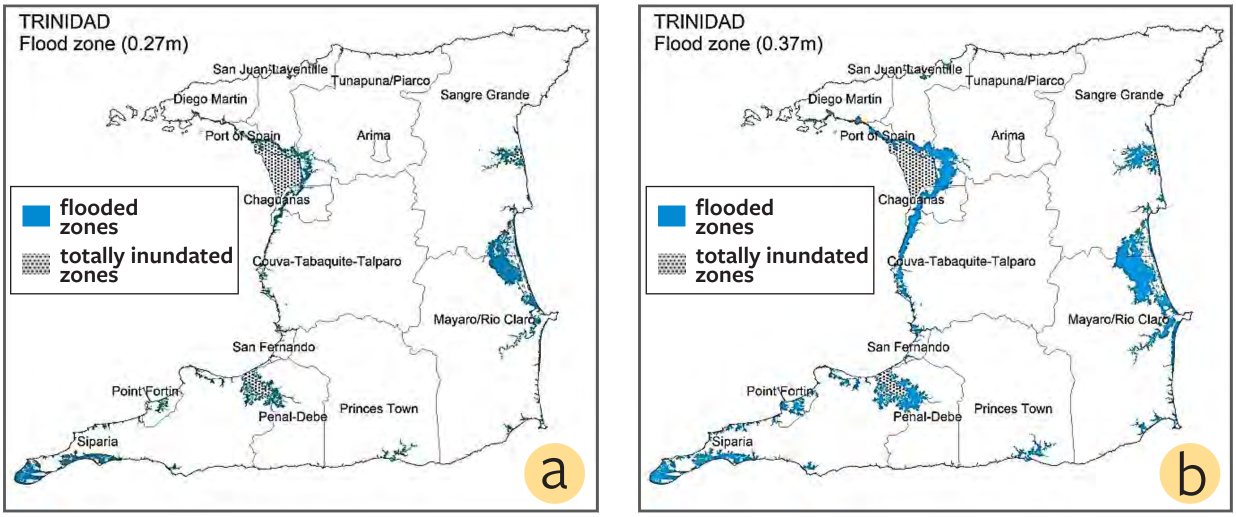


FIGURE 4.18 Sea level rise for Trinidad for the years 2030 (a: 0.27 m) and 2050 (b: 0.37 m)

Trinidad

Sea level rise only

The areas most likely to be affected by inundation and coastal erosion from climate-driven future sea level rise (SLR: 0.27 m) for Trinidad for the year 2030, are the coastlines along the eastern Atlantic coast and along the western Gulf of Paria (Zones T1 and T2), as shown in **FIGURE 4.18a**.

Future sea level rise (SLR:0.37 m) for Trinidad for the year 2050 shows that the areas most likely to be affected by inundation, and to a greater extent than for the year 2030, are also the coastlines along the eastern Atlantic coast and along the western Gulf of Paria (Zones T1 and T2), as shown in **FIGURE 4.18b**.

Sea level rise combined with storm surge from Category 2 and 5 hurricanes

Future sea level rise (SLR: 0.27 m) was combined with the storm surges generated by a Category 2 hurricane (2.27 m), according to the TAOS model for Trinidad for the year 2030, as shown in **FIGURE 4.19a**. It appears that the areas most likely to be affected by inundation along the coastlines of the eastern Atlantic coast and the western Gulf of Paria (Zones T1 and T2) would be much greater than SLR without the hurricane.

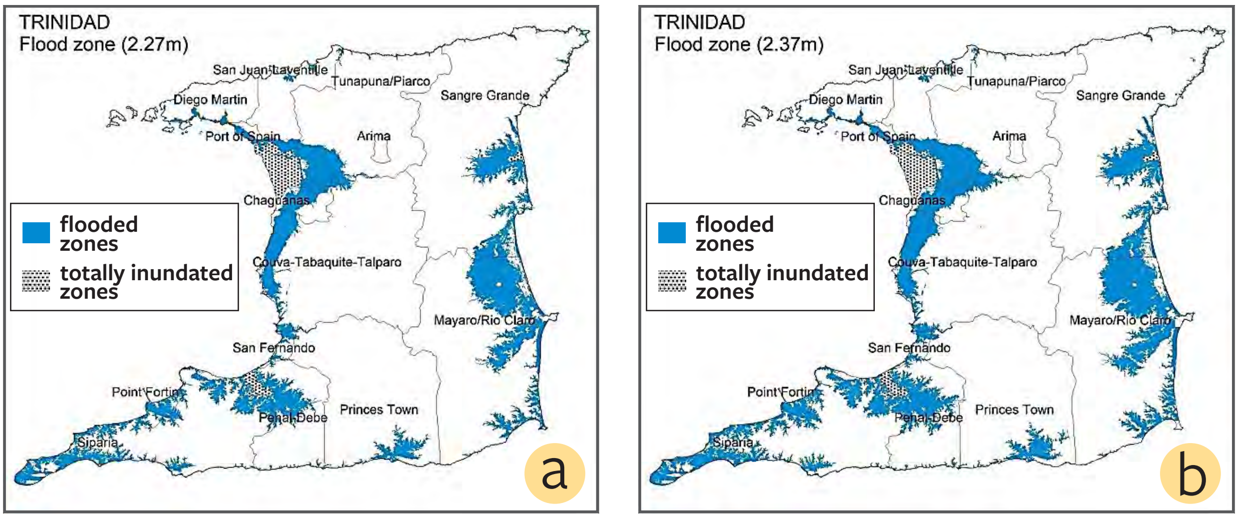


FIGURE 4.19 Sea level rise and storm surge for a Category 2 hurricane for Trinidad for the years 2030 (a: 2.27 m) and 2050 (b: 2.37 m)

Photo Credit: Kishan Ramcharan

▲ Flooding caused by intense rainfall, 2019

Looking at climate-driven future sea level rise (SLR: 0.37 m) with the storm surges generated by a Category 2 hurricane (2.37 m), using the TAOS model for the year 2050, it is evident that in the case of Trinidad the same areas on the coastlines along the eastern Atlantic coast and the western Gulf of Paria (Zones T1 and T2) would be affected by inundation, but to a greater extent, as shown in **FIGURE 4.19**.

By combining future sea level rise (SLR: 0.27 m) with the storm surges generated by a Category 5 hurricane (5.67 m), using the TAOS model for Trinidad for the year 2030, the areas most likely to be affected by inundation would again be the coastlines of the eastern Atlantic coast and the western Gulf of Paria (Zones T1 and T2) and that the inundation of the coastal zone would be significantly greater, to the extent of being catastrophic, as shown in **FIGURE 4.20a**.

Climate-driven future sea level rise (SLR: 0.37 m) combined with the storm surges generated by a Category 5 hurricane (5.77 m), according to the TAOS model for Trinidad for the year 2050, shows inundation of the same areas that would be affected in 2030, but to a greater extent, as shown in **FIGURE 4.20b**.

In every case, the areas that are affected in 2030 are affected to a greater extent in 2050. Similarly, the inundation of the coastal zone is extensive with the storm surge generated by a Category 2 hurricane. With Category 5-driven storm surge, the inundation is much worse, to the extent of being catastrophic for Zones T1 and T2.

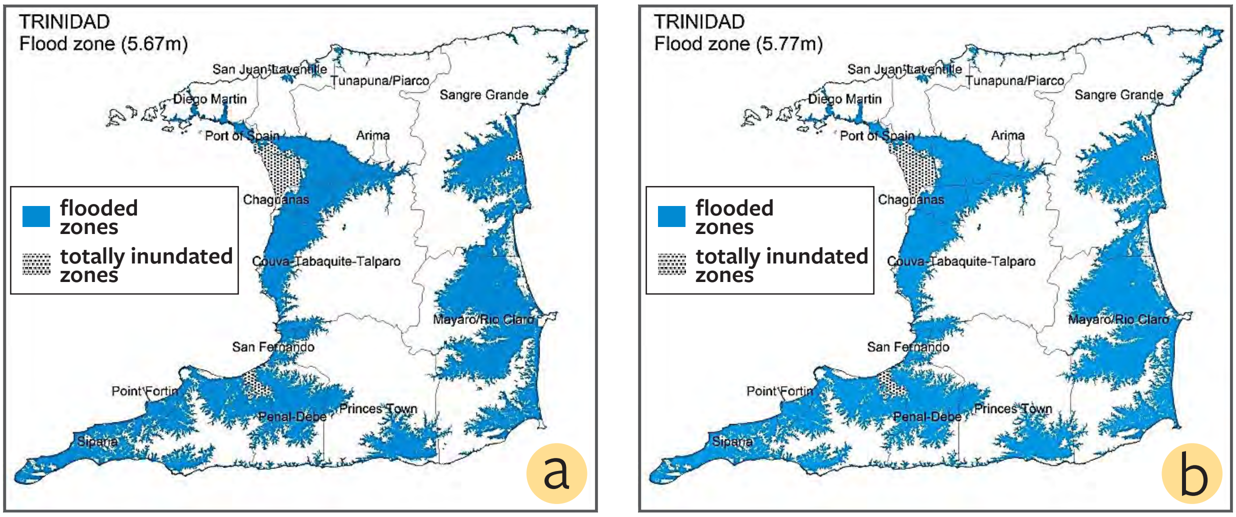


FIGURE 4.20 Sea level rise and storm surge for a Category 5 hurricane for Trinidad for the years 2030 (a: 5.67 m) and 2050 (b: 5.77 m)

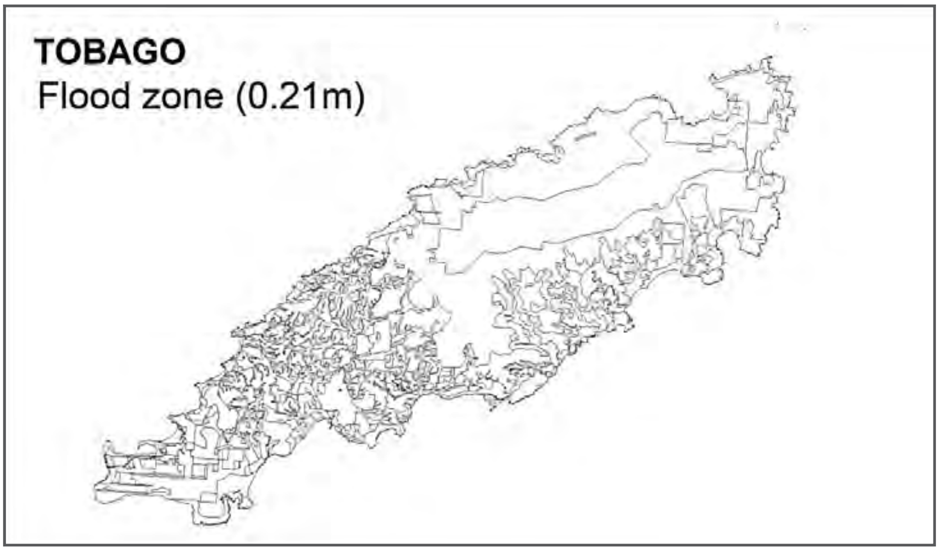


FIGURE 4.21 Sea level rise for Tobago for the year 2030 (0.21 m)

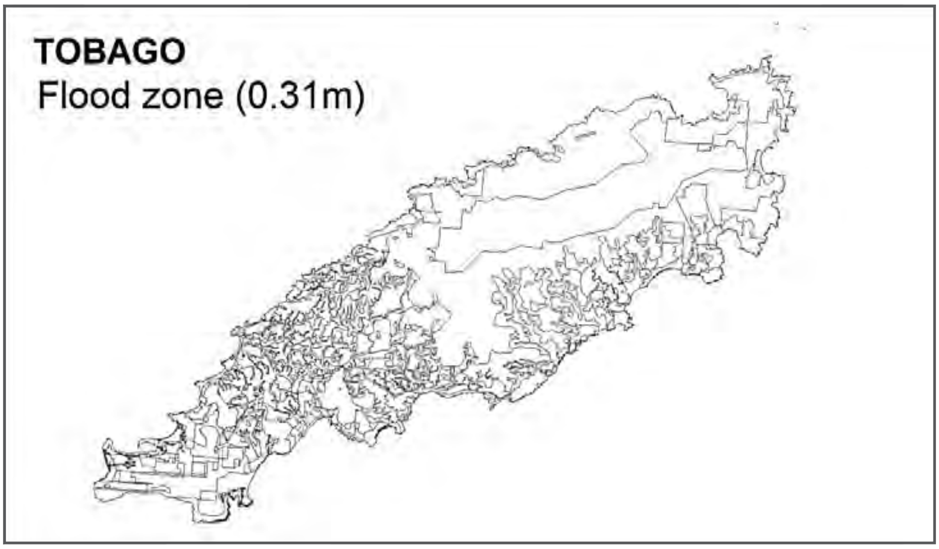


FIGURE 4.22 Sea level rise for Tobago for the year 2050 (0.31 m)

Tobago

Sea level rise only

Climate-driven future sea level rise (SLR: 0.21 m) projected for Tobago for 2030 indicates that the areas most likely to be affected by inundation and coastal erosion are the marshy coastlines along the south-western tip of the island near Buccoo Bay and Canoe Bay (Zones T1 and T2) (**FIGURE 4.21**).

By 2050, climate-driven future sea level rise (SLR: 0.31 m) for Tobago is projected to severely inundate the same marshy coastlines along the south-western tip of the island near Buccoo Bay and Canoe Bay, in addition to Minister Bay, east of the capital city of Scarborough (Zones T1 and T2) (**FIGURE 4.22**).

This does not mean that other coastlines of Tobago will not be affected by sea level rise. The problem is that the low levels of sea level rise for the following analyses on Tobago (0.21 m in 2030 and 0.31 m in 2050) and the spatial resolution of the DTM (10 m x 10 m), did not allow for fully mapping sea level rise along all coastlines, even with interpolation. Also, the fact that Tobago's coastlines are more cliffed contributes to the difficulty in accurately mapping sea level rise for all coastlines of Tobago.

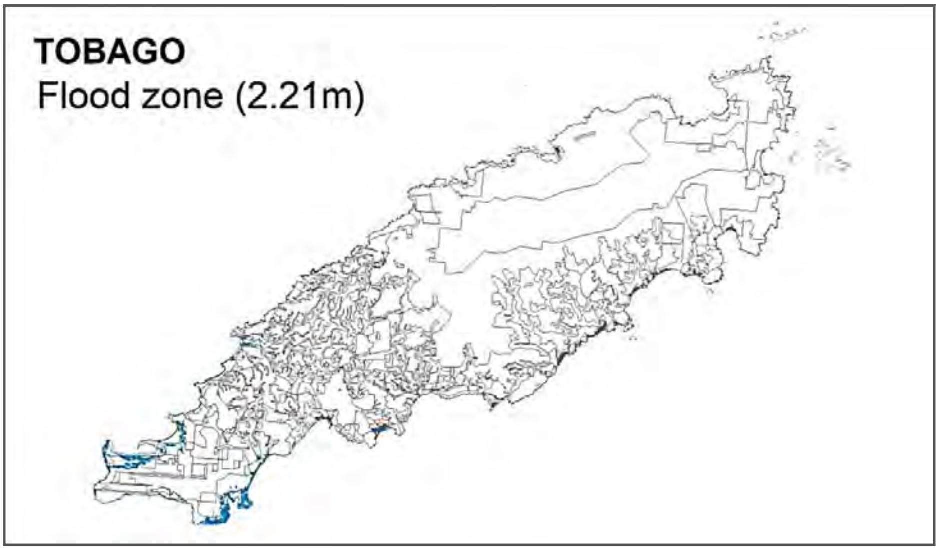


FIGURE 4.23 Sea level rise and storm surge for a Category 2 hurricane for Tobago for the year 2030 (2.21 m)

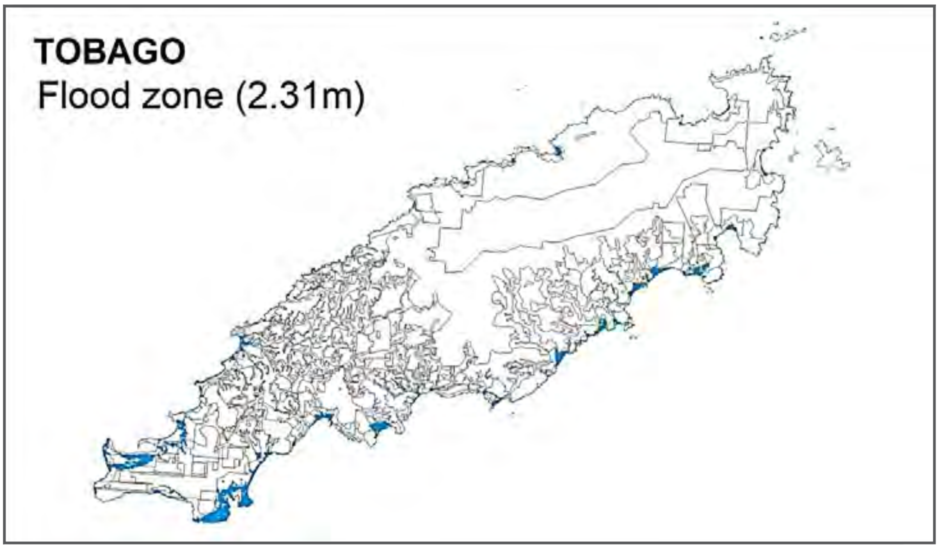


FIGURE 4.24 Sea level rise and storm surge for a Category 2 hurricane for Tobago for the year 2050 (2.31 m)

Sea level rise combined with storm surge from Category 2 and 5 hurricanes

Future sea level rise (SLR: 0.21 m) was combined with the storm surges generated by a Category 2 hurricane (2.21 m), according to the TAOS model for Tobago for the year 2030. The areas expected to be affected by inundation are the marshlands near Buccoo Bay and Canoe Bay to the south-west of the island, Minister Bay near the capital city Scarborough, Goldsborough Bay and the coastal area between Richmond and King's Bay along the west coast and all along the north coast, stretching from Great Courland Bay to Man of War Bay (**FIGURE 4.23**).

But when looking at climate-driven future sea level rise (SLR: 0.31 m) with the storm surges generated by a Category 2 hurricane (2.31 m), according to the TAOS model for the year 2050 for Tobago, it would again appear that the areas that would be most affected by inundation, but to a slightly greater extent, would again be the marshlands near Buccoo Bay and Canoe Bay to the south-west of the island, Minister Bay near the capital city Scarborough, Goldsborough Bay and the coastal area between Richmond and King's Bay along the west coast, and all along the north coast stretching from Great Courtland Bay to Man of War Bay (**FIGURE 4.24**).

Combining future sea level rise (SLR: 0.21 m) with the storm surges generated by a Category 5 hurricane (5.61 m), according to the TAOS model for Tobago for the year 2030, the areas that would most likely be

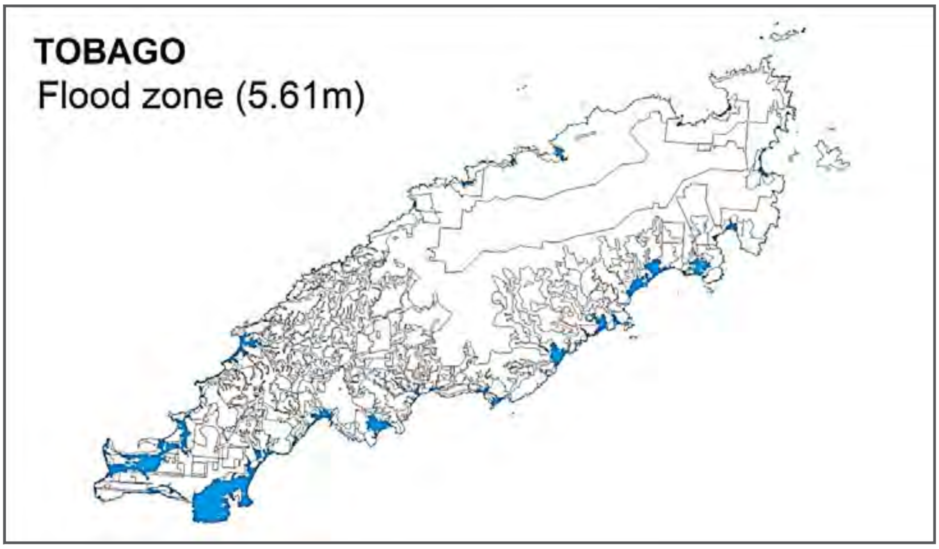


FIGURE 4.25 Sea level rise and storm surge for a Category 5 hurricane for Tobago for the year 2030 (5.61 m)

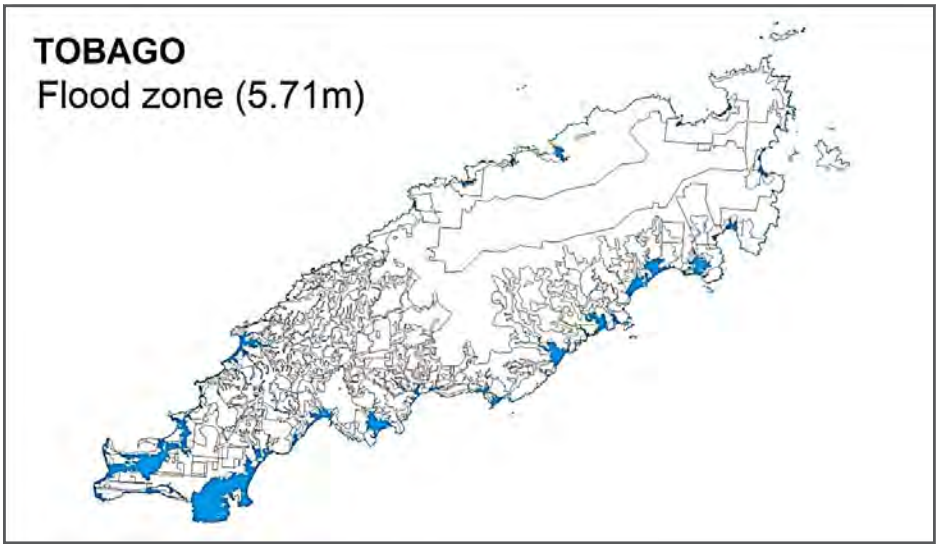


FIGURE 4.26 Sea level rise and storm surge for a Category 5 hurricane for Tobago for the year 2050 (5.71 m)

affected by inundation would be the marshlands near Buccoo Bay and Canoe Bay to the south-west of the island, Minister Bay near the capital city Scarborough, Goldsborough Bay and the coastal area between Richmond and King's Bay along the south coast and again all along the north coast stretching from Great Courland Bay to Man of War Bay (**FIGURE 4.25**).

Similarly, when combining future sea level rise (SLR: 0.21 m) with the storm surges generated by a Category 5 hurricane (5.71 m), according to the TAOS model for Tobago for the year 2050 the areas that would be affected by inundation are the same as for the Category 2 storm surges, but to a slightly higher degree. These include the marshlands near Buccoo Bay and Canoe Bay to the south-west of the island, Minister Bay near the capital city of Scarborough, Goldsborough Bay, the coastal area between Richmond and King's Bay along the south coast, and again all along the north coast, stretching from Great Courland Bay to Man of War Bay (**FIGURE 4.26**).

The land use classes most affected by sea level rise and flooding from a Category 2 and a Category 5 hurricane for Tobago are agricultural lands, hotel resorts along the coast, private residential infrastructure and resort residential infrastructure (Zones T1 and T2), including popular beach front properties at Buccoo Bay and villages near the coastline along most of the coastlands (Zones T1 and T2).

4.5 Physical and Socioeconomic Impacts

Exposure to climate change is manifested in the scenario-based changes in temperature, rainfall and water excess and deficits, as well as sea level rise and associated storm surges as described in previous sections. These changes will have far-reaching impacts on several key sectors in the coastal zones (T1, T2 and S1) of Trinidad and Tobago, including water resources, agriculture and forestry, livestock and poultry, marine ecosystems and fisheries, coastal infrastructure, and tourism in Tobago.

The development pathways, both direct and indirect, of climate change on socio-economic sectors are complex as these are complicated by the ecological thresholds, the magnitude and nature of impacts causing changes, and the drivers of changes. A more complex picture arises from the impacts of extreme events such as unduly intense rainfalls and flooding hazards on populated coasts such as along the Gulf of Paria in Trinidad and along the coast of south-west Tobago (IDB, 2014b). For instance, the increased storm damage attributable to rising seas and intense rainfalls is not only from environmental changes but also from increase in population densities, particularly in vulnerable areas, increase in wealth, increase in insurance and a higher propensity to claim, and more complex and vulnerable production and living (IPCC, 2007). In small island states like Trinidad and Tobago, the adaptive capacities of local coastal communities to cope with the effects of severe climate impacts decline if there is a lack of physical, economic and institutional resources for combatting the effects of climate hazard, and for reducing the vulnerability of high-risk communities and groups exposed to them (IPCC, 2007; Olsson et al., 2014).

This section focuses on the biophysical impacts of the climate changes identified in the preceding sections and how these translate to socioeconomic impacts. The key sectors dealt with include water resources, human health, agriculture, livestock and poultry, marine ecosystems and fisheries, infrastructure and human settlements, tourism and the Main Ridge Forest Reserve in Tobago.

Biological Coastal Resources

TABLE 4.3 is based on qualitative relationships criteria to indicate synergies between key sectors in the coastal zones of Trinidad and Tobago so as to assess cumulative impacts and vulnerabilities across interlinked sectors and accompanying livelihoods. It also highlights cross linkages between sectors and provides a rating of the impacts based on the analyses done in the Vulnerability Assessment and Adaptation report as well as stakeholder input.

The essential components of this integrated approach incorporate:

- interactions and feedback between multiple drivers and impacts;
- policy options and some indication of costs, when available;
- cross-sectoral interactions; and
- integration of climate with other non-climatic drivers.

TABLE 4.3 Cross-linkages between the coastal sectors

Sectors	Climate—Sea Level	Coastal Zone	Water	Agriculture	Fisheries	Tourism	Health
Climate—Sea Level		XX	XX	XX	XX	XX	XX
Coastal Zone	XX		XX	XX	XX	XX	X
Water	XX	XX		XX	X	XX	XX
Agriculture	XX	XX	XX		X	XX	XX
Fisheries	XX	XX	X	X		XX	XX
Tourism	XX	XX	XX	XX	XX		XX
Health	X	X	XX	XX	XX	X	

X: Significant Impact XX: Very Significant Impact

For the coastal zones of Trinidad and Tobago (T1, T2 and S1), for instance, where all the sectors are to be found and are inter-linked, climate change impacts and vulnerabilities are not expected to occur in isolation. As an example, water quality and availability will also have very significant impacts on agriculture and human health.

The potential threats of climate change with sea level rise and storm surges along the coastal zone will be particularly acute due to the fact that a significant percentage of Trinidad and Tobago's population resides within the coastal zone.

Water Resources

Trinidad and Tobago's water resources are under threat from pollution, watershed degradation and climate change. Climate change, in particular, is very likely to have a significant impact on the water sector of Trinidad and Tobago. Rainfall is projected to decrease slightly and become more variable leading to intense rains and flooding on the one hand, and droughts on the other. Warmer temperatures will also exacerbate drought conditions. (McSweeney et al., 2009, 2010; IPCC, 2007, 2013)

Although the country is not considered water-scarce, current and projected rainfall amounts and variability can adversely affect the economy of Trinidad and Tobago. Excessive rainfall will not only lead to the risk of flooding in low-lying coastal lands but also of agricultural fields.

Sea level rise and storm surges will also affect the water sector through saline intrusion into coastal surface waterways, aquifers and agricultural soils while flooding coastal lowlands and towns where large numbers of the population of Trinidad and Tobago are located (Singh & El Fouladi, 2007). Where saltwater intrusion reduces the quality of water in catchments or reservoirs, treating water to become potable would incur additional costs.

Flooding of the coastal zones (T1 and T2) of Trinidad and Tobago caused by an unusual alignment of the Intertropical Convergence Zone (ITCZ) in October 2018 demonstrated the country's immediate vulnerability to climate-driven events and exposed the weaknesses of existing infrastructure to protect the coastal zones and people.

In Trinidad and Tobago, over 60 percent of the annual rainfall may occur during the wet season which occurs from roughly June to December. There is growing evidence that the El Niño Southern Oscillation (ENSO) phenomenon can enhance the probability of extreme events such as droughts, storms and heatwaves (Holthaus, 2014). If climate change results in a more "El Niño-like" climate, precipitation is likely to be lower and could have serious consequences for water supplies for domestic, commercial and industrial purposes, in addition to agriculture (Haites et al., 2002).

The socio-economic implications of climate change impacts on water resources depend on the season of the year. During the dry season from January to May, drought-like conditions prevail and this leads to water shortages for the different major sectors, namely the domestic, commercial, industrial and agricultural sectors. There are already instances when pipe-borne water shortages, especially for the domestic and commercial sectors, have to be supplemented by truck-borne water supplies. Reduced water availability leads to poor sanitation which has implications for health and the general operations of many businesses and could result in direct financial losses for commerce and industry. In terms of the impact on domestic activity there are a host of inconveniences, including personal hygiene and the preparation of food.

On the other hand, extreme rainfall events cause flooding with loss of crops and animals and even human lives, proliferation of disease-spreading vectors, and the destruction of roads and bridges. These are followed by costs for clearing operations, repair of roads and rebuilding/repair of infrastructure.

Agriculture (including Fisheries) and Food Security

Crop Production (Agriculture)

Although agriculture is now a very small contributor to Trinidad and Tobago's GDP, accounting for just 0.5 percent in 2018 (Shik et al., 2018), it still employs approximately 3.4 percent of the country's working population (Shik et al., 2018) and provides an ample supply of local produce. There is widespread agreement about the impacts of climate change and variability on economic sectors such as agriculture.

Projected increases in air temperature are likely to increase the aridity of soils thus decreasing crop yields. Increase in sea level is likely to result in inundation of coastal areas and salination of soils while increased temperatures could result in the increased proliferation of new and existing pests and diseases and increase the demand for water for irrigation purposes.

This evidence is even stronger for a small island state such as Trinidad and Tobago whose economy is impacted by limited land resources and an increased dependence on the energy sector as a major economic activity.

Local agricultural food production and food security will also have important socio-economic impacts. In the dry season food production is limited to those farmers who can afford and use irrigation systems. On the other hand, during the wet season irregular and intense rainfalls lead to loss of crops and ultimately farm profits. Both of these conditions lead to high imports of food products which are high-priced and do not always cater to the tastes of the local population. In this regard, it would be important to assess the transboundary and exogenous vulnerability arising from climate change impacts in countries from which food is imported and how it impacts on food processes and food security.

In order to increase the adaptive capacity in this sector, there is a need for policy choices and initiatives that explicitly seek to reduce adverse impacts on local farmers and assist them in exploiting opportunities. Such initiatives would include crop research, particularly for cultivars that are tolerant to salt and drought and are therefore suitable for a changing climate, and extension programmes consisting of capacity-building geared towards adaptation and mitigation to climate change using suitable local technologies.

Livestock and Poultry

The temperature predictions for 2030 and 2050 are expected to severely affect the livestock industry of Trinidad and Tobago. At present, poultry birds have shown the greatest vulnerability to increasing temperatures with tens of thousands dying each year from heat related illnesses (Singh et al., 2014). However, cooling fans are now being used in several chicken farms/pens to counter this heat stress which requires more energy use (Singh et al., 2014) and which, in turn, increases production costs leading to higher prices for consumers.

Consequently, both egg and meat production are expected to decline, negatively impacting on food and nutrition in Trinidad and Tobago.

Heat stress also reduces both meat and milk production in ruminants. Since most of these animals, especially cows, graze in the sun for much of the day, the projected increases in daily temperatures are expected to cause a reduction in meat and milk production. In the dry season, drier pastures limit food intake and growth of the animals, reducing their milk production and value as meat products. Reduced availability of local meat and meat products will have a negative impact on the livelihoods of livestock farmers, food quality, quantity, and ultimately, on human nutrition. There will also be associated economic problems since local meat producers would have to either alter existing farm buildings or construct new ones to provide adequate shelter for animals in order to obtain maximum production from their farm animals.

Further, low rainfall and increasing drought impact negatively on biomass growth in most, if not all, plants, including the grasslands on which animals and ruminants feed. Certainly, the quality and quantity of grasses, including those that are regularly consumed by large ruminants, would be significantly reduced if precipitation projections for the future of 2030 and 2050 occur. To ensure that farm animals receive an adequate amount of food and nutrition, farmers may either have to increase the sizes of their grasslands or consider other food supplements, both of which will require additional funds.

Marine Ecosystems and Fisheries

The fisheries industry is extremely important in Trinidad and Tobago. In 2018, it was estimated that the marine fisheries sector contributed three percent of national GDP (FAO, 2018). This sub-sector is a means of livelihood for about 50,000 persons, of which about 10,750, including approximately 6,450 fishers, were directly employed in 2012. Others in the industry are employed in processing, wholesale purchasing, roadside retail vending, retailing at fish markets and in providing supplies and services. The participation of women in the industry is not well documented. However, women are more involved in processing and marketing activities (FAO, 2018).

The fishing fleet of around 1,900 vessels operates from 65 landing sites in Trinidad and 32 in Tobago. Climate change will lead to a number of physical stressors to the marine environment, which may in turn result in a range of biological/ecological responses affecting coastal fisheries. The main potential physical stressors are sea surface temperature, currents, stratification and upwelling; ocean acidification; sea level rise; ultra violet radiation; and rainfall patterns. These stressors will impact phytoplankton and primary production; zooplankton and larval supply. They will also lead to changes in species ranges and abundances; habitats that support fisheries production; calcification rates of reef organisms; physiological responses of organisms to climate change and the timing of life history events (Sustainable Management of Natural Resources [MRAG], 2010).

Climate change represents a threat to the sustainability of capture fisheries. The consequences, namely reduced fish populations and catch, will become increasingly evident. Climate change will mainly have a negative impact on fisheries both directly and indirectly. Fisheries will be impacted directly by changing water levels and flooding events and temperature changes will cause a shift in the range of fish species and a disruption to the reproductive patterns of fish. Rising sea levels could also affect important fishery nursery areas such as mangroves. Increased sea surface temperatures could increase disease transmission and have an influence on increasing numbers of marine pathogens. Because of their comparatively small economies, countries like Trinidad and Tobago which are highly dependent on fish for food and for tourism, as in Tobago, have relatively low capacity for adapting to climate change (Calvosa, 2010).

While there is still an incomplete understanding of the link between climate change and fisheries, there is growing acceptance that the global average sea surface temperature has increased by at least 0.60 °C during the last 100 years, and that this trend is expected to continue throughout the 21st Century. It will impact fishery systems, fisherfolk and other economic and food systems that are vulnerable to climate change and climate variability. In the surface layer of the ocean, several components of climate, including solar radiation, wind and temperature may negatively impact the distribution and abundance of fish. Stock production, and to a lesser extent, catchability, is known to be closely tied to climatological factors. Despite the resilience of many species of fishery resources, their ability to overcome changes in weather patterns, including increased frequency and severity of extreme events, such as hurricanes, are at best uncertain (Gillett & Myvette, 2008).

Coral reefs provide the habitat for a wide variety of fishes that are exploited in Trinidad and Tobago. Over the past two to three decades, there has been widespread deterioration of coral reefs worldwide. Much of the deterioration has been attributed to exploitation, pollution, disease, coastal development and, more lately, coral or thermal bleaching caused by increasing SST (Sea Surface Temperature).

Corals may also be affected by increasing levels of ocean acidification. Elevated levels of dissolved CO_2 reduce the ability of corals to deposit their limestone skeletons, affecting coral growth and the ability of these forms to remain in the photic zone of the water column. Predictions are that ocean acidification will have more negative impacts on corals and coral reefs (Gillett & Myvette, 2008).

Increase in sea temperatures may also affect seagrass beds which serve as nursery areas for many species of fish. Additionally, any increase in rainfall caused by climate change may result in increases in freshwater runoff, which could also negatively impact seagrass beds (Gillett & Myvette, 2008).

Reef fish kills have been observed from time to time in waters around Trinidad and Tobago and have been attributed to the influx of water with higher than normal temperatures and chlorophyll concentrations and low nocturnal oxygen levels. This appeared to be associated with an unusual influx of waters from the Orinoco River into the sea. This fish kill was devastating to the local fishing community and is an example of the type of problems which could occur in Trinidad and Tobago under a changing climate (Parker, 1998).

Many fishers have shown an ability to adopt livelihood diversification strategies in an effort to adapt to climate change and variability. Some have ventured farther out into the deeper water, with higher risks and higher costs for fuel and supplies. However, such responses may be lessened in the realm of present-day experience given multiple factors, including high and sometimes prohibitive fuel prices, stresses associated with coastal urbanisation, changes in frequency and intensity of extreme weather events and the impacts of climate change on sensitive coastal ecosystems such as corals and mangroves.

The coral reef ecosystem of Tobago, which supports fisheries, is particularly sensitive to climate change. The primary concern is therefore with the impacts of climate change on marine habitats with the subsequent impacts on fisheries (Gillett & Myvette, 2008). This will eventually lead to lower and less edible fish stocks.

It is important to note that other non-climatic stressors such as over-fishing and the use of illegal nets are also affecting fish catches in Trinidad and Tobago.

Human Health

Public health depends on sufficient food, safe drinking water, secure shelter, good social conditions and a suitable environment for controlling infectious diseases. All of these factors can be affected by climate change which is expected to exacerbate the weaknesses in this sector (Haines et al., 2002; Heslop-Thomas et al., 2009; Martens, 1996).

Climate change will lead to higher levels of some air pollutants, an increasing number of extreme weather events, and increased outbreaks and transmission of vector and water-borne diseases. Many of the major killer diseases are highly sensitive to temperature and rainfall, including diarrhoeal diseases, and to vector-borne diseases especially dengue, chikungunya and zika (World Health Organization [WHO], 2015).

It is very likely, as seen earlier, that climate change has driven extreme high temperatures and has probably contributed to more frequent and extreme precipitation events and more intense tropical storm and hurricane activity. Together, these trends will increase weather-related hazards to human health.

Daily temperatures above a locally specific threshold result in higher mortality rates, particularly among the elderly population (Lindsay & Birley, 1996; Martens, 1996). Continuing global warming and possible increases in temperature variability will make such events more frequent and more severe. The mean annual temperature in Trinidad and Tobago is expected to increase by ~0.5 °C to ~1.0 °C by 2030 and by ~1.0 °C to ~1.5 °C by 2050 and this may place more and more people at risk of heat-related mortalities. Heat stress and cardio and cerebro-vascular conditions resulting from extreme temperature are therefore likely to increase in the future (Climate Change Vulnerability, Risk and Capacity Assessment [VRCA] Brief, 2018).

Although total annual and seasonal rainfalls are not projected to change significantly, the incidence of extremes of rainfall events or dry spells that cause either flooding or drought, both of which can impact human health directly or indirectly, is expected to increase. Floods can cause drowning and physical injury; heighten the risk of diseases transmitted through water, insect vectors and rodents; damage homes and infrastructure; and disrupt the supply of essential medical and health services. On the other hand, droughts can increase the risk of water and food shortages and malnutrition; necessitate greater reliance on contaminated water; and lead to diminished health, especially among vulnerable members of the population. The combination of extreme heat and drought is also an important risk factor for wildfires, resulting in direct health impacts such as an increased risk of respiratory illnesses due to smoke pollution as well as economic losses through reduced productivity.

By far, the most important vector-borne disease in Trinidad and Tobago is dengue which is transmitted to humans when bitten by the *Aedes aegypti* mosquito vector. The number of clinical dengue cases in Trinidad and Tobago reported in 2010 was 24 persons, with an incidence rate (x 100,000 population) of 91.5. It is widely believed that dengue cases increase substantially approximately three weeks following heavy rainfalls, since this is the length of time required for the mosquito larvae to develop. (Amarakoon et al., 2003; Chadee et al., 2007) A good indication of the rate of the incidence of dengue is the Breteau Index. The Breteau Index, namely the number of positive containers (i.e. containing *Aedes aegypti* larvae) per 100 premises or households, is also correlated with the incidence of dengue. When the Breteau index is 50 or more then the risk of transmission is high and when it is 5 and less the risk of transmission is low (Chadee et al., 2007).

Other diseases that may be influenced by climate change include gastroenteritis, a water-borne disease affected by rainfall and sanitation conditions, and respiratory diseases that may be influenced by rising air temperatures and air quality, including the increased ambient air concentration of pollen and spores in response to increasing temperatures.

Mounting water stress fosters a range of long-term public health challenges. Lack of access to clean water supply and sanitation, along with poor hygiene, are already the main contributors to the burden of gastroenteritis. Pressures on agriculture and food production threaten to increase the burden of malnutrition. Climate change is expected to cause decreases in agricultural production in many tropical developing regions, such as Trinidad and Tobago.

However, in the long run, the greatest health impacts may not be from acute shocks such as disasters or epidemics, but from the gradual increases in pressure on the natural, economic and social systems that sustain human health and which are already under stress (WHO, 2009). These gradual stresses include reductions and seasonal changes in the availability of fresh water, regional drops in food production, and rising sea levels, all of which apply to Trinidad and Tobago.

Human Settlements and Coastal Infrastructure

The livelihoods of people located in coastal cities such as Port of Spain and San Fernando in Trinidad, and Scarborough in Tobago, are supported by systems of infrastructure that include transportation facilities, energy supply systems, disaster management facilities and, in certain instances, coastal resorts. Events associated with climate change, especially storms and associated heavy rainfall and storm surges, could therefore have far-reaching impacts on these coastal facilities, communities and local economies, particularly where coastal habitats have been lost, such as in south-west Tobago (Ministry of Environment and Water Resources & Ministry of Planning and Development [MPD], 2019). Further, it is estimated that the probable direct loss due to floods and storms in 2012 was 1.1 billion USD (with a 1/100 return period) and that the average annual loss was 55.7 million USD. Future impacts from climate change therefore need to be considered when developing the coastal zone (Ministry of Environment and Water Resources & MPD). This is especially important since most of the development in coastal areas (Zones T1 and T2) of Trinidad and Tobago has taken place without due consideration to climate change and extreme rainfall events, thereby placing at risk infrastructure and human settlements, such as roads, essential utilities (water, sewerage and electricity), and social services such as hospitals and poorly constructed houses. For example, dykes (levees), flood gates, and drainage systems can fail, as in the case of the widespread flooding from heavy rainfalls which occurred in October 2018.

Further, the increase in the level of the water table resulting from intense rainfalls could decrease the bearing capacity of the soil foundation for structures, through saturation and liquefaction, thereby leading to greater instability and susceptibility of coastal structures from destabilising events such as earthquakes, tectonic plate slippages and subsidence (Shaw et al., 1998).

These conditions also exacerbate the risk of landslides.

Port facilities, roads, bridges and low-lying buildings in particular, as in Port of Spain, will be very susceptible to intense rainfalls and flooding as occurred in October 2018, as well as sea level rise and storm surge. Higher water levels, exacerbated by rivers clogged with sediment and debris, will most likely decrease the effectiveness of breakwaters against rising water levels. Wharves, loading docks and offshore platforms may have to be raised to avoid inundation. Counter-measures to maintain function and stability of port facilities, as in Port of Spain, will translate into increased expenditures.

In the event of extreme rainfall events, the loss of electricity supply increases the need for grid-independent emergency systems. Also, emergency shelters could be vulnerable since some were adversely affected by extreme rainfall events in October, 2018 (Kissoon & Santoo, 2018; Philip, 2018).

Future increases in air temperature will likely necessitate more cooling installations at increased cost to users. However, poorer persons who cannot afford air-conditioning may be at risk of heat strokes. Additionally, increases in intense rainfall events will lead to greater incidences of mudslides on hilly slopes with clayey soils, thereby leading to the collapse of poorly constructed houses or those constructed in areas vulnerable to landslides. Besides, the capacity to respond effectively to these risks is limited by a relatively low adaptive capacity of the average household and government agencies, which is the result of a combination of factors, including limited size and the opportunity to retreat; limited access to capital and technology; a shortage of human resource skills; and the lack of political will to seriously factor climate change considerations into policy decisions.

Vulnerable groups, such as low-income women, children and the elderly are already beset by a number of socioeconomic disadvantages such as poverty, food insecurity, lack of a proper diet, poor shelter and housing, inadequate hygienic conditions and water quality and limited education and labour skills. It is very likely that the circumstances of these groups will be aggravated by climate change and climate-driven sea level rise.

At the same time, climate change is rarely the only factor that affects livelihood trajectories and poverty dynamics. Climate change interacts with a multitude of non-climatic factors such as illegal dumping and over-exploitation of natural resources, which make detection and attribution a challenging endeavour.

Terrestrial Biodiversity and Tourism

Climate change, along with sea level rise will result in further loss of beaches, loss or damage to properties and public infrastructure, and will make Tobago, in particular, less attractive as a tourist destination. The loss of beaches and coastline due to erosion, inundation and coastal flooding and loss of tourism infrastructure as well as natural and cultural heritage will reduce the amenity value for coastal users (IPCC, 2007; Mycoo & Gobin, 2013; Olsson et al., 2014).

The economic vulnerability of the tourism industry of Trinidad and Tobago to climate change and sea level

TABLE 4.4 Average Annual Cost of Economic Marketable Values for Key Coastal Sectors in Trinidad and Tobago | *Source: Mycoo & Gobin, 2013*

Direct Use Values—Key Sectors	Total	Number employed or dependent	Total Value of Sector (M-million $ US)
Fisheries (marine)	13,942 (catch)	63,000	26.48 M $US
Coral Reef (fisheries and reef tourism)	9,432 (number of resource users)	32,400	0.83–1.37 M $US
Coastal Tourism (Hotel and Restaurant activities)	138,166 (number of resource users)	15,939	0.54 M $US

▲ Sargassum seaweed beaching in Little Rockly Bay South Beach near the Magdalena Grand Beach & Golf Resort, Tobago 2018. This is one of the beaches in Tobago that receives 2 or 3 significant beachings of sargassum annually. Mechanical intervention has been made on more than one occasion due to the proximity of the hotel and impact on guests. It is also the index beach for hawksbill turtles in Tobago, which is also a factor to be considered when executing clean-up activities.

rise extends to beach and reef-based activities that attract a high percentage of foreign tourists. Coral mortality from climate change and other human-induced impacts may reduce the appeal of visitors who would like to participate in underwater recreational activities. An assessment further suggested that perceptions of reef quality may be an important factor in assessing the vulnerability of tourism demand to climate change in Trinidad and Tobago (Richardson, 2007).

TABLE 4.4 presents the estimated costs, number of dependent coastal users, and the potential reduction of the amenity value for three key coastal sectors, namely marine fisheries, coral reefs and coastal tourism (Mycoo & Gobin, 2013).

Climate change and climate-driven sea level rise will most likely have important and severe impacts on the tourism industry of Trinidad and Tobago. Increases in air temperature of 1 °C to 2 °C towards the middle of the century may make conditions unbearable, especially for elderly visitors accustomed to cooler temperatures.

The projected variability in precipitation will very likely lead to extreme conditions, namely increasing drought in the dry season and torrential rains and flooding in the wet season, and water and food shortages or higher prices for imported food. Tropical storms and hurricanes and associated storm surges are also likely to increase in intensity and, apart from flooding and erosion of recreational beaches, will also very likely cause flooding and damage to transportation and other infrastructure.

A more recent phenomenon which was not documented prior to 2011 is the influx of massive quantities of Sargassum seaweed onto coastlines of several Caribbean countries. Climate change-driven increases in sea surface temperatures, in addition to increased concentrations of nutrients (nitrogen and phosphorus in particular) in the marine environment, are likely responsible for the rapid growth of the seaweed (Hinds et al., 2016). Such indirect secondary and tertiary effects from climate change as described above, are detrimental to the fishing and tourism industries.

Increased salinity ▶ from sea level rise can cause mangrove dieback, 2018

Photo Credit: Howard Robin

Tobago

The Main Ridge Forest Reserve is the backbone of the island of Tobago, running lengthways across two thirds of Tobago's surface. It encompasses 3,958 hectares (9,780 acres) of tropical rainforest, specifically lower montane, lowland and xerophytic rainforest and reaches a height of 550 metres. The majority of the Forest Reserve is lower montane and is found at heights above 244 metres. This area receives the greatest amount of rainfall, the greatest exposure to wind, and the lowest temperatures, making it an Evergreen Forest. The lowland rainforest is characterised by copious growth and is said to be the most prolific of all forest types, occurring here to a maximum of 366 metres. The xerophytic rainforest is found on the southern slopes of the Forest Reserve at heights above 244 metres and is the driest compared to the other types (Clarke et al., 2018).

The Main Ridge Forest Reserve is home to a number of flora and fauna. It is estimated that the rainforest provides habitats for 12 to 16 species of mammals, 24 non-poisonous snakes, 16 lizards and 210 species of birds, the most outstanding being the Campylopterus ensipennis, the White-tailed Sabrewing Hummingbird that is both rare and endemic to Tobago. The Ridge is also home to the ocellated gecko, an animal not found anywhere else in the world (Clarke et al., 2018).

The Main Ridge Forest Reserve was voted the "World's Leading Eco-Tourism destination" by the World Travel Awards in 2003, 2004, 2005 and 2006, thereby illustrating that it holds an intrinsic ecological value sought by tourists from all over the world. The Main Ridge is managed by the Department of Natural Resources and the Environment of the Tobago House of Assembly (Clarke et al., 2018).

Climate change and variability will have an important impact on the Main Ridge Forest Reserve of Tobago. Moisture is important in determining the extent of forests. Forests generally flourish best in warm, wet environments and do progressively less well as temperature and moisture decrease. Thus, based on the HadCM3 and ECHAM5 projections for 2030 and 2050 the Main Ridge Forest Reserve would be expected to respond to increases in temperature and to decreases in precipitation (Sedjo & Sohngen, 1998).

Climate change and variability also cause more intense rainfalls which can cause catastrophic flooding and landslides. More intense storms accompanied by increased precipitation and an anticipated higher peak wind speeds could also lead to destruction of the forests of the Main Ridge Forest Reserve of Tobago. Additionally, this problem will be exacerbated if the forests are weakened by drier weather conditions.

Climate change can affect forest pests and the damage they cause by directly impacting their development, survival, reproduction and spread; altering host defences and susceptibility; and indirectly impacting ecological relationships such as changing the abundance of competitors, parasites and predators (Moore & Allard, 2008).

Climate influences the structure and function of forest ecosystems and plays an essential role in forest health. Some scientists suggest that climate change could also cause "dieback" - a high incidence of decline and individual tree death because the change in climate conditions, such as drought, would make them vulnerable to disease and insect predation. Alternatively, weakened or non-adaptive species might simply be overwhelmed by competition from tree species or vegetation more suited to the site in the wake of climate change. Most ecological models suggest that temperature increases are likely to be gradual and would lead to a relatively orderly natural transition of vegetation. However, most forests consist of many species which overlap each other's natural range. Thus, while climate change may seriously impact some species, all the forest's species are unlikely to be impacted negatively (Sedjo & Sohngen, 1998).

Changes in plant flowering seasons caused by changes in temperature and rainfall patterns can alter the microclimate of forest ecosystems and these can cause disruptions in mating and feeding habits of birds and insects.

The biodiversity of the Main Ridge Forest Reserve in Tobago is mainly being affected by desiccation due to increasing droughts. This causes the roots and branches of the trees to weaken and become vulnerable to destruction from strong winds and landslides during stormy weather (Stakeholder panel, Tobago, March, 2019).

The socio-economic impacts of climate change on the Main Ridge Reserve in Tobago will be derived from the destruction of the rich flora and fauna. Climate change may alter the biodiversity mix through destruction from strong winds during hurricanes and desiccation resulting from drier conditions. Both climate and non-climate factors will very likely decrease the attractiveness of Tobago's Main Ridge Forest Reserve as a major eco-tourism centre with a consequent impact on the livelihoods that are dependent on it.

4.6 Vulnerability and Adaptation Assessment

In the current context, vulnerability may be defined as the degree of capability to cope with the consequences of climate change and sea level rise (Klein & Nicholls, 1999). As such, the concept of vulnerability comprises (IDB, 2014a):

- susceptibility of the coastal zone such as the low-lying area along the Atlantic Ocean on the eastern seaboard and along the Gulf of Paria on the west coast of Trinidad and almost all coastal areas of Tobago except the central hills (Main Ridge Forest Reserve), to the physical and ecological changes imposed by sea level rise;
- potential impacts of these natural system changes on the socioeconomic system; and
- the capacity to cope with the impacts, including the possibilities to prevent or reduce impacts through adaptation measures.

It is widely known that ecosystems such as the Caroni and Nariva wetlands, infrastructure facilities and settlements near large urban centres such as Port of Spain and San Fernando that are concentrated along the coastal areas of Trinidad and Tobago, are highly exposed to climate change which is projected to result in more frequent extreme rainfall events, rising sea levels and storm surges. Furthermore, ocean encroachment on sensitive ecosystems, infrastructure facilities and settlements may lead to significant and irreversible damage to natural habitats, agricultural lands, built infrastructure facilities, and people.

However, risks must be prioritised for better resource allocation towards adaptive planning. The national policy framework provides policy guidelines for addressing climate change. The National Climate Change Policy (2011) recognises the need to address the challenge of climate change in accordance with the United Nations Framework Convention on Climate Change (UNFCCC). The Policy's key objectives include the protection of the natural environment and human health, reduction or avoidance of GHG emissions from all emitting sectors, increased utilisation of cleaner energy efficient technologies, enhanced agricultural production and food security, and the provision of a sustainable supply of potable water.

TABLE 4.5 provides, in order of priorities as defined by the Technical Working Groups in the VCA project, a summary of the highest risks from climate change currently faced by Trinidad and Tobago.

4.7 Summary

In summary, the findings include the following:

- Mean air temperature is expected to increase by ~0.5 °C by 2030 and by ~1.0 °C by 2050.
- Maximum air temperature is expected to rise between ~1.0 °C and ~1.5 °C by 2030 and between ~1.5 °C and ~2.0 °C by 2050.
- Minimum air temperature is expected to rise by between > 1.0 °C and > 1.5 °C by 2030 and between > 1.5 °C and > 2.0 °C by 2050.
- Seasonal rainfall is expected to decrease slightly, especially in the dry season, by 2030 and decrease slightly more, also particularly in the dry season, by 2050.
- Sea level rise and storm surge projections for 2030 and 2050 (between .27m and 5.77m) will result in inundation and coastal erosion along the eastern Atlantic coast and the western Gulf of Paria coast of Trinidad. In every case, the areas that are affected by 2030 are affected to a greater extent in 2050. Similarly, the inundation is more extensive with the storm surge generated by a Category 2 hurricane and with the inundation of the coastal zone being very much greater with Category 5-driven storm surge, to the extent of being catastrophic for Zones T1 and T2.
- The land use classes expected to be affected by sea level rise and flooding from a Category 2 and a Category 5 hurricane for Tobago are agricultural lands, hotel resorts along the coast, private residential infrastructure and resort residential infrastructure (T1 and T2), including popular beachfront properties at Buccoo Bay, and villages near the coastline along most of the coastlands (Zones T1 and T2).

Barriers to Adaptation

The Pathways Approach to climate resiliency and long-term adaptation requires a "whole-of-Government" approach in order to mainstream climate change into the national development planning process and into national development itself. This is a critical component in developing a climate resilience trajectory as climate change is recognised as a national development issue in Trinidad and Tobago. As a result, there are systemic challenges, such as access to relevant data, in conducting vulnerability assessments and designing adaptation approaches. As such, data is essential for a range of activities including scenario planning, community risk profiling, developing early warning systems and emergency preparedness and response plans. Attendant to this is the disparate and unharmonised coordination for data management.

Additionally, in recent years, the design of an open platform for storing and sharing spatial data in Trinidad and Tobago has commenced. The current Knowledge Management System (KMS) used for mitigation Monitoring, Reporting and Verification (MRV) is being reviewed to include mandatory reporting of data and information related to adaptation and climate resilience with a view to coordinating data collection for policy tracking and international reporting. In addition, this will provide a centralised repository for data relevant to tracking climate resiliency and adaptation through the development of key performance indicators, for example. More significantly, attempts to mainstream climate risks into sectoral planning has also begun through training in various sectors which will also inform national budget processes and funding.

Two major needs across all sectors are therefore climate-related information to support planning and decision-making specific to each sector, and training in the use of the information. The Trinidad and Tobago Meteorological Service (TTMS) hosts a National Climate Outlook Forum designed to strengthen and increase the provision of seasonal outlooks for Trinidad and Tobago. The programme aims to ensure that weather and climate information are integrated into decision-making and planning in key climate sensitive sectors such as agriculture, water management, energy, health and disaster risk reduction. For example, information provided is useful for:

- managing water resources when reduced rainfall (and therefore availability) is expected;

TABLE 4.5 Summary of Highest Ranked Risks from Climate Change[1]

Ranking	Event and Outcome Risk	Severity of Impact	Probability/ Frequency of Risk	Agriculture, Food Security & Fisheries	Terrestrial Biodiversity & Coastal Resources	Human Health	Human Settlements & Infrastructure	Water Resources	Tobago (Island ecosystem)
1	**Sea level rise and storm surge** with associated flooding and damage to fish landing sites and fisheries infrastructure	High	Very High	✓					
1	**Extreme Weather Events (intense precipitation)** resulting in increases in flash flooding leading to power supply interruption, injury, interruption of routine health service delivery and response	High	Very High			✓			
1	**Sea level rise and storm surge** resulting in damage to access roads and major roads and transportation links like marinas, ports, jetties and sea defences and offshore industrial, residential infrastructure, utilities, industrial facilities and plants including sewerage	High	Very High				✓		
1	**Variations in precipitation (localised)** resulting in more instances of water contamination as pollution control systems are not designed to deal with variations resulting in increased instance of pollution and sedimentation of water resources	High	Very High					✓	
1	**Variations in Sea Surface Temperature** and associated impacts on fish migration and changes in marine biodiversity resulting in increased costs and loss of productivity, reduced income and reduced opportunities for recreation, increased costs for management of Sargassum including air quality and health issues, food security issues (Tobago)	High	Very High						✓
2	**Extreme Weather Events (intense precipitation)** resulting in flash flood damage to bridges, roads, residential and commercial properties, utilities, access, services, critical infrastructure, cultural historical buildings and recreational structures and impacts on sewage and garbage management and infrastructure	Moderate	Very High				✓		

1 The table reflects the sector groupings from the VCA project.

TABLE 4.5 (CONTINUED) Summary of Highest Ranked Risks from Climate Change

Ranking	Event and Outcome Risk	Severity of Impact	Probability/ Frequency of Risk	Agriculture, Food Security & Fisheries	Terrestrial Biodiversity & Coastal Resources	Human Health	Human Settlements & Infrastructure	Water Resources	Tobago (Island ecosystem)
3	**Extreme Events (increased incidence of Category 4 and 5 and change in hurricane tracks)** resulting in deaths, damage to infrastructure, loss of essential services, loss of critical infrastructure, loss of livelihoods, shut down of transportation, increased stress amongst population, increased crime & social disorder (localised), population displacement, migration, increased demand for recovery and response, increased diseases (Tobago)	High	Moderate						✓
3	**Sea level rise and storm surge** causing coastal and inland flooding due to drainage constraints, presenting a risk to agriculture and livestock, vermin and domesticated animals and related spread of diseases (e.g. leptospirosis is water borne)	High	Moderate			✓			
3	**Sea level rise and storm surge** causing coastal and inland flooding due to drainage constraints resulting in disruption to marine transport of food and medical supplies	High	Moderate			✓			
3	**Sea level rise and storm surge** causing coastal and inland flooding due to drainage constraints presenting risk to water quality and waste disposal and associated spread of diseases (e.g. Beetham Dump, San Fernando Wastewater facilities and overflowing sewage tanks and related spread of contaminated matter)	High	Moderate			✓			
3	**Sea level rise and storm surge** causing coastal and inland flooding due to drainage constraints resulting in disruption of electrical supply and associated health impacts (e.g. not boiling potentially contaminated water or having cold storage, heat stroke, disruption of vaccine and blood supply)	High	Moderate			✓			
4	**Extreme weather events (likelihood of increase in category 4 and 5 hurricanes and change in hurricane tracks)**, resulting in damage and destruction of coastal infrastructure, fisheries infrastructure and equipment, coastal ecosystems and biodiversity and terrestrial ecosystems, agriculture, forests	Very low–low	Very low		✓				

- determining which crops to plant, based on forecasts of rainfall and temperatures;
- advising hotels on the number of really hot days expected which has implications for energy usage for cooling; and
- advising tourists of the probability of rainfall which may impact their activities.

Decision-makers in the public and private sectors could then determine the measures and resources required to reduce these impacts. However, the need remains for training decision-makers in how to understand and effectively use such information, particularly when there is a dearth of other useful information on that sector. For example, the Ministry of Health has only anecdotal and incomplete data on incidences of water and vector-borne diseases, viral and respiratory infections – all of which can be affected by weather and climate. The reasons for the poor data are that not all cases are reported, and not all persons with symptoms associated with these conditions are counted. Climate Outlook information will still be useful for forecasting potential cases of vector and water-borne illnesses so that medical care facilities and pharmacies can plan ahead and public advisories can be issued in an attempt to reduce cases, in the first place.

In terms of adaptation in the short-term, the policy and regulatory frameworks are in place for the most part but require more effective enforcement to support policies.

Financing remains a key challenge and barrier to effectively implementing recommended training programmes, and technical, administrative and institutional capacity-building and coordination.

Existing domestic funding and financing mechanisms, such as the Green Fund of Trinidad and Tobago, should also be used towards dedicated climate budgeting to support climate risk management programmes. Once the Strategic Framework is finalised, it can be used as a guide for ministries to request financial support.

Perhaps the most challenging types of barriers to address are the cultural challenges, particularly as they relate to resource use in Trinidad and Tobago. The relatively inexpensive electricity rates which is significantly subsidised, and the fixed rates for virtually unlimited water usage (as opposed to uniform metering to allow for pay-as-you-use) has resulted in a culture of entitlement and wastage.

Climate Monitoring (Early Warning) Systems

In addition to the National Seasonal Climate Outlook and National Climate Outlook Forum, the Trinidad and Tobago Meteorological Service (TTMS) has also implemented a Multi-Hazard Impact-based colour-coded Early Warning System (EWS) in line with the Common Alert Protocol standard for hydro-meteorological hazards such as severe weather, thundershowers, flooding, dry spells/droughts, extreme (high) temperatures, hazardous seas, and tropical cyclones (depressions, storms, and hurricanes) in Trinidad and Tobago. The "risk-based" system complies with the World Meteorological Organization's international standards for effective early warnings. This EWS was credited with saving lives in the flooding that occurred in Trinidad in October, 2018. Specific activities within this service are:

- National Seasonal Climate Outlook issued each month (seasonal outlooks on ENSO and rainfall and temperature for 1, 3 and 6 months);
- National Dryness Indicator and Outlook using the standardised precipitation index (SPI) that is issued each month as an outlook for dry spells and drought for the upcoming three months, while keeping track of the level of dry conditions and rainfall deficit over the previous three months, across Trinidad and Tobago;
- advisory services to the Government of Trinidad and Tobago prior to the hurricane season on risk transfer policies for excessive rainfall and tropical cyclone;
- site-specific quantitative rainfall total predictions issued monthly (for 1, 3, 6, 12 months) for the Water Resources Agency's (WRA) reservoir and intake sites. The product also includes

probability of exceedance totals, which are used for scenario modelling and water supply projections by the WRA to manage resources;

- SMS text messages of the daily weather forecasts and adverse weather warnings, when available, to the mobile phones of fishers and farmers;
- agro-meteorological weather information and forecasts every 10 days to the agriculture sector in the form of bulletins and forecasts;
- a daily three-day weather forecast for all tourism stakeholders in Tobago;
- a mobile weather app with push notifications which provide timely weather warnings and information.

In addition to direct communication with relevant agencies, the TTMS uses its website and mobile App to convey key information to the general public and others who wish to use the information in their planning and decision-making. The website and mobile App not only offer information on daily weather forecast and Seasonal Outlook but also radar and satellite images, and watches and warnings on various extreme hydrometeorological events when these approach Trinidad and Tobago. An agrometeorology bulletin and 10-day forecast are also available on the website. This information, although very useful to agriculture and food production, requires alignment especially with end users such as agricultural extension officers and farmers. This was evidenced during the meeting with the Ministry of Agriculture and with agricultural users in Tobago. The agrometeorological information is available in a more simplified form (more graphics and less technical messages) to some users via mobile phone applications.

The TTMS has advised that a critical element for enhancing these services for the agriculture and other sectors is a sufficiently dense network of Automatic Weather Stations (AWS) strategically located within the country's agricultural areas. This is especially important given the high dependence of local farming on rainfall, the large temporal and spatial variations in rainfall, and the increasing trend in dry spells and meteorological drought. The TTMS has determined that there is an urgent need to increase its observation network. Such investment is critical to adaptation under a changing climate in order to secure the food supply in a warming Trinidad and Tobago.

The TTMS is a critical actor in managing risks from climate change and in the implementation of national climate change adaptation strategies and plans within almost all sectors since it serves as the major custodian and provider of data required to support climate services at the policy level, including climate change research. It also provides other key competencies and services, including interpretation of information and scientific advice on climate variability, trends and change, particularly on climate extremes, all of which underpin adaptation at the national level.

Senior management within TTMS are well aware that functioning effectively in meeting the needs of the country requires it to provide appropriate and timely information for decision-making, particularly as it relates to early warning systems which would require the development and provision of innovative products and services based on relevant research. Having committed to this, the TTMS has renewed its efforts to generate the knowledge and competencies required for achieving climate change risk management and adaptation planning, as well as the delivery of products and applications aimed at enhancing Trinidad and Tobago's weather and climate-readiness.

The TTMS recognises that climate change is becoming a prominent issue in national discussions at all levels that will continue to increase the demand for climate data, information and expertise. In order to address this, the TTMS has embarked on a plan within the framework of the established principles of the United Nations Environment Programme (UNEP) and the World Meteorological Organization (WMO) Global Framework for Climate Services (GFCS)—to be implemented at the national level. The aim of this is to position the TTMS as the key national agency providing climate services to support national climate change adaptation.

TABLE 4.6 Capacity Resource Need Activities Status and Priority

Task/Activity	Status			Priority
	Acceptable	Needs Strengthening	Needs Establishing	
New National Meteorological Office			✓	Highest
Updated Organisational Working Structure		✓		Highest
Climate Change-Aligned Legal Framework			✓	Highest
National Climate Data Centre within TTMS		✓		Highest
Climate Prediction Modelling		✓		Highest
Climate Projection Modelling & Downscaling			✓	Highest
Land Observation Automatic Weather Station (AWS) Network		✓		Highest
Sea Observation Tidal/Weather Automatic Stations			✓	Highest
AWS Operation and Maintenance		✓		Highest
Geographic Information System		✓		High
Trained Climate Scientists		✓		High
Climate Change Public Outreach and Awareness			✓	Highest
Climate Variability and Change Research		✓		High
Relevant climate change information for advising Government on Climate Science issues		✓		Highest
Climate Services Information System		✓		Highest

The TTMS also recognises that managing risks from climate change and adapting to climate variability and change represents an important challenge for the sustainable development of Trinidad and Tobago and that to be effective, adaptation requires a strong policy framework, technology and practices in order to adjust to the expected changes. Relevant climate information and tools must support this. In pursuit of these objectives, the TTMS has developed a ten-year strategic development plan that serves as its policy framework to assist the country in its adaptation to climate change. As such, and as it relates to climate change, the TTMS sees its primary role as providing climate services that cover broad time domains from climate detection and climate monitoring (the past) to long-range or seasonal forecasting (the present) into climate projections (the future).

To adequately fulfill these new roles, two primary things are needed:

1. The TTMS must establish within its structure the necessary mechanism that will allow it to function as the National Climate Centre providing climate data, climate monitoring and policy support information for the country's sustainable socio-economic development thrust.
2. The TTMS must be the owner/custodian of Trinidad and Tobago's most sustainable meteorological network providing data sets that will serve as baseline input for national climate services.

Recognising the importance of sound and defensible climate information as the basis for climate change risk management, and in response to the adaptive capacity assessment undertaken as part of the VCA project, senior management within TTMS undertook and developed a detailed capacity/resource needs assessment (with indicative costs) which focuses on further strengthening the TTMS' capacity to contribute more effectively in climate change risk management and adaptation planning in the country. This is an important part of a broader capacity resource need for the TTMS to support capacity-building and institutional strengthening of the Service in carrying out commitments to the *Convention of the World Meteorological Organization*, adopted on 11 October 1947 and revised in 2007. **TABLE 4.6** presents the key needs in terms of capacity and resources and their priorities.

Proposed Climate Change Adaptation Measures

The proposed adaptation measures seek to reduce vulnerability and build resiliency in the short, medium and long terms to the impacts of climate change and sea-level rise, including intense rainfalls and flooding, and storm surges on coastal and adjoining low-lying areas of Trinidad and Tobago in, for example, the zones along the eastern and western coasts of Trinidad and almost all coastal areas of Tobago.

Adaptation to climate change in the short term presents an opportunity to address, as far as possible, current climate risks and associated barriers, thus enabling effective and proactive measures for long-term adaptation to future climate change. Short to medium term measures include capacity-building of relevant stakeholders, improved design standards, data collection and management, early warning systems, evacuation plans and emergency services. Since the coastal zone covers most of the country, integrated assessments and management of coastal systems, together with a better understanding of their interaction with socio-economic and cultural development are also important components of successful climate resiliency and adaptation to climate change in Trinidad and Tobago.

The following adaptation measures are proposed in order for Trinidad and Tobago to manage climate change risks (and therefore build its resilience) to the adverse effects of climate change. Three key sectors, water resources, human health, and agriculture are treated separately due to their significance to the economy and their sensitivity to climate change, as well as their cross-sectoral linkages and synergy.

Additionally, indicative costs for implementation are provided for some adaptation measures in Appendix 1. These adaptation measures have been developed to address:

- no-regrets activities to address key barriers to adaptation; and
- the highest risks posed by future climate change.

Water Resources Sector

- The finalisation of the National Integrated Water Resources Management Policy is critical, due to the prospects of more frequent droughts, and ongoing land-use practices (slash and burn, improper waste disposal, unsustainable exploitation of natural resources).
- The creation of an independent entity to regulate water resources supported by a sound legal and governance framework.
- Expansion of watershed management projects in Navet Reservoir, Hollis Reservoir and Arena Reservoir in Trinidad and Hillborough Reservoir in Tobago to include awareness and action on reducing risks from climate change.
- Protection and management of watersheds through integrated and adaptive land use planning. Specific actions could include the following:
  + Delineation and survey of water catchments and groundwater catchments (land use, land condition/degradation, sources of pollution) where not currently done
  + Definition and adoption of source protection zones, and accompanying management regulations for the preservation of aquifer recharge and water quality

  + Analysis of aquifer and surface water quality, with special focus on areas at risk from salinisation resulting from climate change
  + Detailed risk assessment and prioritisation of catchments requiring intervention
  + Development of action plans with appropriate interventions to support catchment resilience—and link to ongoing initiatives
- Water demand management through the implementation of a universal metering programme that would facilitate the monitoring of household usage with the goal of efficient and conservative use of water. Specific actions could include:
  + identification of illegal connections;
  + ensuring meter accuracy and accurate meter readings;
  + implementing an accurate billing and customer information system;
  + incentives for timely/early bill payment;
  + a public education campaign to raise awareness on water conservation.
- Climate change risk management for water utilities in the existing regulatory and legislative framework since population growth and climate change will exacerbate existing water quality and availability challenges thereby placing increasing pressure on the ability of water bodies to process wastewater, nutrients and contaminants before they lose their life-supporting functions.
- An inventory of water pollution control systems in the most vulnerable communities which could be compiled from information supplied by the known and potential polluters and should form the base data for an evaluation of these systems to facilitate pollution reduction programmes or changes in control systems used as a means of improving water quality and managing climate change risks.
- An evaluation of pollution control systems on a site-by-site (watershed/reservoir) basis to assess if climate change risks have been taken into consideration in the treatment process. Additionally, improve the current pricing and monitoring mechanisms for effluent discharges into watersheds, watercourses and other ecologically sensitive areas to strongly deter pollution.
- Modelling software to determine the extent of aquifer mining in order to assess saline intrusion based on sea level rise and to maintain a freshwater pressure head. Employ Information and Communications Technology (ICT) to collect, analyse and store all information required to make sound planning and engineering decisions for water resources.

Public Health Sector

- Improved monitoring and surveillance systems to strengthen data-based decision-making to support the legislation and policies already in place for the majority of the issues relevant to the determinants of health (related to the physical, social and economic environments).
- Climate change risks in the *Infection and Prevention Control Policies and Guidelines for Healthcare Services* that is being updated currently.
- Monthly Climate Outlook information from Caribbean Institute for Meteorology and Hydrology (CIMH) to develop and implement early warning systems for climate sensitive health hazards (water and vector-borne illnesses, and viral and respiratory infections). The basis of such a system is a communications strategy—one that includes the effective issuance and packaging of early warnings as well as the creation of supportive communications products and outreach efforts that will support resilience practices at the household, community, business and sectoral levels. An early warning system for dengue outbreaks in the Caribbean has been formulated by the Ministry of Health.
- Enhanced collection of comprehensive data on the prevalence of water and vector-borne illnesses, viral and respiratory infections as well as Non-Communicable Diseases (NCDs),

disaggregated on the basis of geographic location, conditions in the environment, weather and local climate.

- Longer-term data sets should be analysed for correlations in cases and climate signals (long-term trends in climate variables that could be attributed to climate change). As climate varies naturally over time (and is one of many determinants of disease rates) modelling is required to identify the climate-attributable part of disease/ conditions and the long term trends.
- National health strategies with supporting communication plans as part of a national adaptation plan/The Strategic Framework and Programme for Climate Change Risk Management. The strategies and plan should be supported by a monitoring and evaluation plan in order to understand the effectiveness and cost-effectiveness of strategies (interventions).

Agriculture Sector

- Evaluation of the effectiveness of the National Food Production Action Plan (2012–2015) and expand /replicate its successes, and restructure to address existing and future climate risks, as appropriate.
- Re-orientation of agricultural support policies towards goals and actions that address agricultural productivity and profitability that include climate risk assessments. Policy directions focused on the profitability and productivity of the sector, such as enhanced research, including on the feasibility of climate-tolerant crops, development and extension support; creation of efficient post-harvest value chains; and pest, disease and quality management systems, will help create a possibly small, but efficient agricultural sector and exploit some specific competitive advantages.
- Irrigation development needs a long-term investment strategy to ensure availability and maintenance of existing irrigation infrastructure for agricultural production and to adapt to future climatic (hotter and drier) conditions.
- The development of a comprehensive land management policy to ensure that land is dedicated to agriculture and not lost to, or threatened by other industries, such as real estate.
- Development of a Sustainability strategy and plan to achieve self-sustainability for some crops (such as potatoes, onions, broccoli, peppers) and proteins (goat, sheep and tilapia) over a three to five-year period. Encourage the use of local root crops such as cassava and sweet potato to increase self-sufficiency. Increasing the production and consumption of local food will help ensure food security, and provide import substitution.
- Improved pesticide testing and farm certification to ensure that safety standards are met and adhered to with respect to maintaining water supply and soil used for farming. The National Agricultural Marketing and Development Corporation (NAMDEVCO) has a Farm Certification and Monitoring Programme. In collaboration with the Ministry of Agriculture, it has developed trade protocols to enable Trinidad and Tobago's farmers to export their produce. The key component of the trade protocols is the judicious use of pesticides, the adoption of IPM (Integrated Pest Management) and record-keeping to ensure that the farmer is compliant with all the relevant rules and regulations necessary for good agricultural production. NAMDEVCO also promotes good agricultural practices as part of the Certification and Monitoring Programme.
- Expansion of cultivation and storage facilities, and the use of technology and machinery to allow multiple farmers to grow one specific crop in accordance with the Sustainability strategy. Farmers should be registered and certified and working with extension officers in the Ministry of Agriculture to ensure production (quality and quantity) targets are met and are safe for consumption.

- Expand the training and awareness from the Rocrops innovative agroecology model to other small farmers throughout the country. The farm's development has revolved around an integrated system of agroecology practices to rehabilitate degraded soils for horticultural and agricultural production, with minimum external inputs in an economically sound and environmentally friendly manner. The goal is to promote sustainable agricultural techniques and practices with the potential to contribute to rural development and food security of Trinidad and Tobago. The approach promotes:
  - sustainable agricultural techniques and practices; and
  - rural development and national food security.
- A sustainable aquaculture industry should continue to be promoted in support of food and nutrition security, employment generation and rural development, creation of investment opportunities and foreign exchange.

ICZM Policy Framework (short-term)

- Revise and operationalise the ICZM Policy Framework, integrating DRM, Climate Change Adaptation (CCA) and EbA. It is proposed that the ICZM Policy Framework integrate risk resilient ICZM principles and support the achievement of Sustainable Development Goals (SDGs).
- Revise the legal framework for ICZM, DRM and CCA—either through (i) the single comprehensive legislation approach or (ii) amending existing and proposed laws to incorporate risk-resilient ICZM.
- Improve public participation mechanisms with respect to ICZM. Conservation, climate change and development projects in the coastal zone should have accompanying public engagement plans and strategies that go beyond merely what the law stipulates for public consultation.

Risk Assessments and Repairs of Coastal Infrastructure (short-medium term)

- Design, build, and modify, as appropriate, existing revetments to address coastal erosion, instability and flooding along the coastline of Trinidad, to take into consideration:
  - sea level rise and storm surge projections; and
  - natural and hybrid solutions, including incorporation of natural protection features of the biophysical environment.
- Develop a national-level risk management plan for vulnerable fish landing sites and fisheries infrastructure.

Education and Awareness (short, medium and long-term)

- Improve environmental literacy within the general population, including the incorporation of climate change into academic curricula.
- Education and awareness campaigns should be developed and implemented for land use planners and developers with interests in the coastal zone.

Capacity Building, Strengthening of Institutional Processes and Collaboration

- Integrate climate change risk assessment and management in the environmental impact assessment and Certificate of Environment Clearance (CEC) process, as well as the development planning approval process. Develop building guidelines based on international best practice.

Improving Policy Frameworks

- Sustainable Development Goals and the goals of the Sendai Framework should be incorporated in relevant policy objectives and actions, where feasible.

Financial and Other Support for Vulnerable Livelihoods

- Finalisation of the Draft National Disaster Management Policy
- Expansion of the incentive programme for the fishing industry to include larger fuel-efficient engines; solar Photovoltaic (PV) technology; and retrofits for vessels for ice storage on board since fishers now need to fish farther offshore
- Improved fisheries management measures to ensure that subsidies do not artificially sustain vulnerable livelihoods (such as fishing and farming)

Improved data and information to support decision-making at all levels

- Collection of geo-referenced data and information on climate change risks to specific fish landing sites and fisheries infrastructure which should be made freely available to key stakeholders.
- Conduct a KAP (Knowledge, Attitudes and Practices) survey amongst coastal communities (including fisherfolk) to identify what is known about climate change risks and adaptation, and to develop a robust public awareness campaign to suit needs.
- Conduct an appraisal of unregulated settlements, particularly those in high-risk areas, with the aim of regularisation.
- Develop a GIS interface to show storm surge levels, areas of coastal erosion, and potential climate change-induced displacement (for 2030 and 2050 projections) to inform coastal planning, and which should be made public.

Addressing Climate Change Challenges Specific to Tobago

Recommendations from previous sections are, of course, relevant to Tobago as well. However, this island has unique assets and vulnerabilities that should be considered when adapting to climate change, such as beaches, coral reefs and forest ecosystems that support many socio-economic activities and are vulnerable to climate change.

- Improve Disaster Risk Management at the Community and Household Levels by building capacity at the community and household levels to establish and maintain climate resilience, and develop an education programme in support of this.
- Protect and conserve the Main Ridge Forest Reserve and its Watersheds taking into consideration its vulnerability to current climate variability and future climate change projections.
- Improve the management of coastal and marine areas and their resources taking into consideration vulnerability to current climate risks and future projected vulnerabilities.
- Explore opportunities to capitalise on the resource value of Sargassum, including through seeking financial and technical assistance from international and regional institutions/partners that may have useful information on case studies which could be adopted.
- Support the Tourism Industry
  + Incorporate climate change issues into various aspects of the tourism sector (including hotels, taxi and tour operators, restaurants, etc.), including through training and public education of all stakeholders such as tour guides, tourism promoters etc.

Appendix 1: Adaptation Measures and Their Costs for Implementation

"No-regrets" Adaptation Measures (short to medium-term)

The following "No-regrets" measures support the implementation of a Strategic Framework and Programme for Climate Change Risk Management. The actions mainly relate to capacity-building and data / information collection and accessibility to support decision-making. Costs were provided by national stakeholders in the VCA project.

Photo Credit: Lorraine Barrow, Institute of Marine Affairs

◀ The Institute of Marine Affairs (IMA) and the Environment Policy and Planning Division (EPPD) of the Ministry of Planning and Development with volunteers from the public gathered to replant 1,000 mangrove seedlings at the Brickfield Fishing Facility, 2018

Photo Credit: Lorraine Barrow, Institute of Marine Affairs

◀ Replanted mangrove seedlings at Brickfield Fishing Facility, 2018

TABLE 4.7 “No-regrets” Adaptation Measures (short to medium-term)

Institution	Human Resources needed	Technical Resources needed	Budget needed (total in USD)
Environmental Research Institute Charlotteville (ERIC)	» Community Climate Change Officer » Community Based Field Technicians » North East Tobago Climate Change Champions	» Drone mapping of NE Tobago » Community outreach and resilience activities	544,299
University of Trinidad and Tobago—Managing Climate Change Risk GIS	» Trained Climate Change Risk Module Developers » Trained Instructors » Trained Accreditors	» Climate Change Risk Software—Licenses and scenarios » Emergency and Disaster management Software licenses » GPS, ARC-GIS (mapping) » Desktop computers (classroom), Tablets (field)	1.5 million
COPE (ENGO)	» Resources for Public Outreach and Education	» Training facilities » Visibility material » Administration material	Year 1: 217,779 Year 2+: 139,654
Climate Change Unit, Environmental Management Authority (EMA)	» Professionals to staff the Climate Change Unit (seven persons)—Technical staff, Data management professionals, GIS professionals and Administrative support staff	» Develop a data and information management system, inclusive of a database, for the collection and analysis of data and information that will inform reporting on indicators for climate resilience and inputs into the MRV GIS » Build capacity to use Geographic Information System (GIS) in climate change risk management related activities » Build capacity to effectively communicate climate change risk issues to different audiences	2,038,160
Environment Tobago (ENGO)	» Trained and dedicated staff for building capacity in local communities » Trained staff for sensitisation and public awareness delivery	» Media kits » Survey forms for climate observations, impacts, experiences, practices and coping strategies » Database of adaptations and mitigations » Education tool kits for meteorological (quakes, floods, hurricanes and tsunamis), health (diseases and injuries), pollution (chemical, spills, waste water, sewage), water (potable and rain water catchment) agriculture, food supplies and shelter » Partnerships with MET services etc.	77,651

TABLE 4.7 (CONTINUED) "No-regrets" Adaptation Measures (short to medium-term)

Institution	Human Resources needed	Technical Resources needed	Budget needed (total in USD)
Ministry of Agriculture, Land and Fisheries/ Fisheries Division	» Statistical data collectors	» Mapping of Critical Fish Habitats in Trinidad and Tobago » Review and update of the current fisheries statistical system in Trinidad and Tobago to enable monitoring of the impact of climate change on fisheries » Review and update of the existing material on Trinidad and Tobago species to build a unified national species catalogue for fisheries stakeholders » Stock Assessment on major commercial species and the impacts of climate change on these species » Development of Fisheries Management Plans based on the results of the stock assessment in collaboration with stakeholder and socioeconomic data » Study to determine the migratory pattern of commercially important species such as pelagic species and lobster and the impacts of climate change on these species » Develop a Fisheries Spatial Management System » Acquisition of spatial data relevant to climate change in the fisheries sector » Identifying gaps in spatial data » Provision of fishers with VHF Radios	537,199
Protecting Health from Climate Change through Health Adaptation Planning (HNAP)	» Costs for Component 6: Climate Resilient and Sustainable technologies and infrastructure which are yet to be determined		2,206,774
Institute of Marine Affairs (IMA)	» Trained oceanographer with numerical modelling experience » Coastal engineer » Resource economist and communication expert	» Coastal vulnerability assessments » Development of ICZM Plans for different coastal regions (taking into consideration ecosystem-based approaches (EBA), legal framework and institutional arrangements » Shoreline Monitoring Programme Ecosystem Monitoring Programme » Ocean acidification Monitoring » Capacity building / training programme for local government and communities on ICZM » Marine Spatial Plan for the Gulf of Paria » Communication Plan for ICZM, climate change adaptation » Restoration Plan for Critical Ecosystems	3,719,864

TABLE 4.7 (CONTINUED) "No-regrets" Adaptation Measures (short to medium-term)

Institution	Human Resources needed	Technical Resources needed	Budget needed (total in USD)
LARPDU, Ministry of Rural Development and Local Government (MRDLG)	» Consultant » GIS Technicians » Database Specialist » Network Administrator	» Various, including diverse licenses and equipment	1,385,363
Met Services	» Human, technical resources	» Automatic Weather Stations (AWS), Deployed AWS and instruments » Automatic Tide Gauge Stations » Air Quality Monitoring Stations » Moored weather buoys	433,960
Coastal Protection Unit, Ministry of Works and Transport	» Shoreline Management Specialist » Coastal Numerical Modeler	» Programme Management and Information System » Coastal Information Management System » Training and capacity building » Instruments and software for monitoring coastal parameters & design	1,242,420
Organisation—ENGO Environment Tobago	» Staff for sensitisation and public awareness delivery. » Staff for building capacity in local communities » Trained staff for measurement of CC effects	» Media kits » Survey forms for climate observations, impacts, experiences, practices and coping strategies » Database of adaptations and mitigations » Other hardware and software tools » Education tool kits for meteorological (quakes, floods, hurricanes and tsunamis), health (diseases and injuries), pollution (chemical, spills, waste water, sewage), water (potable and rain water catchment) agriculture, food supplies and shelter » Partnerships with MET services, etc.	349,209

TABLE 4.7 (CONTINUED) "No-regrets" Adaptation Measures (short to medium-term)

Institution	Human Resources needed	Technical Resources needed	Budget needed (total in USD)
Ministry of Public Utilities/ Water Resources Agency, WASA	Trained professionals in (for details, see proposal): » Human Capacity Building—Data Management Training » Human Capacity Building—Climate Modelling training » Human Capacity Building—Training in the utilisation of GIS application for climate research » Hydroclimate—Increasing the Climatic and Hydrological Data Monitoring Capacity of Trinidad and Tobago » Hydroclimate—Increasing the Hydrological Data Monitoring Capacity of the Aquifer systems of Trinidad and Tobago in relation to salt water intrusion » Development of a National Water Resources Information System web-based portal including User Training » Water Security and Water Related Disasters—Flood Monitoring and Management » Water Security and Water Related Disasters—Drought and Water Security » Water Security and Water Related Disasters—Water Quality Monitoring programme	» Required items for training, » Etc. (see proposal)	» 33,279 » 29,581 » 33,279 » 1,171,424 » 1,080,166 » 1,626,978 » 887,443 » 887,443 » 81,349
TOTAL over 5 years			**19,573,005 USD (US$3.915 million/ Per year)**

Medium to Long-term Adaptation Measures

The following adaptation measures, if implemented, will help Trinidad and Tobago address current vulnerabilities to coastal erosion as well as to longer term impacts from climate change-induced sea level rise and storm surge. Such actions are in keeping with the country's "Pathways Approach" to climate change resilience. One way in which they do this is to provide an understanding of the resources needed for implementation.

The measures are proposed for sea level rise and storm surge associated with a Category 2 hurricane. However, attention should be paid to projections for 2050 as well as climate events over the next decade. Alternatively, and where budget allows, engineering designs for hard protective structures should include a combination of different resiliencies. For example, a coastal revetment or boardwalk could be designed with a base to withstand storm surges from a Category 5 storm and 'sacrificial' elements (from timber and/or concrete) that may be lost in a Category 2 storm.

The costs for these measures approximate the costs from a study conducted by the IDB (2016) as part of Component 2 of the Design and Feasibility Study for a Risk-Resilient ICZM Program. That study focused on increasing the level of Trinidad and Tobago's resilience to coastal management issues and proposes some solutions focusing on the following communities: Manzanilla, Guayaguayare, Sans Souci and Otaheite in Trinidad and Speyside in Tobago.

These coasts have been used as proxies for coastal works for the areas under threat based on the projections in this report, namely:

- Along the western Gulf of Paria (zone T2):
  - Port of Spain (impacts on infrastructure, namely buildings, roads, bridges, ports and transmission lines)
  - Zone bordering the coastline between Port of Spain and Chaguanas, which includes the Caroni Swamp
  - Couva, Debe, Fyzabad and Cedros and Buenos Ayres along the south-western peninsula

Case Study 1: Protecting towns and communities along the western Gulf of Paria

The Southern Main Road is a vital link to the livelihoods of all residents in the communities of La Brea, Point Fortin, Cedros and Icacos, among others, and directly serves the Otaheite Fishing Facility at Bay Road. The Southern Main Road is situated generally inland except for a section that curves around an uphill bend that veers dangerously close to the shoreline which is being eroded.

The Southern Main Road also services the country's main export industry, the oil and gas sector which relies heavily on the operation of numerous local and international companies in this sector. A loss or delay of access to this region would significantly impact the operation of these facilities and the country's revenue. There also exists a small eco-tourism industry that has developed with tours to the La Brea Pitch Lake that attracts both local and international visitors.

Loss of this road would result in significant social disruption and economic impact to the country. The main beneficiaries that would be impacted by a resulting intervention are:

- Utilities and Infrastructure: The Southern Main Road would be protected, along with overhead telecommunication lines supported on utility poles, underground water, and telecommunication lines.
- Residents/Livelihoods: This road is the main link for the built-up communities of La Brea, Point Fortin, Cedros and Icacos as well as smaller dispersed villages.
- Economy: The south western peninsula is the location of a main industrial sector for the country that includes the La Brea Port, Union Industrial Estate along with an LNG export hub in Point Fortin.
- Tourism: Main connection to La Brea Pitch Lake, an important national tourism attraction.

The IDB study has identified a shoreline length of approximately 75m (Otaheite) as requiring coastal protection and slope stabilisation measures. The shoreline at this site originally consisted of natural mangrove vegetation. The historical precedence of mangroves and the relatively benign coastal conditions on site make a strong case for a form of natural protection for shoreline stabilisation.

A feasibility study would be required to consider the options to stabilise the frontage. Given space constraints between the shoreline and the Southern Main Road, it is likely a solution that incorporates coastal protection and slope stabilisation will be required.

A. Estimated cost and source of financing

Items	Estimated cost (USD)
Gap analysis, data collection, technical studies, feasibility and designs	200,000
Construction, incl. supervision[1]	575,000
Total Capital Cost	**775,000**
Operation & Maintenance every 25 years for repairs (incl. monitoring and evaluation)	100,000

1 Comprises 50m length of living shoreline reef (submerged breakwater), native planting at shoreline, 100m timber boardwalk, localised landscaping and 15% optimism bias (contingency)

A further breakdown of the construction cost is given below:

Item	Estimated cost (USD)[1]
Living shoreline reef	250,000
Mangrove and Sea Grape planting	50,000
Timber boardwalk	75,000
Landscaping works	50,000
Slope works	50,000
15% Optimism Bias (contingency)	71,250
Supervision (5%)	27,313
Total Construction and Supervision Costs	**573,563**

1 Typically based on unit cost rates of constructed schemes in Trinidad and Tobago.

B. Management model

Options for management to be considered within the design including options for local municipality partnership with waterfront landowners.

Case Study 2: Protecting the coastline between Port of Spain and Chaguanas, which includes the Caroni Swamp

Photo Credit: Kishan Ramcharan

▲ Caroni Swamp in its splendour, 2020

The distance between Port of Spain, City of Port of Spain and Chaguanas is approximately 20–24 km. Similar to the protection for the south-western coast, a feasibility study would have to be conducted to determine the best solution. In this case, due to the presence of the Caroni Swamp, the solution should incorporate a "living shoreline" such as slope stabilisation through planting with appropriate natural vegetation. Mangrove planting may prove most suitable (specifically Red Mangrove which is native to this shoreline) for the existing/new back of beach areas. The more landward areas are dominated by black mangrove.

The innovative planting of native almond and sea grape could also be considered on the shoreline slopes to provide further resilience. Additional landscaping and the construction of a timber boardwalk would be viable. This could be used to demonstrate these natural ICZM approaches, and has the potential to be adopted as a low-cost shoreline stabilisation option in many other areas of Trinidad and Tobago, and further afield. Other more traditional engineering approaches could be considered, such as shoreline stabilisation with revetment or seawall.

Given the cost of approximately 8,000 USD per km, the construction cost for this project is estimated at 192,000 USD.

Case Study 3: Protecting areas around San Fernando

The driver for intervention at Lady Hailes Avenue in San Fernando is to replace an existing dilapidated seawall with new shoreline structures. San Fernando is Trinidad's second largest city and located adjacent to the relatively sheltered Gulf of Paria on the west coast of Trinidad. The proposed shoreline reconstruction is approximately 1.1 km in linear length, running parallel to Lady Hailes Avenue in the southern section and Kings Wharf to the north.

The vast majority of this urban shoreline is currently stabilised through hard engineered structures. These structures are of various forms (typically vertical structures), many of which are in poor condition (particularly along Lady Hailes Avenue section). Failure of these structures, or flooding from overtopping would primarily impact fishing, marine transportation and other commercial facilities along the shoreline, plus potentially other urban infrastructure (including the main road) and property set back from the shoreline.

The northern sections of this shoreline are typically underused and inaccessible to the public, which disconnects the city's residents/workers and the coast. The Lady Hailes Avenue section is underused apart from informal recreational purposes (swimming, fishing etc.).

A feasibility study would be required to consider the optimal option to stabilise the frontage with the aim of underpinning the wider development of this frontage. Options are likely to include traditional engineered retaining walls combined with green infrastructure and amenity elements. For example, a boardwalk has been proposed, similar to what was constructed in Chaguaramas in the north western peninsula.

Estimated cost and source of financing

Items	Estimated cost (USD) (related to shoreline works only)
Gap analysis, data collection, technical studies, feasibility and designs	1,000,000
Construction, incl. supervision[1]	14,000,000
Total Capital Cost	**15,000,000**
Operation & Maintenance every 25 years for repairs (incl. monitoring and evaluation)	1,000,000

1 Comprises 700m of seawall, 400m of boardwalk seawall, 400m of vegetation terracing, allowance for mooring/access points and 60% optimism bias (contingency).

B. Management model

Options for management to be considered within the design, including options for local municipality partnership with waterfront landowners.

5

OTHER INFORMATION CONSIDERED RELEVANT TO THE ACHIEVEMENT OF THE OBJECTIVES OF THE CONVENTION

Photo Credit: Cindy Chandool

▲ National Climate Change Policy Consultation held in Trinidad, September 2019

The following information is relevant to Trinidad and Tobago's quest to meet its commitment to the Paris Agreement and expands on the Mitigations Analysis covered in Chapter 3.

Emission reduction targets

Trinidad and Tobago has set a cumulative emissions reduction target in the power generation, transportation and industrial sectors under the Paris Agreement through its Nationally Determined Contribution (NDC) amounting to 15 percent from a business-as-usual baseline to 2030, amounting to 103,000,000 metric tonnes of carbon dioxide equivalent. Of this, an unconditional component equivalent to 1,700,000 metric tonnes of carbon dioxide equivalent is targeted to be reduced in the public transportation sector by 2030 relative to 2013. The gases covered are carbon dioxide, methane and nitrous oxide.

Progress in achievement of such emission reduction targets

To date, the country has invested approximately 32 million USD in a fuel switching programme in the transportation sector (See Case Study 1.1, page 60), and has realised the avoidance of 31,509 metric tonnes of carbon dioxide equivalent. Plans are also underway to construct a 112.5 MW capacity solar power generation plant that will introduce the equivalent of 10 percent renewable energy in the power generation mix targeted for 2022. Additionally, with the support of the European Union, a solar park is to be constructed by 2022 at the Piarco International Airport with an annual generation capacity of 1,443,830 kWh which is equivalent to an avoidance of 1,010 metric tonnes of carbon dioxide, and represents approximately 7 percent of power consumption at the airport. Also with the support of the EU, roof top solar is being installed at 12 sites around the country that would realise the generation of 98kW.

Projects are being formulated for funding under the GCF to implement other activities identified in the NDC Implementation Plan in order to achieve its targets.

Integration of adaptation measures and mitigation activities

Trinidad and Tobago views climate change as a national development issue and has adopted a Pathways Approach to adaptation through the building of climate resilience and integration of climate change into the national development process by assessing climate risk vulnerability in the short to medium term while aiming at long term adaptation. Accordingly, a vulnerability capacity assessment study was conducted which identifies the sectors and geographical areas, and a financial investment plan for implementing the recommendations of the study has been completed. The integration of the recommendations, including the potential financing of activities, into sectoral strategies will be pursued. To this end, training on conducting vulnerability and climate risk assessments will be done within various sectors.

Trinidad and Tobago has developed an operational monitoring, reporting and verification (MRV) system for greenhouse gas emissions and mitigation actions (*See Chapter 3*). The system was tested through a pilot programme, gaps identified and addressed. The MRV system is being incorporated into law to make GHG emissions reporting mandatory as well as designed to report, monitor and evaluate mitigation actions taken or contemplated by emitting entities. The MRV system is currently being upgraded to allow for the reporting of data and information related to climate resilience and adaptation to facilitate reporting under the Paris Agreement as well as tracking of the integration of climate resiliency into the national development process, and the implementation of the National Climate Change Policy. It is expected that such reporting will further allow for the collection of data and information to facilitate relevant reports as required, such as the Biennial Transparency Reports (BTRs) under the Paris Agreement, and create a sustainable and institutionalised mechanism for compiling reports such as national communications and BTRs.

Gaps, Constraints and Capacity Building Needs for Convention Implementation

This section outlines the main barriers and opportunities for the sectors. First, the information needs are identified, followed by the main barriers to the development of the sectors, and the potential strengths and opportunities.

Power Generation

Information needed

- Behavioural models for energy usage
- Data on school sizes and available areas for RE installations
- System Parameterisation (e.g., Generator Models) for optimisation studies
- Site identification for community RE
- Comprehensive system studies for increasing penetration of RE
- Wind and Solar (and other RE) resource assessments for feasibility studies
- Enhanced knowledge about customers for providing comparison information in billing
- Site identification for Utility Scale RE

Main barriers

1. Inadequate legislation and policy frameworks to create an enabling environment for facilitating energy efficiency and renewable energy
2. Subsidised electricity costs contribute to low adoption of energy efficient and RE technologies
3. Insufficient system information to do proper optimisation studies

Potential Strengths and Opportunities

1. School curriculum changes can create meaningful long-term behavioural change
2. Good levels of internet penetration to improve customer engagement in electricity sector

3. High level of existing industrialisation and industrial service sector to support ramp-up of new industries if feasible
4. Job creation from new green economy
5. Creation of an enabling environment through legislative and policy reform
6. Incentivisation for commercial RE investments to encourage job creation

Industry

Information needed

- Feasibility studies for developing captured carbon industries
- Feasibility studies for implementing renewable fuels
- Feasibility studies for developing hydrogen industries

Main barriers

1. Highly competitive international markets make it difficult for companies to adopt best available technologies that do not improve their market position in addition to reducing GHG emissions
2. Ready supply of fossil fuel natural gas makes alternative fuel supplies uneconomical

Potential Strengths and Opportunities

1. High level of existing industrialisation and industrial service sector to support ramp up of new industries if feasible
2. Job creation from new green economy

Transport

Main barriers

1. Policy challenges to revitalise urban centres and to decentralise public services, and PAYD
2. Inadequate know-how and experience by decision-makers in public–private financing of urban development
3. Cultural acceptance of park and ride systems and arrangements
4. Free and abundant parking
5. Cultural acceptance of public transport largely based on an inefficient system

Potential Strengths and opportunities

1. The transport impacts of Comprehensive Smart Growth programmes are the reduction of resident and employee vehicle travel by 10–30%, or even more, compared with automobile-oriented development (Litman, 2003)
2. PAYD insurance applied to private automobile travel, and PAYD registration fees and taxes applied to all vehicles. PAYD pricing typically reduces affected vehicles' average annual mileage 10–15%, depending on how fees are structured (Litman, 2003)
3. Off-site or urban fringe parking facilities can provide a typical reduction of vehicle trips by 10–30% (Litman, 2003)
4. Parking management strategies to reduce vehicle travel directly, and support more compact, multi-modal development. Parking management programmes typically reduce vehicle trips 5–15% if financial incentives (such as pricing) are excluded, and 10–30% if included (Litman, 2003)
5. Transit improvements for urban travel
6. Switching from internal combustive engines to electric vehicles charged with RE

Waste and Wastewater

Information needed

- Capacity needs for specific training for the sectors
- Specific surveys such as knowledge, attitudes and practices (KAP) on reuse, recycling, and composting
- Feasibility studies for plants and technologies. for wastewater treatment plants and waste-to-energy plants

Main barriers

1. Capital cost for new projects and funding for capacity building and research

2. Capacity issues

Potential Strengths and Opportunities

1. Community programmes such as community composting programmes
2. Innovative reuse of plastic products such as tile stones, furniture, etc.
3. Incentivising investment for waste reduction, reuse and recycling
4. Centralised wastewater treatment plants

AFOLU

Information needed

- Quality activity data for estimating greenhouse gas emissions

Main barriers

1. Change in cultural and traditional practices
2. Resource constraints for effective forest management
3. Reluctance of private land owners to maintain forest stock

Potential Strengths and Opportunities

1. The sequestration potential of the forest stock is significant and can be increased through reforestation, rehabilitation of degraded land, and agroforestry, which will further increase the negative emissions of the country as well as create sustainable jobs
2. Vertical Farming practices to maximise nutrient and fertiliser application and use

Steps taken to integrate climate change considerations into national development and policy formulation

Trinidad and Tobago is currently updating its National Climate Change Policy (NCCP) to incorporate the provisions of the Paris Agreements and decisions taken under the Paris Agreement. The National Environmental Policy was updated and approved in 2018, and expressly incorporates issues relevant to climate change into the national development framework. The provisions of these policies are being integrated into sectoral development plans and strategies, including through the work of the National Sustainable Development Council established in 2020.

Notably, as a small island developing state where there are, invariably and inevitably, overlaps in land use, a major challenge is distilling the development impact signal from the climate change impact signal, particularly in respect of slow-onset impacts. This in turn provides a challenge to formulating approaches to mitigating impacts. To this end, climate change impact assessments are being incorporated into the environmental impact assessment process and procedures to ensure climate change considerations are taken into account in the development process. Such considerations will include socio-economic implications arising from climate change impacts such as those on amenities, communities and livelihoods.

Linkages between the national communication process and national development priorities

Actions being undertaken to mainstream the compilation of information through administrative, institutional, policy and legislative frameworks not only aim to facilitate reporting requirements of the UNFCCC and the Paris Agreement, but to provide updated data and information to inform the national development process, and build climate resiliency by taking into account climate risks, sectoral vulnerability, their interlinkages and long-term adaptation.

Activities related to transfer of environmentally sustainable technologies

A technology needs assessment (TNA) has been conducted in collaboration with the Technical University of Denmark (DTU). The approach taken by Trinidad and Tobago recognises that the TNA process is not a stand-alone process but an opportunity to identify, assess, adapt, adopt, synergise, and implement relevant technologies within the national development process, to address climate change through low carbon development pathways to build climate resilience, in keeping with the foundation already laid

Photo Credit: Sindy Singh

◄ Vulnerability and Adaptation Training Workshop, Tobago, 2019. Participants were introduced to some of the key methodological components used to conduct a vulnerability assessment of Trinidad and Tobago's coastal zone, namely, how to select the most suitable climate model projections for your needs; how to deal with uncertainty; vulnerability assessment methodologies; identification and prioritisation of adaptation measures in the coastal zone.

in the form of the National Climate Change Policy, the Carbon Reduction Strategy, the Vulnerability Capacity Analysis (VCA) and the NDC (and its Implementation and Financial Investment Plans) under the Paris Agreement. The TNA was therefore focused on the NDC Implementation Plan and the climate risks identified in the sectors covered in the VCA. The TNA and the TNA process delves into more detail about the specific technological applications and technologies that could be employed using further multi-criteria analysis. The prioritised technologies will fast-track and facilitate decision-making at the policy and practical levels, and implementation at the ground level. The TNA forms the basis of project proposals for funding and therefore facilitates the transfer of environmentally sustainable technologies.

Activities related to participation in global research and observation systems

The Government of the Republic of Trinidad and Tobago (GoRTT), through the Trinidad and Tobago Meteorological Service (TTMS), has continued to promote and collaborate in research and systematic observations related to climate change. Meteorological observations have been made in Trinidad and Tobago for more than 70 years. In 2021, the observation network of the TTMS comprised two meteorological synoptic observation stations, one upper air observation station, eight Automatic Weather Stations, and one automated weather observation station. Enhancement of this network is ongoing. Both synoptic weather stations disseminate synoptic weather messages every three hours, internationally. The data exchanged internationally by the TTMS is provided consistently with WMO Resolution 40 (Cg-XII) on policy and practice for the exchange of meteorological and related data and products. The TTMS has one Doppler radar which was installed in 2009 and one satellite receiver system installed in 2020, which replaced a 20-year-old system. The routine surface and upper air weather observations made by the TTMS continue to be the principal source of atmospheric observations relevant to climate change from Trinidad and Tobago. The radar data are used to serve T&T society and sectors, from applications in aviation weather service to flood protection and disaster reduction.

Under the World Meteorological Organization (WMO), Trinidad and Tobago through the TTMS continues to participate in several observation programmes such as the WMO's Global Climate Observing System (GCOS) programmes. The TTMS' two reference climatological stations at Piarco and Crown Point are part of the GCOS. The purpose of the GCOS is to ensure that climate data needed to address climate-related issues are obtained and made available to all potential users. Within the GCOS, the TTMS' climate stations are also part of the Regional Basic Synoptic Networks (RBSNs) engaged in surface and upper-air observing stations and part of the Regional Basic Climatological Networks (RBCNs). Data from these stations are exchanged globally in real time and the TTMS maintains a climatological database of its hourly and daily synoptic climate data. The long climatological time series of the TTMS forms the basis of climate research and estimating climate change impacts at the national level. The upper air observations provide important information which is vital for both the forecast models and meteorologists.

The TTMS climate observations are also being included in the WMO's World Weather Records programme. The Purpose of the WWR is to ensure that the world records of weather and climate extremes are complete, accurate and up to date. Similarly, the TTMS participates in the World Weather Watch Programme (WWWP). The WWWP facilitates the monitoring and exchange of meteorological observations to ensure that countries have access to the required information that enables them to provide weather data, prediction and information services, and products to users. In addition to these, the TTMS climate data also form part of the World Data Center for Meteorology database in the USA, the National Climate Data Center in the USA, while its solar radiation data are included in the World Radiation Data Centre in Russia. The TTMS also provides its daily climate data to the Caribbean Institute of Meteorology and Hydrology, the WMO's Caribbean Regional Climate Centre. These datasets are used by regional and international scientists and research groups to contribute to the World Climate Research Programme. The TTMS climate data continues to contribute to national and regional research work which are used within the framework of the IPCC to determine climate change-relevant policy positions for national and regional policy makers.

Within the framework of the WMO's World Climate Programme, the TTMS contributes to its publications by providing an overview of the climate conditions over Trinidad and Tobago in the past year, along with information on observed extreme weather and climate events. The TTMS continues to participate actively in the publication of the Caribbean Climate Outlook Forum's (CariCOF) Caribbean Climate Outlook Newsletter, a monthly print and web-publication which provides updates of current climate conditions with 3 to 6-month outlooks for the coming seasons to help the region and individual countries adapt to climate variability and change.

Annually since 2015, the TTMS has participated in the international research effort of the peer-reviewed State of the Climate Report, an annual supplement to the Bulletin of the American Meteorological Society (BAMS). The TTMS contributes to the regional climate section of the preceding calendar year by assessing the local climate and placing it into a historical context. The TTMS participated significantly in the recently published *State of the Caribbean Climate* (2020), produced for the Caribbean Development Bank. Additionally, the TTMS participates in joint activities on climate variability and climate change with the Caribbean Institute of Meteorology and Hydrology, within the framework of the Caribbean Climate Outlook Forum.

As it relates to coastal zone management and monitoring, Trinidad and Tobago through its Institute of Marine Affairs (IMA) participates in:

1. a new lower maintenance Coral Reef Early Warning System (CREWS) buoy to be moored at Buccoo Reef, Tobago. CREWS buoys were originally procured and installed in Speyside and Buccoo in 2013 as part of a regional CREWS network developed by the Caribbean Community Climate Change Centre and National Oceanic and Atmospheric Administration (NOAA);
2. SEABED 2030 project, a Meso-American Caribbean Hydrographic Commission (MACHC) initiative to map the entire seabed by the year 2030, with a focus on data-sharing for the common good;
3. the provision of a national report at the Data Buoy Conservancy Panel (DBCP) in 2020 and attended the DBCP-36. The DBCP is a component of the Global Ocean Observing Systems (GOOS) under the Intergovernmental Oceanographic Commission IOC sub-commission for the Caribbean and adjacent regions IOCARIBE.
4. Sandy Shorelines Project funded by Korea International Cooperation Agency (KOICA) which is a regional beach monitoring network with nine other Caribbean island states.

Identification of needs and priorities for climate change research and systematic observations

Trinidad and Tobago has a unique climate vulnerability profile among the Eastern Caribbean islands due to its complex terrestrial terrain and its proximity to the equatorial belt. This has caused it to straddle multiple potential hazardous climatic threats, including being located within the southern fringe of the hurricane belt, the migration path of the tropical rain belt known as the Intertropical Convergence Zone (ITCZ) and the belt traversed by tropical waves. There is a clear need for research which distils climate variability impacts from those of climate change. This is important to show the scale of the climate change problem. There is also a clear need for research which addresses the understanding of ongoing climate change and research on climate change projections based on the most up to date greenhouse gas concentration trajectories (not emission scenarios), but which are appropriately scaled to the individual needs of each island. With regard to the country's emissions profile, there is a clear need for cross-sectoral climate change programmes aimed at increasing understanding of the scientific basis of climate change, sectoral impacts of climate changes, and available or emerging options for mitigation and adaptation.

There are a number of significant challenges in meeting the country's climate change research needs. These challenges are driven primarily by an insufficient climate monitoring network to adequately represent the high temporal and spatial variability of the country's rainfall and an inadequate organisational structure and human resource capacity for conducting targeted and innovative climate change research. In addition, the TTMS lacks the legal framework for a mandate making it accountable for specific areas of research. There is a need for funding to support a climate change research programme and to build capacity for climate modelling. The TTMS lacks appropriate modelling output and data which will enable it to undertake research to understand climate change impacts and adaptation impacts for energy production, generation, supply and distribution.

Ongoing and future impacts of climate change on the development of Trinidad and Tobago depend on four main, inter-linked physical factors: the extent of the warming; the changes in amount and variability of rainfall; the increase in extreme events; and the extent of sea-level rise. Both local private and public sector decision-makers need accessible, credible and relevant climate data and information to increase the country's resilience to more intense and frequent weather extremes. Experience has shown that when these decision-makers request data, they typically want climate data that cover their local area, to as fine a scale as possible, in formats that they can easily understand and incorporate into existing decision-making frameworks. In most cases, there is a gap between what is currently available at the TTMS and what is needed by decision-makers. To be effective and contribute optimally to the national climate research and climate actions, there is a need to proactively observe and collect appropriate climate datasets, necessary for preparing for current and future likely changes. This data need to be at a high enough spatial resolution to satisfy the needs of users in the private and public sectors. With ongoing climate change and an increase in the occurrence of weather and climate extremes, there is a great need for an improved hydro-meteorological surface observation network in Trinidad and Tobago. This will entail upgrading and rehabilitation of the observing network of the TTMS, including real time collection of data from the network, which is important for effective early warning systems (EWS) and disaster risk reduction (DRR) management decisions.

The Automatic Weather Stations (AWSs) component of the TTMS network is playing an increasing role in the observation networks and offers numerous advantages in weather and climate applications. Notwithstanding this, there are many current and anticipated challenges facing the AWS network. The current AWS network has irregular spacing, is inadequate and limited in geographical coverage with the result of large data-sparse areas. In addition, it lacks completeness in climate data records and does not meet the spatial resolution required for key climate elements needed to effectively monitor and represent the local climate. Furthermore, the actual density of the AWS network is significantly poorer than that recommended by the WMO for rainfall and temperature parameters. Apart from these, there is a demand for increasing the resolution of the TTMS's surface Automatic Weather Stations observation network. There is a critical need to improve the number of monitoring stations and grow the capacity of the TTMS to manage and analyse data that are collected.

Given the diverse nature of its rainfall climatology, it means that any TTMS research programme will need to address climate change projections and the likely effects of climate change on a wide range of ecosystems (both natural and human). At the same time, the country's mitigation and adaptation priority research has to cover a wide range of issues including marine and land transport; agricultural and forestry activities; coastal zone management including coral reefs, energy demand and supply; and sustainable development of urban settlement and infrastructures, including proximity to coastal areas. Given Trinidad and Tobago's economic dependence on fossil fuel and international trade, the country's climate change mitigation research options need to be in line with the commercial needs and technology standards of the international market.

Given the existing national gaps, there is need to strengthen cooperation with international institutions for research programmes/projects and to grow local research programmes. While advancing this, there is also a need to improve collaboration among researchers and government, and for government agencies to share climatic and other data, openly. At the same time there is a need to better articulate the specific climate change research needed for integrating climate-related information into sectoral policy development.

A key barrier is inadequate research funding. There is a need to build capacity to secure research funding. This will enable the government's efforts towards working with the disaster risk management community and the local climate change communities in terms of research efforts.

Measures and recommendations to improve national programmes for climate change research and systematic observations

- Over the next one to five years, there is a need to augment the TTMS Automatic Weather Stations network to meet the required needs, as part of an overall programme to attain an optimal surface observation weather stations network. Initially, the target should include at least a network of 35 AWS, which is half of the 70 surface observation stations required by the country.
- The country seeks to acquire five radar-based non-contact river stage/gauge monitoring stations with a telemetry system to measure water levels at key points along the main flood-causing rivers. These stations should also have the ability to measure rainfall. The river stages will aid effective flood forecasting and warnings, and flood frequency studies.
- In addition, the need for at least five radar-based tide gauge stations with the capacity to measure weather elements is regarded as critical to building the requisite database at a minimum. The tide gauges will assist with providing flood and hazardous seas warnings, tides for port operations, fisherfolk operations, tourism recreation and leisure activities, tsunami and general sea level monitoring and, eventually, research into sea-level change. This could engender the establishment for a national Sea Level Monitoring System with a joint maintenance effort among government agencies.
- There is a need to develop a centralised coastal information management system as a data repository with the attendant data-sharing agreement protocols established.
- The meteorological network needs to be expanded by establishing observation alliances with the agriculture, water resource, energy, forestry and volunteer weather observers.
- Trinidad and Tobago may benefit from a programme of data rescue to unearth data held in historical documents, locally and internationally.

- As part of ongoing public education and awareness, climate change symposia or workshops which target young climate change scientists and students and highlight climate change research lessons learnt and their usage for policy development are seen as a critical part of the capacity-building agenda.
- There is a need for alignment of local climate research and information with regional and international research programmes. The ability of Trinidad and Tobago to engage in rapid uptake of emerging new global technologies, including finely detailed down-scaled climate modelling to appropriate levels for both islands, which are sufficient to unearth near real state of local climate change, is also a recognised capacity need.
- Participation in regional and international research programmes of the World Meteorological Organization, such as the World Climate Research Programme, as well as continued and increased participation in WMO observations programmes, such as the Global Climate Observing System (GCOS), are also seen as essential components for fully assessing climate change impacts.
- Apart from existing times slices over which climate change research are carried out, there is need for the country to refine the study of climate change modelling and greenhouse gas concentrations on shorter timescales (5–20 years) than is often presented in climate change studies and Summaries for Policy-Makers, in order to ensure their consistency with the country's development priorities and investments.
- There is need to expand the current climate change research areas in order to understand the sector-specific nature of vulnerability and adaptation, of socio-economic circumstances and other prevailing conditions. This could complement the development of a national climate change research agenda.
- Appropriate educational content on climate change (measuring, detecting, and assessing the impacts of climate change on natural and human systems and effective adaptation strategies) should be promoted at all levels of the education system.

Information on climate change education, training, and public awareness

Trinidad and Tobago has established a Multilateral Environmental Agreement/Climate Change Focal Point Network with representatives from government ministries and agencies, non-governmental organisations, civil society organisations and private sector entities including industry, trade unions, fiduciary organisations and academia. The network aims to facilitate an exchange of information, disseminate educational and awareness material on MEA and climate change, and solicit views to inform policy, projects and activities related to implementing MEAs and climate change. Such activities are frequently complemented by press releases, media interviews, social media content and public lectures. In particular, specific effort has been expended on training media personnel on climate change and MEAs regarding the relevant science and the engendering of understanding to foster informed, accurate and responsible reporting on climate change. Additionally, undergraduate modules on climate change are being taught at The University of the West Indies involving climate science, greenhouse gas inventorying, vulnerability assessments, climate change technology and needs assessments, and climate diplomacy and the international policy response to climate change.

Information on capacity-building activities, options and priorities

As the government moves to institutionalise and legislate its mitigation MRV system, capacity gaps have been primarily identified in greenhouse gas inventorying and quality assurance/control within state institutions. To redress this, training for government agencies and stakeholders in the private sector has been conducted and facilitated through the UNFCCC and the Greenhouse Gas Management Institute, with the aim of building capability for developing

Photo Credit: Ministry of Planning and Development

▲ "Training of Trainers": Multilateral Environmental Agreements Capacity Development for Improved Management of Multilateral Environmental Agreements for Global Environmental Benefits project, July 2020

greenhouse gas inventories for submission to the MRV system. In order to sustain the training on an on-demand basis, a certification programme has been developed and will be administered through local universities. This programme also aims to satisfy certification requirements for the regulatory authority.

Promotion of synergy in implementation of the Rio Conventions

The Ministry of Planning and Development is collaborating with the Global Environment Facility (GEF) and the United Nations Development Programme (UNDP) to implement a project titled "Capacity Development for improved management of Multilateral Environmental Agreements for Global Environmental Benefits." This project takes an incremental approach towards strengthening the capacity of the country's public sector staff; raising public awareness about global environmental issues and the related international conventions; strengthening the links between sectors, including the mainstreaming of environmental concerns in development policies and projects; contributing to an ecologically safe and sound environment; and meeting the objectives of the Rio Convention.

This project is implementing a number of activities to strengthen the ability of the Government of Trinidad and Tobago to create, leverage and maintain synergies for the national implementation of MEAs and to strengthen integrated approaches to environmental management, including the meeting of MEAs guidance and national reporting requirements. A number of key activities have been completed, including policy and legislative mapping, mapping of civil society organisations, mapping of MEA reporting requirements, and capacity-building as it relates to MEA obligations, all of which have been undertaken across all sectors.

6

CONSTRAINTS AND GAPS, AND RELATED FINANCIAL, TECHNICAL AND CAPACITY NEEDS

Photo Credit: Keegan Callender, Ministry of Planning and Development

▲ Mr. Kishan Kumarsingh delivers opening remarks at Inception Workshop for the Preparation of Trinidad and Tobago's Third National Communication and First Biennial Update Report, 2017

6.1 Support received for capacity-building

Steady progress is being made in advancing climate action in Trinidad and Tobago to achieve the objectives of the UNFCCC and implement country obligations, in spite of constraints and gaps. The availability of quality data and information continues to be a challenge and creation of the policy, legislative, institutional, and administrative enabling environment remains a priority. Support received was interpreted to mean funding and technical assistance. To this end the following activities have commenced:

National Climate Mitigation Monitoring, Reporting and Verification System

This system has been described in detail in Chapter 2.1. The system was developed with the support of multiple donors under the Low Emission Capacity Building Programme and the Nationally Determined Contribution (NDC) Support Progamme in collaboration with the UNDP. The National MRV System facilitates the collection, analysis and transparent reporting of accurate and reliable information and data on GHG emissions, efforts to mitigate them and resources/support devoted to enabling these efforts. The system is supported by templates that have been designed to systematically capture relevant information/data for easy retrieval and checking.

Trinidad and Tobago's National Climate Mitigation MRV System and its supporting Knowledge Management System (KMS) are designed to allow stakeholders (i.e. Executing Entities [EE]) to calculate their GHG emissions using the Intergovernmental Panel on Climate Change (IPCC) Guidelines and upload the information into the KMS. Since the KMS is operated by the EMA, its Air Unit will then perform the required quality control and assurance checks on the data before incorporating into the National Inventory.

A pilot project was designed and conducted (with the support of the NDC Support Programme and the Initiative for Climate Action Transparency [ICAT]) as an initial small-scale implementation of the Emissions Component of Trinidad and Tobago's National Climate Mitigation MRV System with the following objectives:

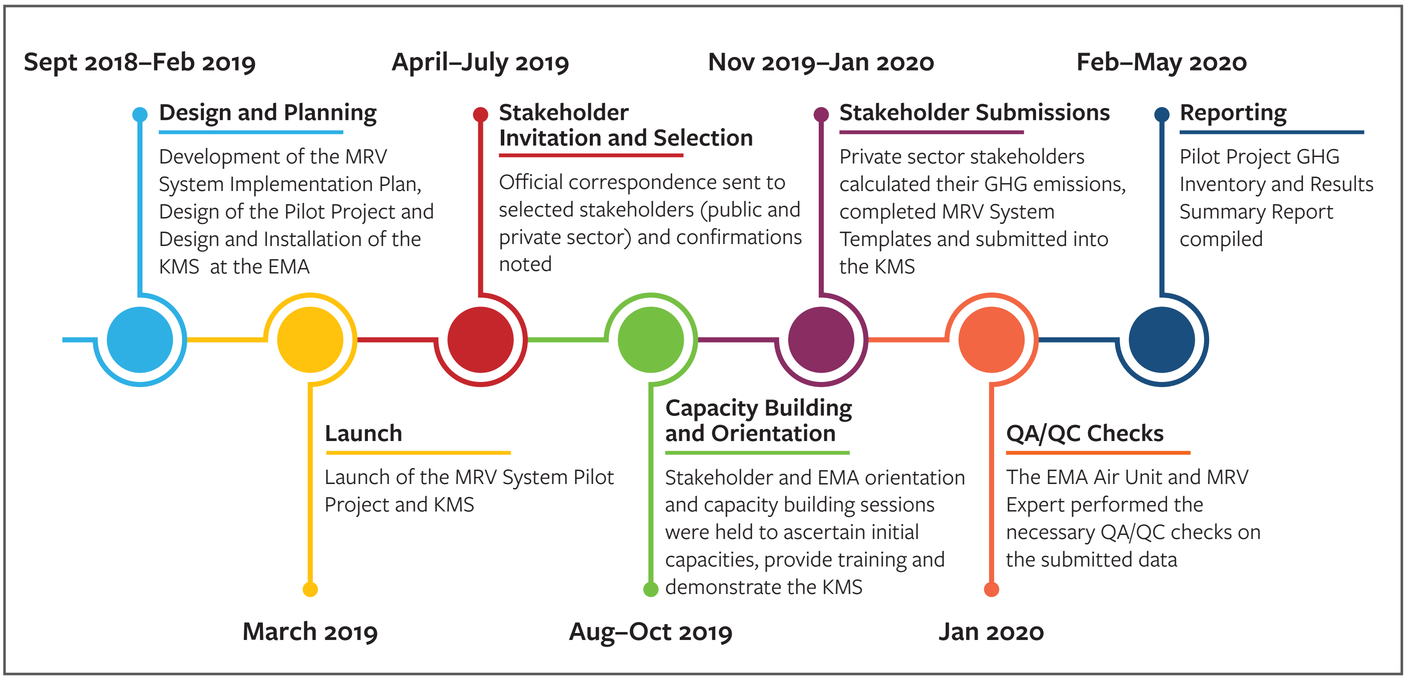


FIGURE 6.1 Pilot project timeline and activities

- Ensuring that Trinidad and Tobago's MRV of its GHG emissions is in accordance with applicable international standards, while taking national circumstances into account
- Coordinating and enhancing cooperation amongst the selected ministries and stakeholders in T&T's MRV System through their designated roles and responsibilities
- Testing the efficacy of the organisational structure of T&T's National MRV System
- Testing the operational procedures of data flow inputs/outputs to the KMS by identified institutional players
- Testing the ease of use of T&T's MRV System Templates by the relevant stakeholders and identifying any additional technical capacity necessary for their use
- Ensuring that stakeholders are adhering to the TACCC principles throughout their use of the MRV System Templates and Implementation Plan Action Tasks during the pilot project
- Supporting key institutional players with relevant technical information, knowledge and guidance to implement the National Climate Mitigation MRV System Pilot Project through the use of detailed tasks and templates
- Identifying obstacles and opportunities for the improvement of the National MRV System, highlighted action tasks for each stakeholder and the recommended templates.

The main activities of the pilot project, including stakeholder submissions into the KMS and the EMA conducting the necessary QA/QC checks, took place from November 2019–January 2020. Fifteen stakeholders from the public and private sectors participated voluntarily.

The Pilot Project Timeline and Activities are highlighted in **FIGURE 6.1.**

A number of capacity-building activities were facilitated under the pilot project.

- Stakeholders participated in an orientation session in October 2019, where they completed a capacity assessment survey and were introduced to the KMS. The results of the survey identified their initial individual technical capacities, organisational capacity and additional requirements for full participation in the National MRV System. Participants were also graded based on their GHG calculations, which were submitted into the KMS.

Photo Credit: Keegan Callender, Ministry of Planning and Development

▲ Participants at Inception Workshop for the Preparation of Trinidad and Tobago's Third National Communication and First Biennial Update Report, 2017

- Four members of the EMA Air Unit participated in this pilot project and completed a capacity assessment survey, practical exercises and the QA/QC checks on the stakeholder submissions of GHG calculations. These participants were also assessed based on a multi-criteria analysis.
- The KMS has two interfaces, one for the stakeholders (submitters of data/information) and the other for the EMA (receivers and holders of data/information). After being introduced to the KMS at the orientation session, stakeholders were provided with secure login credentials which granted them individual access to the KMS, along with the capability to upload their submissions.
- Regular capacity-building sessions and one-on-one tutorials were also held with the EMA Air Unit and the MRV and KMS Experts on the features of the system.
- The utilisation of the system by the stakeholders and EMA personnel allowed for the identification of various avenues for improvements and greater functionality of the KMS.
- A QA/QC Guidance document was developed to facilitate the process and to ensure consistency and sustainability of the system.

The following challenges were encountered on the stakeholder side:

- Limited technical capacity with respect to calculating GHG emissions using the IPCC Guidelines and Software
- Limited accessibility and availability of data required to conduct emissions calculations
- Institutional overlaps that may require clarification in processes related to emissions calculations
- Constrained human resources and inadequate time for carrying out the additional task of calculating and submitting emissions information into the KMS

The EMA also experienced some challenges:

- The need to improve working knowledge of sector specific GHG methodologies, 2006 IPCC Guidelines and QC checks
- The need to improve working knowledge of National MRV System Templates and KMS
- Limited human resources and time necessary for carrying out the additional tasks associated with the MRV System
- Lack of a comprehensive communication plan for formalised interactions with assigned stakeholders and the Coordinating Entity

The pilot project resulted in a number of recommendations which are already under development and/or implementation. These are:

- Development of a suite of MRV tutorial videos for convenient and step-by-step guidance for the users of the KMS and expected participants of the National MRV System
- Development of GHG Inventorying Certification Programme. This activity was supported by the NDC Support Programme which is detailed below:

Greenhouse Gas Inventorying Certification Programme

The Ministry of Planning and Development, through the NDC Support Programme and in collaboration with the UNDP and the Greenhouse Gas Management Institute (GHGMI), has developed a formal programme for Trinidad and Tobago to train, mentor, test, and certify experts with specific capabilities in:

- proper collection of input data and estimation of GHG emissions according to designated emission or removal categories;
- compliance with GHG reporting programmes rules and requirements;
- rigorous implementation of quality control (QC) procedures;
- application of international good practice for GHG estimation (i.e. IPCC guidelines).

The GHG Certification Programme aims to ensure that Trinidad and Tobago has access to qualified experts and supports the submission of high-quality data for its international climate change reporting and domestic policy implementation. The rollout of the Certification Programme is underway in collaboration with The University of the West Indies (UWI) and the GHGMI, to deliver the programme via a virtual learning platform with guided learning by experts. The instructors are also expected to benefit from training to ensure its continuity in the system through the building of national capacity.

Quality Control and Assurance Activities

Under the project to prepare the Third National Communication and First Biennial Update Report the support of an expert was engaged to conduct quality assurance of the draft inventory, through which a number of key recommendations were made for improvement. More importantly, this activity sought to build capacity with the EMA's Air Unit through practical exercises in inventory quality assurance. QA guidance which was developed and recommended under the MRV Pilot Project was further refined. The expert conducted QA/QC training in the application of the Transparency, Accuracy, Completeness, Consistency and Comparability (TACCC) principles for the development and review of GHG Inventories for relevant staff members of the Environmental Management Authority (EMA).

Technical Support for Quality Assurance

The UNFCCC Secretariat through its activities to strengthen the capacity of developing countries to prepare and manage National Greenhouse Gas (GHG) Inventories as a basis for the Enhanced Transparency Framework (ETF) under the Paris Agreement, provided technical assistance to Trinidad and Tobago for quality control and quality assurance, as the country developed its TNC and FBUR, and institutionalisation of GHG inventory and MRV processes. A GHG Inventorying Quality Assurance Training programme by the UNFCCC Secretariat was convened in February 11–15, 2019 in Port of Spain, Trinidad with stakeholders from all key

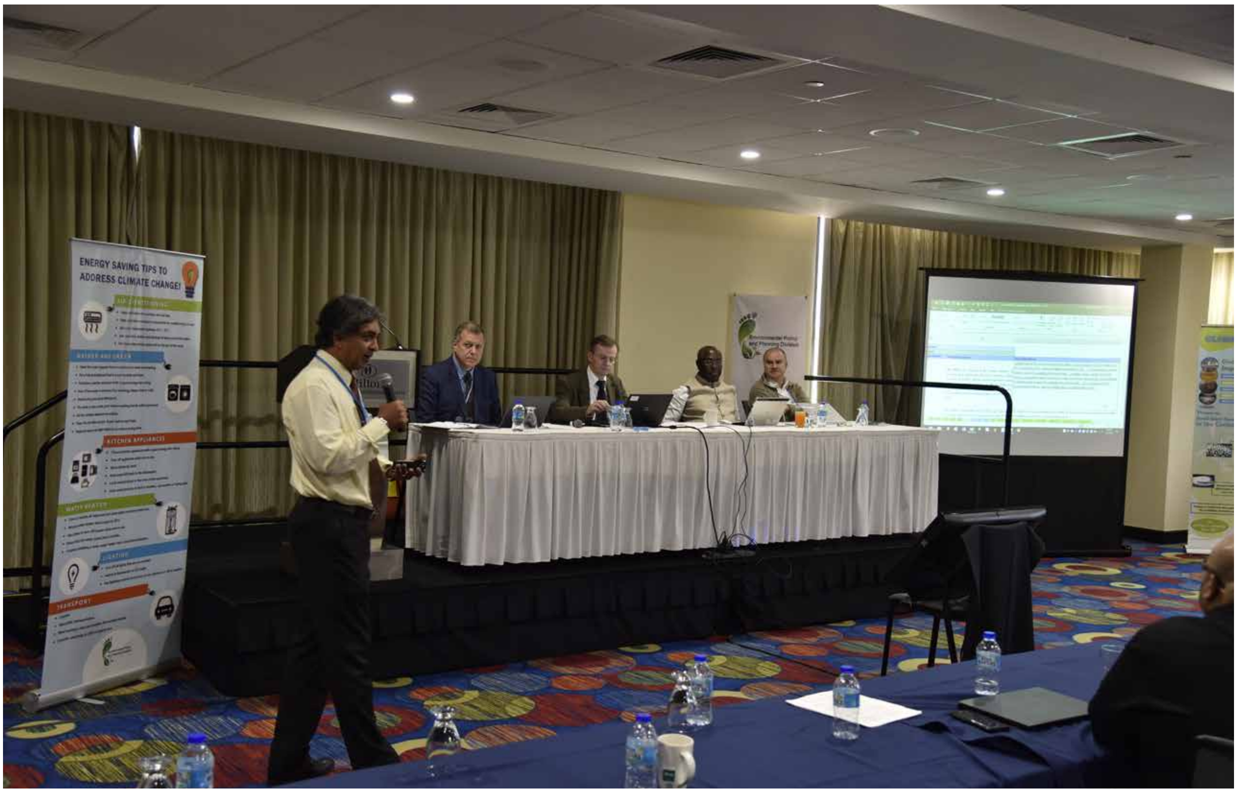


Photo Credit: Ministry of Planning and Development

▲ Panellists at the Greenhouse Gas Inventorying Quality Assurance and Control Training Workshop—United Nations Framework Convention on Climate Change (UNFCCC), Trinidad, February 11–15, 2019

sectors in attendance. The recommendations from the exercise are summarised below. It is important to note that some recommendations were taken on board to improve the inventory submitted with this report.

- Many participants were still unfamiliar or uncomfortable with the IPCC 2006 Guidelines. Capacity building in this area was recommended.
- There is currently no institutionalised relationship with the inventory compiler, Ministry of Planning and Development, and the suppliers of activity data. The National MRV System is recommended to routinise the institutional framework.
- No regular meetings of the inventory compiler, data suppliers and QA/QC personnel. These were conducted on an as-needed basis. It is recommended that all parties meet regularly to assess data quality and data needs (expected to increase as the inventory completeness and complexity increase).
- T&T should apply an archiving system to assure the availability of the inventory data including IPCC worksheets and activity data. The KMS will assist in this process.
- Routine inventory cycles are recommended with the aim of moving towards higher tiers with each progressive cycle (as data become available).
- Ensure that activity data, emission factors and global warming potentials are all consistent for the categories covered by the greenhouse gas inventory currently being prepared;
- An MoU or similar formal type of agreement should be established with all data providers when required to ensure quality and timeliness of data provision.
- Clarification of roles and responsibilities as well as coordination and data-sharing between government agencies and between public and private experts can and should be enhanced and strengthened.

Photo Credit: Ministry of Planning and Development

▲ Participants in attendance to the Greenhouse Gas Inventorying Quality Assurance and Control Training Workshop—United Nations Framework Convention on Climate Change (UNFCCC), Trinidad, February 11–15, 2019

Climate Promise

The Ministry of Planning and Development of Trinidad and Tobago is participating in the UNDP's Climate Promise initiative. The Climate Promise is UNDP's programme to support countries to increase the ambition of their national climate pledge (i.e. NDCs). Climate Promise activities in Trinidad and Tobago build upon its work for the preparation of greenhouse gas inventories. The preparation of the most recent national greenhouse gas (GHG) inventory for Trinidad and Tobago (included in this report) which included a comprehensive data collection exercise, highlighted certain weaknesses and gaps in the data collection process in various ministries and agencies, including in the agriculture, forestry and land use (AFOLU) and waste sectors. The Climate Promise work supported the execution of in-depth training workshops on data collection and management to improve the GHG Inventory compilation in the agriculture, forestry and land use (AFOLU) and waste sectors with a view to addressing the gaps and weaknesses identified. This would support a trajectory towards including all sectors in future NDCs as the country strives to develop economy-wide targets consistent with the objectives of the Paris Agreement.

6.2 Technology and capacity building support received

Trinidad and Tobago participated in a multi-country project titled "Technology Needs Assessment (TNA) - Phase III" in collaboration with the United Nations Environment Programme and Danish Technical University (UNEP/DTU) Partnership with funding from the Global Environment Facility (GEF). The TNA process undertaken built on the results of climate risk assessments and the NDC implementation plan for adaptation and mitigation respectively.

Photo Credit: Institute of Marine Affairs

▲ Swells at Store Bay, Tobago, 2008

▼ Relaxing in the Matura National Park, Trinidad. 2010

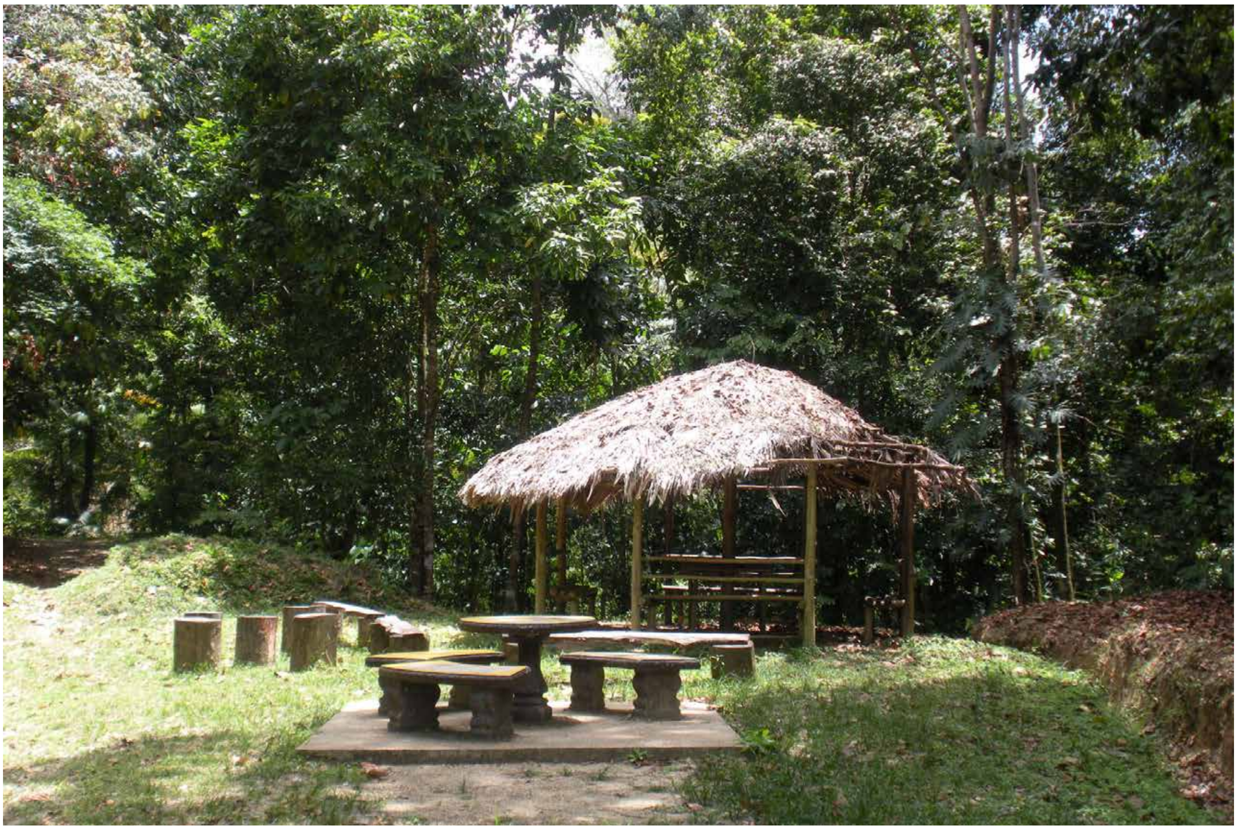


Photo Credit: Environmental Management Authority

TABLE 6.1 List of support needs

Need identified	Support needed	Specific type of support requested	When and for how long is support needed?	Where financial support is needed, please indicate	
				National budget available in USD	Financial support needed in USD
Country-wide wind atlas to assess wind RE feasibility	Wind measurements to inform and develop the wind atlas.	Technology transfer and Capacity building	As soon as possible for about 18 months		2,000,000.00
Institutional capacity for sustainable collection of GHG data in relevant sectoral institutions	Financial support for the establishment and staffing of specialised units in identified institutions	Financial support	2022 as seed start-up for five years		930,000.00
Identification of feasible sites for carbon capture and storage	Financial support for collecting and analysing data	Financial support and technology transfer	2022		500,000.00
A fully functional MRV/ETF unit	Financial support for the establishment and staffing of specialised MRV/ETF unit at the country's regulatory agency	Financial support	2022 as seed start-up for three years		450,000.00
Infrastructure requirements for sustainable transport	Financial support for assessing requirements for RE charging stations to transition to electric vehicles charged with RE	Financial support	2022		20,000.00

6.3 Gaps, Constraints and Support Needed

In the context of mitigation, the challenges have been identified in Chapter 5 under the section titled Gaps, Constraints and Capacity Building Needs for Convention Implementation.

However, full implementation of the foregoing activities would require additional support in the form of finance, capacity building and technology transfer. Support in this context refers to finance, capacity building activities, including technical training, provided through multilateral or bilateral donors specifically for climate related actions that are in alignment with the National Climate Change Policy. **TABLE 6.1** provides further details. The estimates are derived in consultation with experts in the respective fields identified as needing support. Projects that have been developed and executed have incorporated a post-project sustainability component aimed at integrating the outputs and outcomes into the policy, legislative, institutional and administrative framework. In some instances, additional funding may be required to create this framework where it is not already established. Therefore, the support needs identified in **TABLE 6.1** will be similarly structured to ensure sustainability.

6.4 Financial support received

TABLE 6.2, TABLE 6.3, and **TABLE 6.4** provide an overview of financial support received from the Global Environment Facility, bilateral sources, multilateral sources (including the Green Climate Fund).

TABLE 6.2 Climate-specific financial support received by origin

	Reporting period (timeframe covered)				
	2010–2020				
	Climate-specific amount				
Finance mobilised	**Domestic currency**	**USD equivalent**	**Status** (Committed/ Disbursed)	**Funding sources** (ODA, OOF, etc.)	**Financial instrument** (Grant, Concessional loan, Non-concessional loan, Equity, Other)
Public finance support—bilateral	TTD 1 million		Disbursed	European Union Environment Programme—Trinidad and Tobago	Grant
Public finance support—bilateral	TTD 900,000		Disbursed	European Union Environment Programme—Trinidad and Tobago	Grant
Public finance support—bilateral	TTD 3.5 million	$600,000 (approx.)	Disbursed	European Union Environment Programme—Trinidad and Tobago	Technical Assistance—Grant
Public finance support—Global Environment Facility	TTD 6.4 million (approx.)	$952,000	Disbursed	Global Environment Facility	Grant
Public finance support—Global Environment Facility	TTD 8.2 million	$1,207,800	Disbursed	Global Environment Facility	Grant
Public finance support—Global Environment Facility	TTD 897,600	$132,000	Disbursed	Global Environment Facility—UNEP DTU	Grant
Public finance support—Green Climate Fund	TTD 1.7 million	$260,000	Disbursed	Green Climate Fund	Grant-Readiness Programme
Public finance support—Green Climate Fund	TTD 3.9 million	$662,306	Disbursed	Green Climate Fund	Grant-Readiness Programme
Public finance support—Green Climate Fund	TTD 2.8 million (approx.)	$425,420	Committed	Green Climate Fund	Grant-Readiness Programme
Public finance support—Green Climate Fund	TTD 2.5 million (approx.)	$375,986	Committed	Green Climate Fund	Grant-Readiness Programme

TABLE 6.2 (CONTINUED) Climate-specific financial support received by origin

Reporting period (timeframe covered)		
2010–2020		
Focus of support (Mitigation, Adaptation, Cross-cutting, Other)	**Sector**	**Additional information**
Mitigation of emissions in the transport sector. The objective of the initiative was to pilot the use of a fully electric vehicle in Trinidad and Tobago to demonstrate the applicability and use of the technology.	Electric Bus purchased in collaboration with the University of Trinidad and Tobago (UTT)	The project was completed and the bus is used as a campus shuttle by the UTT.
Mitigation and Adaptation. The project aimed to conduct infrastructural upgrades/retrofit of the Toco Health Centre to increase climate resilience in the event of a climate related disaster.	Health Sector	The project is 66% complete.
Adaptation. Vulnerability, Risk and Capacity Assessments were completed for the following sectors: Agriculture and food security, Water resources, Human health, Coastal resources and fisheries, Human settlements and infrastructure, Biodiversity, Finance Sector (including insurance), Tobago. The project also supported the demarcation of the Main Ridge Forest Reserve.	All sectors	Project was completed
Mitigation and Adaptation, Cross-cutting. Preparation of Trinidad and Tobago's Third National Communication and First Biennial Update Report to the UNFCCC.	All sectors	Project was completed
Mitigation and Adaptation. The project's objective is to implement capacity development activities in Trinidad and Tobago to improve the synergistic implementation of MEAs and contribute to increased national and global environmental benefits.	All sectors	Project is ongoing with expected completion by the end of 2021
Adaptation and Mitigation. Cross-cutting. Support to Trinidad and Tobago to conduct a technology needs assessment and to prepare a Technology Action Plan.	All Sectors	Project is ongoing with expected completion by June 2021
Adaptation. Cross-cutting. Improving the monitoring system for climate change impacts on the agriculture sector in Trinidad and Tobago.	Agriculture	Project is ongoing
Cross-cutting. This project aims to develop the NDA's systems in addition to developing a national country programming including a pipeline of priority projects. The current readiness proposal complements this project by enabling the NDA to further identify and enhance areas of Climate change adaptation nationally and in so doing would help identify potential areas which allow for more efficient utilisation of GCF resources in synchronisation with the national climate change agenda.	Cross-cutting	Project is ongoing
Cross-cutting—Accreditation of the Environmental Management Authority by the Green Climate Fund.	Cross-cutting	Project is ongoing
Adaptation. Building climate resilience into Trinidad and Tobago's Healthcare System through creating an enabling environment for Climate SMART facilities and improved domestic incident management systems.	Health	Project is ongoing

TABLE 6.2 (CONTINUED) Climate-specific financial support received by origin

	Reporting period (timeframe covered)					
	2010–2020					
	Climate-specific amount					
Finance mobilised	**Domestic currency**	**USD equivalent**	**Status** (Committed/ Disbursed)	**Funding sources** (ODA, OOF, etc.)	**Financial instrument** (Grant, Concessional loan, Non-concessional loan, Equity, Other)	
Public finance support—Green Climate Fund	TTD 680,000	$100,000	Committed	Green Climate Fund	Grant-Readiness Programme	
Public finance support—Green Climate Fund	TTD 680,000	$100,000	Committed	Green Climate Fund	Grant-Readiness Programme	
Public finance support—other multilateral	TTD 625,000	$92,000	Disbursed	UNEP DTU/ European Commission	Grant	
Public finance support—other multilateral	TTD 2 million	$307,500	Disbursed	Inter-American Development Bank	Technical Assistance Grant	
Public finance support—other multilateral	TTD 5 million	$742,000	Disbursed	European Commission, UNDP and others	Grant	
Public finance support—other multilateral	TTD 3.9 million	$587,795	Disbursed	European Commission, UNDP and others	Grant	
Public finance support—other multilateral	TTD 850,000	$125,000	Disbursed	Initiative for Climate Action Transparency	Grant	
Public finance support—other multilateral	TTD 32 million	$4,800,000	Disbursed	European Union–Global Climate Change Alliance	Grant	

TABLE 6.2 (CONTINUED) Climate-specific financial support received by origin

Reporting period (timeframe covered)			
2010–2020			
	Focus of support (Mitigation Adaptation Cross-cutting, Other)	**Sector**	**Additional information**
	Cross-cutting. World Health Organization (WHO)/Pan American Health Organization (PAHO) readiness seeks to support The Caribbean Community and Common Market (CARICOM) member states in implementing the Caribbean Action Plan on health and climate change which ensures that the region is fully engaged in global climate change processes and agreements, that benefit Caribbean countries and territories by strengthening their technical cooperation methods, and facilitate the access to human, technical and financial resources necessary to address the effects of climate change on health. This readiness project is aligned with regional efforts to build climate resilience in the heath sector.	Health	Project is ongoing
	Cross-cutting. The aim of this project is to strengthen the foundation on which the region's agriculture sector prioritises investments for resilience and enhance conditions for improved reporting on greenhouse gas emissions in specified agricultural value chains. The project will help to compile and assess existing legal, market, financial, and data gaps and barriers, and define measures to address them.	Agriculture	Project is ongoing
	Mitigation. Capacity building for participation in carbon markets under the Clean Development Mechanism.	All mitigation sectors	Project completed
	Cross-cutting. The project focused on policy and legislative review and made recommendation for mainstreaming climate change into national development.	All sectors	Project completed
	Mitigation. Trinidad and Tobago participated in the Low Emission Capacity-Building Programme. Nationally Appropriate Mitigation Actions were designed, MRV System designed. NDC Implementation Plan developed.	Industry, power generation, transportation	Project has been completed
	Mitigation. Trinidad and Tobago participated in the NDC Support Programme. MRV System operationalised. NDC Financial Investment Plan developed. Gender Action Plan developed.	Industry, power generation, transportation	Project Completed
	Mitigation. Project supported the MRV Pilot Project, and is supporting the development of a policy framework for e-mobility.	Industry, power generation, transportation	Project is ongoing
	Mitigation. The project supports Trinidad Tobago in meeting its commitments to the global community under the UNFCCC/Paris Agreement as laid down in its Nationally Determined Contribution (NDC) as well as in the achievement of its national policy target of 10% of total electricity generated from renewable energy sources by 2021. Specifically, the action aims at an increased availability and use of energy from renewable sources and at increased efficiency levels in the consumption of energy.	Power Generation	Project is ongoing

TABLE 6.2 (CONTINUED) Climate-specific financial support received by origin

	Reporting period (timeframe covered)					
	2010–2020					
	Climate-specific amount					
Finance mobilised	**Domestic currency**	**USD equivalent**	**Status** (Committed/ Disbursed)	**Funding sources** (ODA, OOF, etc.)	**Financial instrument** (Grant, Concessional loan, Non-concessional loan, Equity, Other)	
Public finance support—national (optional)	TTD 500 million	$72 million (approx.)	Committed	National Budget	Budget Disbursements to the CNG National Gas Company	
Public finance support—national (optional)	TTD 3.1 million	$479,984	Disbursed	National Budget	Budget Disbursement to UNDP as the Implementing Agency	
SUBTOTAL Public finance support						
Private finance mobilised (optional, only if available)						
TOTAL						

Photo Credit: Environmental Management Authority

▲ Scarlet Ibis searching for small fish, crustaceans and insects, Trinidad, 2018

TABLE 6.2 (CONTINUED) Climate-specific financial support received by origin

	Reporting period (timeframe covered)		
	2010–2020		
	Focus of support (Mitigation Adaptation Cross-cutting, Other)	**Sector**	**Additional information**
	Mitigation. Mitigation of emissions through the CNG programme.	Public Transportation	219 million TTD spent at the end of 2020. Programme is ongoing.
	Mitigation. Elaboration of a Strategy for the reduction of Carbon Emissions in Trinidad and Tobago.	Industry, Transportation, Power Generation	Project completed in 2015 with the publication of the *Carbon Reduction Strategy*

TABLE 6.3 Support pledged for the future, by origin

	Commitments/disbursements related to timeframes not covered by the reporting period[1]	
	Timeframe covered	
	2020–2024	
	Total USD	**Sources of funding**
Public finance support—bilateral		
Public finance support—Global Environment Facility	$1,060,400	Global Environment Facility—Capacity Building Initiative for Transparency (CBIT)
Public finance support—Green Climate Fund	$300,000	GCF—Readiness Programme Green Ports
Public finance support—other multilateral	$800,000	GCF Readiness—Advancing E-mobility in the Caribbean Region
Public finance support—national (optional)		
SUBTOTAL Public finance support		
Private finance mobilised (optional, only if available)		
TOTAL	**$1,664,000**	

1 This relates to pledges which are made for a point of time in later than the reporting period, e.g. for 2017 if the reporting period is 2014–2016.

TABLE 6.4 Capacity-building support received in the reporting timeframe

Reporting period (timeframe covered)		
2010–2020[1]		
Type of support [capacity building]	**Support activity**	
Technology Needs Assessment	Conduct a technology needs assessment	
Capacity Development for improved management of Multilateral Environmental Agreements for Global Environmental Benefits	The project's objective is to implement capacity-development activities in Trinidad and Tobago to improve the synergistic implementation of MEAs and contribute to increased national and global environmental benefits.	
Preparation of Trinidad and Tobago's Third National Communication and First Biennial Update Report to the UNFCCC	GHG Inventorying Training (Sectoral Training Workshop for Greenhouse Gas Inventorying Using IPCC 2006 Guidelines.) QA/QC Review of GHG Inventory Training (EMA QA/QC training was designed to simulate their identified QA/QC action tasks in a typical GHG inventory cycle.) Mitigation Analysis Technical Training. (Train-the-trainer in constructing BAU baselines for emissions profiling and projections within the main GHG-emitting sectors of Trinidad and Tobago.) Vulnerability and Adaptation Workshop. (This workshop disseminated information on: • vulnerability assessment methodologies. • identification and prioritisation of adaptation measures in the coastal zone.) Development of a Just Transition Policy to facilitate just transition of the workforce Development of MRV Informational Videos Public Awareness activities undertaken such as TV Programmes	
Pilot testing MRV system	Pilot testing the MRV system in the power generation sector, industry, transportation and waste sectors. Testing the efficacy of the MRV System, specifically the reporting of GHG emissions.	
Private Investment Mobilization Training	Private Investment Mobilisation Training Course including stakeholders from NDC sectors. The objective is to build capacity to implement low carbon strategies and programmes through leveraging private finance.	
E-mobility policy	Development of an e-mobility policy—Development of a framework for an e-mobility Policy for Trinidad and Tobago using the ICAT's Transformational Change Guidance.	
Development of carbon pricing recommendations	Development of carbon pricing recommendations for Trinidad and Tobago	

1 This period covers the timeframe for which the Ministry of Planning and Development can provide data

6.5 Data/information gaps

There are no formal arrangements for collecting information or data on financial, technology and capacity building needs. However, this was assessed through project-based activities as illustrated in **TABLE 6.4**.

The establishment of the MRV system is expected to gather information on support received as well as support needs for the future.

TABLE 6.4 (CONTINUED) Capacity-building support received in the reporting timeframe

Reporting period (timeframe covered) **2010–2020** **Year(s) received**	**Status [ongoing, finalised]**	**Focus [mitigation, adaptation, unspecified]**	**Source of support**
2018–2021	Completion in June 2021	For NDC implementation and addressing climate risks.	UNEP/DTU
2017–2021	Completion in December 2021	The project's objective is to implement capacity-development activities in Trinidad and Tobago to improve the synergistic implementation of MEAs and contribute to increased national and global environmental benefits.	GEF/ UNDP
2017–2021	Completion in May 2021	Mitigation and Adaptation. All sectors.	GEF/UNDP
2019–2020	Completed	Mitigation.	ICAT (UNEP-DTU) and NDC Support Programme
2020–2021	Ongoing	Mitigation.	UNDP, The Centre for Climate Strategies
2020–present	Ongoing	Mitigation.	ICAT (UNEP-DTU)
2020–2021	Completed	Mitigation.	UNFCCC

7

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TECHNICAL ANNEX

TECHNICAL ANNEX TABLE 1 GHG Inventory IPCC Short Summary Table (2018)

Inventory Year: 2018

	Emissions (Gg)			Emissions CO_2 Equivalents (Gg)			Emissions (Gg)			
Categories	**Net CO_2 (1)(2)**	**CH_4**	**N_2O**	**HFCs**	**PFCs**	**SF_6**	**NO_x**	**CO**	**NMVOCs**	**SO_2**
Total National Emissions and Removals	35051.53363	183.9537715	4.069461548	NE	NE	NE	0.351895791	22.78739219	0	0
1—Energy	17057.17585	78.08901308	0.155149766	NE	NE	NE	0	0	0	0
1.A—Fuel Combustion Activities	15283.84219	0.930382261	0.15112716				NE	NE	NE	NE
1.B—Fugitive emissions from fuels	1773.333665	77.15863082	0.004022606				NE	NE	NE	NE
1.C—Carbon dioxide Transport and Storage	NO						NO	NO	NO	NO
2—Industrial Processes and Product Use	20668.77599	12.477584	3.87033	0	0	0	0	0	0	0
2.A—Mineral Industry	328.2656703	NE	NE				NE	NE	NE	NE
2.B—Chemical Industry	19787.41652	11.68745	3.87033	NE	NE	NE	NE	NE	NE	NE
2.C—Metal Industry	553.0938	0.790134	NE	NE	NE	NE	NE	NE	NE	NE
2.D—Non-Energy Products from Fuels and Solvent Use	NE	NE	NE				NE	NE	NE	NE
2.E—Electronics Industry	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2.F—Product Uses as Substitutes for Ozone Depleting Substances				NE	NE		NE	NE	NE	NE
2.G—Other Product Manufacture and Use	NO	NO	NO	0	0	0	NO	NO	NO	NO
2.H—Other	NO	NO	NO				NO	NO	NO	NO
3—Agriculture, Forestry, and Other Land Use	−2674.41821	5.255619233	0.043860613	0	0	0	0.351895791	22.78739219	0	0
3.A—Livestock		3.7658447	NE				NE	NE	NE	NE
3.B—Land	−2708.317277		NE				NE	NE	NE	NE
3.C—Aggregate sources and non-CO_2 emissions sources on land	33.89906667	1.489774533	0.043860613				0.351895791	22.78739219	NE	NE
3.D—Other	NO	NO	NO				NO	NO	NO	NO

TECHNICAL ANNEX TABLE 1 (CONTINUED) GHG Inventory IPCC Short Summary Table (2018)

Inventory Year: 2018

	Emissions (Gg)			Emissions CO_2 Equivalents (Gg)			Emissions (Gg)			
Categories	**Net CO_2 (1)(2)**	**CH_4**	**N_2O**	**HFCs**	**PFCs**	**SF_6**	**NO_x**	**CO**	**NMVOCs**	**SO_2**
4—Waste	0	88.13155521	0.000121169	0	0	0	0	0	0	0
4.A—Solid Waste Disposal		78.54335058					NE	NE	NE	NE
4.B—Biological Treatment of Solid Waste		NE	NE				NE	NE	NE	NE
4.C—Incineration and Open Burning of Waste	NE	NE	NE				NE	NE	NE	NE
4.D—Wastewater Treatment and Discharge		9.58820463	0.000121169				NE	NE	NE	NE
4.E—Other (please specify)	NO	NO	NO				NO	NO	NO	NO
5—Other	0	0	0	0	0	0	0	0	0	0
5.A—Indirect N_2O emissions from the atmospheric deposition of nitrogen in NOx and NH_3			NE				NE	NE	NE	NE
5.B—Other (please specify)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Memo Items (5)										
International Bunkers	384.7439613	0.003921943	0.010748252	0	0	0	0	0	0	0
1.A.3.a.i—International Aviation (International Bunkers)	370.6663335	0.002592072	0.010368289				NE	NE	NE	NE
1.A.3.d.i—International water-borne navigation (International bunkers)	14.07762782	0.00132987	0.000379963				NE	NE	NE	NE
1.A.5.c—Multilateral Operations	0	0	0	0	0	0	0	0	0	0

TECHNICAL ANNEX TABLE 2 Summary Detail of GHG in CO_2-eq (2006–2018)

Year	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Sectors	Gg CO_2—CO_2												
Energy	17303.20	18459.38	18618.10	18947.42	19545.65	19006.84	19288.93	19595.22	19191.77	19333.88	17796.42	17383.36	17057.18
IPPU	22579.38	22734.9	21310.06	22458.31	24689.56	23969.24	23174.43	22613.85	22412.82	21661.66	20764.48	21269.10	20668.78
AFOLU	–2719.08	–2713.95	–2708.83	–2703.71	–2698.58	–2699.80	–2701.02	–2702.23	–2703.45	–2704.67	–2705.88	–2707.10	–2708.31
WASTE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	**37163.50**	**38480.32**	**37219.34**	**38702.01**	**41536.63**	**40276.28**	**39762.34**	**39506.84**	**38901.15**	**38290.87**	**35855.02**	**35945.37**	**35017.64**

Year	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Sectors	Gg CO_2e—CH_4												
Energy	2474.07	2559.54	2530.15	2597.38	2669.96	2554.27	2525.40	2538.64	2497.62	2358	2054.21	2070.88	2186.85
IPPU	440.76	440.06	411.83	427.24	431.09	427.99	400.77	411.76	398.73	380.45	341.75	364.96	349.37
AFOLU	122.47	171.42	127.57	108.65	381.11	99.15	104.43	167.39	155.23	179.89	198.03	213.83	147.37
WASTE	1647.09	1736.98	1836.13	2007.89	2045.05	2111.77	2184.93	2274.72	2351.96	2427.95	2430.49	2450.13	2462.29
Total	**4684.38**	**4907.99**	**4905.68**	**5141.15**	**5527.22**	**5193.18**	**5215.53**	**5392.51**	**5403.54**	**5346.29**	**5024.48**	**5099.8**	**5145.88**

Year	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Sectors	Gg CO_2e—N_2O												
Energy	39.95	43.13	46.47	45.68	50.34	45.81	46.22	47.16	47.22	49.02	46.22	44.20	41.13
IPPU	0.00	0.00	0.00	0.00	1024.63	1120.67	1070.90	787.27	976.45	1077.02	971.36	1007.08	1025.64
AFOLU	292.48	304.92	304.64	316.22	399.49	328.48	334.53	357.29	350.65	363.62	379.72	386.93	368.52
WASTE	0.02447524	0.02447524	0.02458591	0.0246985	0.02670824	0.02780325	0.02795301	0.03005577	0.03104804	0.03124625	0.03142934	0.03159522	0.03174427
Total	**332.46**	**348.07**	**351.13**	**361.93**	**1474.49**	**1494.98**	**1451.68**	**1191.76**	**1374.35**	**1489.69**	**1397.33**	**1438.24**	**1435.33**

TECHNICAL ANNEX TABLE 2 (CONTINUED) Summary Detail of GHG in CO_2-eq (2006–2018)

Year	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Sectors	Gg CO_2e—HFCs												
Energy	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
IPPU	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
AFOLU	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
WASTE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
Total	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**

Year	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Sectors	Gg CO_2e—PFCs												
Energy	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
IPPU	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
AFOLU	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
WASTE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
Total	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**

Year	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Sectors	Gg CO_2e—SF_6												
Energy	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
IPPU	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
AFOLU	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
WASTE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
Total	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**