Jamaica

Technology Action Plan

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JAMAICA
TECHNOLOGY ACTION PLAN

National TNA Coordinator
Ms. Una May Gordon

Assistant Coordinator
Ms. Ayesha Constable

TNA Project Regional Coordinator
Mr. Lindy Charlery UNEP DTU Partnership

TNA Regional Centre Coordinator
Mr. Donovan Campbell The University of the West Indies (Mona Campus)

National TNA Consultants
Mrs. Eleanor Jones Adaptation
Mr. David Barrett Mitigation
Mr. Richard Coutou Specialist Researcher

FOREWORD

As a Small Island Developing State (SIDS) Jamaica is extremely vulnerable to the adverse impacts of climatechange. These impacts on the physical landscape and across critical economic sectors threaten the country's long-term development.

In recognition of the seriousness and urgency of these threats, and in line with the recommendations for ambitious and immediate action by the Sixth Assessment Report (2022) of the Intergovernmental Panel on Climate Change (IPCC), the Government of Jamaica (GOJ) has been taking prudent actions to enhancethe enabling framework for climate change response. This commitment is demonstrated in the efforts todevelop robust polices and plans for climate action, build national capacity to cope with climate change, and contribute to the global emissions reduction goal through strategic domestic targets.

The Technology Needs Assessment (TNA) is one such effort. It aligns with a range of initiatives being led by the GOJ to bolster the country's leadership in climate governance and action, chief of which is the updated Nationally Determined Contributions (NDCs), which outline more ambitious targets for adaptation and mitigation.

The TNA process was an opportunity for Jamaica to outline strategic actions for adaptation and mitigationin key sectors and enhance implementation of the Paris Agreement. The process has allowed for closer examination of the current strengths and gaps for NDC implementation and the range of technologies that can support the achievement of the NDC targets. The synergy in these and other actions reflect the integrated approach that the GOJ is taking to optimize success in climate change adaptation and mitigation.

The TNA development relied on a wide range of national stakeholders, in line with the inclusive and participatory approach to climate action nationally. The truly country-driven process has provided insight into the often-overlooked challenges and barriers to technology adoption and adaptation, such as social and cultural factors. It is therefore our hope that the TNA will act as a catalyst for broader adoption of technology as we strive to reduce the adverse impacts of climate change, particularly for the most vulnerable in society.

The GOJ thanks UNEP DTU and The University of the West Indies (UWI) for the technical guidance in the TNA development; and the Global Environment Fund (GEF) for funding this important work. Such supportis critical to Jamaica and other SIDs, and we welcome any further assistance to complement the capacityand resources available in-country.

It is our hope that the results of the TNA can be successfully integrated into national climate change planning for development and Jamaica will take the necessary steps to build on the outcomes.

Una May Gordon,
National TNA Coordinator

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Abbreviations

BAEF	Barrier Analysis and Enabling Framework
CAF	Customs Administrative Fee
CARDI	Caribbean Agricultural Research and Development Institute
CASE	College of Agriculture, Science and Education
CCD	Climate Change Division
CET	Common External Tariff
CH_4	Methane
CMS	Centre for Marine Sciences
CO_2	Carbon Dioxide
CO_{2e}	Carbon Dioxide Equivalent
CSGM	Climate Studies Group Mona
CSP	Concentrated Solar Power
DBJ	Development Bank of Jamaica
DEFRA	Department for Environment, Food and Rural Affairs
DTU	Technical University of Denmark
EFJ	Environmental Foundation of Jamaica
EfW	Energy from Waste
ESL	Environmental Solutions Limited
EST	Environmentally Sound Technology
FAO	Food and Agriculture Organization
FIT	Feed-in Tariff
GCT	General Consumption Tax
GDP	Gross domestic product
GEF	Global Environment Facility
Gg	Giga tonnes
GHG	Greenhouse Gas
GoJ	Government of Jamaica
GWh/yr	Gigawatt hours per year
IDB	Inter-American Development Bank
IRP	Integrated Resource Plan
IWEco	Integrating Water, Land and Ecosystems Management in Caribbean
Project	Small Island Developing States
JAMIN	Jamaica Awareness of Mangroves in Nature
JCA	Jamaica Customs Agency
JCCCP	Japan Caribbean Climate Change Partnership
JPSCo	Jamaica Public Service Company
JSIF	Jamaica Social Investment Fund
Kg	Kilogram
kJ	Kilojoule
KMA	Kingston Metropolitan Area
kW	Kilowatt
kWe	Kilowatt-electric
kWh	Kilowatt-hour
MCA	Multi-Criteria Analysis
MEGJC	Ministry of Economic Growth and Job Creation
Met Office	Meteorological Office of Jamaica

MGD	Mines and Geology Department
MICAF	Ministry of Industry, Commerce, Agriculture and Fisheries
MJ	Megajoule
MLGCD	Ministry of Local Government and Community Development
MOHW	Ministry of Health and Wellness
MSW	Municipal Solid Waste
Mt	Mega tonnes
MW	Megawatt
MWh	Megawatt-hour
NAMA	Nationally Appropriate Mitigation Action
NDC	Nationally Determined Contribution
NEP	National Energy Policy
NEPA	National Environment and Planning Agency
NEPT	Negril Area Environmental Protection Trust
NIC	National Irrigation Commission
N_2O	Nitrous oxide
NSWMA	National Solid Waste Management Authority
NWA	National Works Agency
NWC	National Water Commission
OHS	Occupational Health and Safety
OUR	Office of Utilities Regulation
PCJ	Petroleum Corporation of Jamaica
Ppt	Part per thousand
PV	Photovoltaic
RADA	Rural Agricultural Development Authority
R&D	Research and Development
RDF	Refuse Derived Fuel
RFP	Request for Proposal
ROI	Return on Investment
RWH	Rainwater Harvesting
RWSL	Rural Water Supply Limited
SDC	Social Development Commission
SWTP	Soapberry Wastewater Treatment Plant
TAP	Technology Action Plan
TEF	Tourism Enhancement Fund
The UWI	The University of the West Indies
TNA	Technology Needs Assessment
TNC	Third National Communication
UDP	UNEP DTU Partnership
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
UTech, Ja	The University of Technology, Jamaica
UK	United Kingdom
UV	Ultraviolet
WHO	World Health Organization
WRA	Water Resources Authority
WTE	Waste-to-energy

EXECUTIVE SUMMARY

This Report on the Technology Needs Assessment Project presents the culmination of the three step Technology Needs Assessment (TNA) process which has been implemented in Jamaica over the period 2019-2021. The Technology Needs Assessment Plan (TAP) has been drafted in keeping with the UNFCCC/UNEP DTU document '*Enhancing Implementation of Technology Needs Assessments – Guidance for Preparing a Technology Action Plan'*. Described as the "keystone" between the Technology Needs Assessment (TNA) and technology Implementation, the TAP presents a set of concrete actions as part of the implementation process, as well as associated indicative investment proposals that can be advanced for funding consideration.

Four sectors were selected by the Government of Jamaica (GOJ) for assessment of technology needs for both Climate Change Adaptation and Mitigation, i.e., coastal and water resources and agriculture for adaptation, and energy and agriculture for mitigation. Selection of the sectors was made through the Technology Needs Assessment (TNA) Steering Committee of the Government of Jamaica through the Climate Change Division in accordance with the sectors identified in the National Climate Change Policy (2015) as particularly vulnerable to the impacts of climate change. The TNA is expected to help identify pathways to achieve targets set out in the enhanced Nationally Determined Contributions (NDC).

The main objectives of the TNA Project are therefore:

1. To identify and prioritize, through country-driven participatory processes, technologies that can contribute to the adaptation and mitigation goals while meeting the national sustainable development goals and priorities.
2. To identify barriers hindering the acquisition, deployment, and diffusion of prioritized technologies, followed by the identification of enabling frameworks to overcome these barriers.
3. To develop Technology Action Plans (TAPs) specifying activities and enabling frameworks to overcome the barriers and facilitate the transfer, adoption, and diffusion of selected technologies in the participating countries.

The first step in the TNA process entailed the identification of technologies to meet adaptation and mitigation interventions deemed priorities for the selected sectors. The climate technologies were identified and prioritized through an extensive and iterative process of key stakeholder consultations, document review, and TNA Multi-Criteria Analysis. The technologies identified and prioritised in each sector are as presented below:

Technologies for Adaptation	
Agriculture	Sub-canopy Sprinkler and Drip Irrigation for crop farmers
	Rainwater Harvesting Systems and water storage for irrigation
Coastal Resources	Wetland Restoration (mangrove)
	Artificial Coral Reef and Coral Reef Ecosystem Restoration
Water Resources	Rainwater Harvesting and Restoring of Barbeque Catchments
	Creation and Restoration of Minor Tank Networks
Technologies for Mitigation	
Agriculture	Concentrating Solar Power Systems
	Aerobic Biological Treatment (composting)
Energy	Refuse-Derived Fuel Production
	Biogas

The second stage of the TNA process entailed analysis and prioritization of potential barriers and measures to overcome the challenges to implementation. Sector working group consultations and expert advice guided prioritization as well as market categorization and identification of root causes. Cross-sectoral discussions further assisted the formulation and outline of the enabling framework to overcome the identified barriers. The Barrier Analysis and Enabling Framework (BAEF) helped to inform Target/Goal/Ambition for each technology, and to identify measures and activities to overcome barriers that would inhibit diffusion of the technologies to achieve the targeted ambition. Identification of sources of Funding, responsible Focal Point, Identification of Risk, Determination of Success Criteria, Indicators for Monitoring of Implementation, and the proposed Budget have been articulated in the respective Technology matrix.

On-going iterative key stakeholder consultations, together with review of several base documents underpinned the recommended approaches to technology diffusion. Of particular note was the Third Nationally Determined Contributions (NDCs), and the Nationally Appropriate Mitigation Action (NAMA) for the water and energy sectors. Vision 2030 - Jamaica's National Development Plan and the United Nations Sustainable Development Goals (SDGs) also formed part of the reference framework for the TAP.

The **Agriculture Sector** was examined for both adaptation and mitigation technologies. The sector is one of the largest contributors to GHGs, and the availability of water is one of the biggest challenges facing the agriculture sector in Jamaica. The sector accounts for up to 75% of the local water demand (CSGM, 2016) with most small and medium-sized farmers in Jamaica depending on rainfall as their primary source of water for irrigation (Young, 2020). The effects of climate change are already being felt across the sector with climate modelling predictions estimating an overall reduction in precipitation of up to 40% and increased temperatures of up to 3.2^{o}C above 1986 – 2005 base levels (CSGM, 2016). Therefore, the sector is set to experience decreased rainfall and severe drought periods. Water management practices and

technologies are therefore imperative for current and future use. For adaptation the technologies proposed for the irrigation and, water supply and storage subsectors respectively include:

Sub-sector	Irrigation
Technology	**Drip and Sub-canopy /Micro Sprinkler Irrigation with Rainwater Harvesting Infrastructure:** Install rainwater harvesting systems integrated with drip and sprinkler irrigation systems powered by smart sensor integrated solar PV panels, controllers, DC motors and pumps.
Ambition	Implement capacity building programmes across farming districts in Jamaica and provide support (grants and/or loans) for vulnerable smaller farmers operating ¼ acre farms (10 kW SPV systems each). Implement at a rate of ten (10) small farms (≤1/4 acre) per year from 2021–2023 and expand to include five (5) larger farms (¼ – 5 acres) per year from 2023 – 2025 (vulnerable farms in need of support to be identified through RADA and other agricultural support entities). Larger farms will receive 10 – 100 kW SPV systems. The intervention is estimated to avoid 753.6 metric tons of CO_2 equivalent[1] from 74,056 gallons of diesel fuel for pumps; and generate 1,063.76 MWh from renewable energy over the project period (4 years) for pumping.
Benefits	• Rainwater harvesting infrastructure secures water resources to be used during periods of water stress, lowers the demand on treated water for domestic and other uses and incorporates nutrients such as nitrates from rainfall. • Rainwater Harvesting Systems also reduces the cost for delivering water, thus improving the economics of operations. • Subcanopy Sprinkler and drip irrigation technology is a more efficient distribution system for irrigation water • Addition of smart sensors for detecting crop root/soil moisture will activate pumps when needed to deliver irrigation volumes specific to the crop and appropriate for real-time weather conditions. • Solar pumping avoids the resulting emissions from diesel water pumps and have lower operating costs. • Eliminates use of water conveyance channels therefore reducing water loss. • Distributes water more evenly across crops, thus helping to avoid wastage and increases crop/farm yields. • Most suitable for rows, field and tree crops that are grown closely together. These include sugarcane, groundnut, cotton, vegetables, fruits, flowers, spices and condiments.

Sub-sector	Water Supply and Storage
Technology	**Rainwater Harvesting for Irrigation**
Ambition	Establish 3 selected pilot areas per year from 2021–2023 and install sustainable harvesting and storage systems, providing access to vulnerable farmers in each of 3 areas over the specified period. Implement sensitization and awareness programme in farming districts across Jamaica through the selected pilot areas
Benefits	• The technology can help to collect and store water for use during low water periods, as well as reduce pressure on existing groundwater systems

[1] https://www.epa.gov/energy/greenhouse-gas-equivalencies-calculator

Given the climate related challenges faced by Jamaican farmers each year, projects identified have been associated with water use efficiency and storage, targeted at facilitating increased access to such technology, whilst incorporating elements of capacity building. Providing ***Drip and Sub-canopy /Micro Sprinkler Irrigation with Rainwater Harvesting Infrastructure*** would help to increase the resilience of agricultural production systems to climate impacts on the water availability while considering green energy use. Recommended in support is the establishment of a funding policy/financial framework that would enable the Government of Jamaica through RADA or the parent Ministry to provide guarantees to selected lending institutions for providing credit to private entities to supply sprinkler and drip irrigation systems to local farmers who meet the determined criteria.

Under the ***Rainwater Harvesting Systems for Irrigation Water Collection and Storage,*** small and medium sized farmers would be able to access special grants or subsidy to fund the initial cost of installation of rainwater harvesting systems. The project would also include the establishment of farmer field schools as one modality through which capacity building programs could be implemented. Overall, the recommended projects will contribute to improved food security and enhance livelihoods that are undermined by the effects of climate change.

Climate Change is expected to bring increased temperatures and more frequent and longer drought periods across Jamaica. These climatic parameters will exacerbate the existing challenges of reduced water access during extensive drought periods, contaminated water during heavy rainfall periods and saltwater intrusion along over abstracted coastal areas. Additionally, capital and operational budgetary constraints, aging assets, population growth, urbanization and environmental degradation are just some of the factors which have compounded the impact of these existing climatic challenges. There is also the problem of inconsistent water supply negatively impacting local communities and business operators.

Given the water resources landscape in Jamaica, technology needs identified by key stakeholders for the **Water Resources Sector** included those that will improve water capture, storage, and distribution for communities. Two project interventions have been identified to augment initial projects which have been introduced in some parts of the island, i.e., rainwater harvesting and storage, and installation/or repair of minor tank networks and distribution. A summary of each is provided below.

Sub-sector	**Water Supply and Storage**
Technology	**Community-Scale Rainwater Harvesting System**
Ambition	Increase rainwater harvesting, and storage systems in non-utility supplied rural communities by approximately 50% of existing coverage over a three-year period, 2021–2024. Currently, there are 353 community-scale rainwater harvesting systems across Jamaica.
Benefits	Rainwater harvesting can help to adapt to the effects of climate change as it allows for the: - • Diversification of potable water supply • Creation of new sources of water • Increase in stormwater control and capture. • Increase in water storage. • Low setup cost for simple systems, however, this can vary with more complex systems. • The use of a system which is easily scalable, and components can be added over time. • Use of technology which can be simple and easily maintained without specialised persons.

Sub-sector	Water Supply and Storage
Technology	Minor Water Tank Networks for communities
Ambition	Increase water storage and distribution systems for minor tank networks for potable uses by 20% in non-utility supplied rural communities by 2024. This target is in keeping with the National Water Sector Policy and Implementation Plan 2019, which outlines the GoJ's goal to provide potable water access to everyone by 2030 (GoJ, 2019).
Benefits	• Creation and Restoration of tanks which harvest water from surface water bodies, runoff and from direct rainfall. Restoration of tanks that have been damaged or silted. These tanks can provide water for domestic, agricultural and livestock needs. • These tanks are large and usually gravity feed to houses or to a communal pipe. They are large enough to support small communities. Water will require some treatment for potable uses. • Diversification of water supply • Control and capture of storm water

A number of rural communities in Jamaica do not have access to water utilities. The community tank networks together with rainwater harvesting systems are intended to improve water security and resilience to climate risk. Community residents would be able to access water from large rainwater harvesting and storage systems that would be placed at central locations in selected communities or from minor water distribution networks established within the community. Facilities such as schools, police stations, fire stations, health centres and other facilities could provide the catchment and storage area for the harvesting systems. Additionally, these facilities can house filters and the water treatment equipment for potable water supply. Potential area of focus will be determined in consultation with WRA, Rural Water Supply and other relevant entities. Other potential water resources projects include:

- ***Digital Maps (DEM) of Watersheds***
- ***Basin level modelling and seasonal forecasting for water allocation of the Rio Cobre***
- ***Restoration of Community Tanks***

The **Coastal Resources Sector** has been experiencing the effects of climate change including coastal erosion from sea level rise; reduced fish production, and coral bleaching due to increases in sea surface temperatures; reduction of reefs and calcareous species due to ocean acidification and storm damage; and the destruction of coastal ecosystems, marine habitats and spawning grounds by hurricanes and tropical storms (CSGM, 2016). Additionally, the removal of mangroves, seagrass beds, and coral reefs occasioned by this multi-purpose use of the coastal zone has increased Jamaica's vulnerability to hurricanes and storm surges and continues to pose a major threat to coastal ecosystems and marine life. Therefore, the impacts of climate change on an already deteriorating coastal ecosystem are likely to become more severe and heighten the vulnerability of coastal communities. Jamaica's coastal zone with its natural and built resources, supports a significant proportion of the island's population, economic lifelines and is responsible for over 70% of the GDP. As such, interventions which have been suggested include:

Sub-sector	Coastal Protection
Technology	Wetland (mangrove) Restoration
Ambition	Over a five-year period, 2021–2026, complete the enhancement and/or replacement of 20% of critical wetland (mangrove) areas across Jamaica, based on a list of critical areas identified in consultation with NEPA
Benefits	Wetland restoration re-establishes the following advantageous functions: • Coastal protection through coastal flood and erosion management. • Induce wave and tidal energy dissipation (Brampton, 1992) • Act as a sediment trap for materials, thus helping to build land seawards. The dense root mats of wetland plants also help to stabilise shore sediments, thus reducing erosion (USACE, 1989).

Sub-sector	Coastal Protection
Technology	Coral Reef Restoration
Ambition	Over a five-year period, 2021–2026, complete coral reef restoration at two sites. Site selection, method, implementation, and monitoring should be done in consultation with NEPA.
Benefits	• Decrease coastal erosion and create marine coral reef environments. • Protection of coastal areas and wetlands • Form a more effective barrier, thus reducing wave action and erosion along the coastline, • Provide shelter for other marine organisms • Improve the overall stability of the reef and ecosystems • Contribute to preserving marine life and fisheries in the reef zone

Attention to this aspect of the island's vulnerability has been emphasised by the Climate Change Division and the National Environment and Planning Agency (NEPA). These entities, along with other stakeholders within the coastal resources sector, have identified the need for coral reef and wetland restoration. The agencies have also identified specific areas for integrated and hybrid coastal protection/restoration initiatives. The Hellshire coast and Half Moon Bay of southern St Catherine has been a major recreational area and a key resource that contributes to the livelihood of fisherfolk from surrounding communities. It is also an ecologically rich area that has experienced major loss and damage from sea level rise, storm surge and anthropogenic activity. It is therefore proposed that the area be given priority for restoration. This will require a detailed study of the coastal processes, and the impact of the built environment on the area, as well as an understanding of the coastal changes that have occurred over the years, inclusive of changes to beach profile and marine ecosystems. The development of the Hellshire Master Plan and supporting studies will likely provide the necessary insight required and will inform the various redevelopment projects for the area. Other coastal projects suggested include:

- ***Dune Restoration in Alligator Pond***
- ***Seagrass Restoration in Hellshire Beach***
- ***Rehabilitation of the Royal Palm Reserve in the Negril Morass***
- ***Coral Reef Restoration***
- ***Black River Morass Insurance Policy for Storm Protection***
- ***Grow 40 by 2030 Protect the Bight Project***

The **Energy Sector** in Jamaica is a net importer of fossil fuel energy resources (91% of the energy mix). Primarily for electricity, heat and transport applications and the electricity and heat generation alone contributes over 70% of Jamaica's total emissions over the past years. The electricity sector is powered primarily from a high proportion of old and inefficient fossil-based plants which adversely influences Jamaica's high GHG emission levels. Local renewable energy sources contribute only 9% of the total energy mix, being primarily biomass, wind, hydro and solar.

The proposed projects which include waste to energy, biogas, and composting for GHG avoidance are well aligned with Jamaica's National Energy Policy, Third National Communication (TNC), Nationally Determined Contributions (NDCs) and Integrated Resource Plan (IRP) to reduce fossil fuel use. The policy is to increase electricity generation from renewables to 30% by 2030 and approximately 49% from renewables by 2037, with commensurate reduction in CO_2 emissions to 2030. The proposed mitigation projects target under-utilized energy resources for electricity in the energy sector (WTE), water sector (biogas) and agricultural sector (composting) for GHG emissions avoidance. A summary of the mitigation interventions for the **Agriculture Sector** are provided below:

Sub-sector	**Energy**
Technology	**Concentrated Solar Power (CSP) for small and medium sized farms**
Ambition	To reduce GHG emissions from the multi-dimensional agricultural sector through implementation of Concentrated Solar Power where there is demand for electricity. CSP systems up to 5 MW may be applicable for large commercial farms with large power demands for water pumping, electrical equipment (e.g., cold storage), conveyors, external security lighting and offices, etc. Due to the cost for the CSP technology focus will be placed on 3 opportunities: • A 100kW CSP Stirling engine system (4 x 25 kWe) at one (1) of the 9 Agro Parks[2]. Agro Parks operate under a cooperative structure with multiple users so power demand within the park boundary will be continuous throughout various crop cycles therefore improving commercial viability of the investment. • 100kW CSP Stirling engine system each at 2 private sector farms in Jamaica. • Potential avoidance of 7 metric tons of CO_2/annum (700 gallons of diesel/annum).
Benefits	• Production of clean electricity on farm site , • Reduction of electricity costs and GHG emissions avoidance. • CSP energy can be stored before or while powering a steam generator • Can be used either as a flexible provider of electricity, as a "peaker" plant, or as a base load source of electricity similar to a traditional power plant, however, without the GHG emissions.

Sub-sector	**Soil Management**
Technology	**Aerobic Biological Treatment (Composting)**
Ambition	To allow for an effective system for handling agricultural waste while contributing to the reduction of greenhouse gases from decomposition of the organic matter. Small farmers are already composting in small containers, used barrels and wooden troughs at a subsistence level. At least a 1-acre commercial composting operation be established in each of the 3 counties of Jamaica (Cornwall, Middlesex, and Surrey, i.e., 3 in total) to demonstrate the feasibility of

[2] *An Agro Park is an area of intensive, contiguous, parcel of land for agricultural production which seeks to integrate all facets of the agricultural value chain from pre-production to production, post harvesting and marketing.*

	commercial composting and give easier access to visits and observation for interested parties across the island. Agro Parks, with their mixed cropping, be ideally used as various crops mature at different times, hence the possibility of year-round organic material based on crop cycles. Also, the compost can be utilized at the same location by the farmers, or the excess sold.
Benefits	• Varied economic, social, and environmental benefits for Jamaica. • Can reduce the overall need for waste collection in rural areas which therefore has an impact on economics, and this is generally expensive. • Sorting and reuse of bio-degradable waste will mean that waste management authorities can focus more efforts and resources on the management of non-biodegradable waste, therefore contributing to an overall cleaner environment. • Results in the emissions of carbon dioxide instead of methane. Carbon dioxide is thirty times less potent as a greenhouse gas than methane. Therefore, composting contributes overall to climate change mitigation • Reduction in the use of chemical fertilizers which contribute to GHG emissions.

Additionally, a summary of the mitigation interventions for the **Energy Sector** are provided below:

Sub-sector	**Waste-to-Energy**
Technology	**Refuse Derived Fuel (Waste-to-Energy)**
Ambition	One (1) power 10 MW plant at a waste facility is proposed for this mitigation technology, producing lower GHG emissions than a typical fossil fuel plant. RDF/WTE will be included in the next generation Request for Proposals (RFP) based on the 2019 Integrated Resource Plan.
Benefits	• Reduction of vermin and improvement of health locations by reducing breeding environment. • Reduced pollution to waterways and the marine environment. • Production of useful clean energy • Reduction in GHG emissions (to be determined from updated and detailed waste characterization studies at the project location).

Sub-sector	**Waste to Energy**
Technology	**Biogas (Anaerobic Biodigestion)**
Ambition	At least one (1) medium commercial scale biodigester facility producing electricity and secondary or tertiary stage treated water for irrigation, is being targeted as a catalyst for development at other sewerage sites island wide. A system this scale could be tested at any of the nearly 100 sewerage (wastewater) treatment plants operated by the National Water Commission Island wide. The largest single sewerage treatment plant is in Greater Portmore (18,180 m^3/day). The proposed system should receive approximately 100,000 – 200,000 m^3 of wastewater/annum, with potential to generate enough biogas for power generation of approximately 4,000 MWh_e/annum[3]. A system such as this has the potential to save 2,500t CO_{2e}/annum. A continuous digester may be best suited for sewage operations, where the organic material can be constantly or regularly fed into the enclosed digester. Of special interest for immediate intervention would be the Soapberry Wastewater Treatment Plant (SWTP) and associated sewerage infrastructure (i.e., Pumping Stations and Transmission mains), for which NWC has an 85% shareholding, and is now required to expand its current

[3] Bio-engineering Installations - HoSt Holding B.V. 2020. https://www.host.nl/en/biogas-plants/sludge-biogas-plants/?gclid=CjwKCAiArIH_BRB2EiwALfbH1NadycAC4sewP7buB0XA3_lgfd4Wqh4vjYGlSEaTx5cc3E8KN8bZixoCe5EQAvD_BwE

	treatment capacity from 75,000 m^3/day to 150,000 m^3/day, in order to meet the medium-term requirement for treatment of wastewater collected by NWC in the Kingston Metropolitan Area (KMA). In the expansion, it is envisaged that the output from SWTP be reused for agricultural purposes to offset the current use of potable water sourced from the Rio Cobre. Electricity will also be produced to offset high electricity costs for pumping (majority of which are electrical motors island-wide). Irrigation water will provide an additional revenue source for economic viability. It is mandated that in privatization, the SWTP should have the climate change mitigation and adaptation designs via new technologies and renewable energy solutions.
Benefits	• Avoids the emission of methane as the fuel is combusted for heat or electricity. • National energy self-sufficiency is increased due to the local energy production. This also would reduce Jamaica's dependency on other countries for fossil fuel imports, which in turn would lead to an improved economic balance sheet of the country and a higher level of energy security. • Anaerobic digestion offers a number of air and water quality benefits. Digester systems isolate and destroy disease causing organisms that might otherwise enter surface waters and pose a risk to animal and human health. Moreover, anaerobic digesters help protect ground water. Synthetic liners provide a high level of groundwater protection for manure management systems (EPA, 2002). • The concrete or steel in plug flow and complete mix digesters also effectively prevent untreated manure from reaching the ground water. Biological treatment of waste, such as composting and anaerobic digestion reduces volume of waste and therefore the lowers landfill requirements. Recycling of the residual solids as fertilizer further reduces waste volume. • Climate change mitigation benefits of this technology is the prevention of methane emissions associated with conventional manure management practices. In addition, the energy produced by the biogas facility offsets energy derived from fossil fuels. Therefore, anaerobic digesters with a biogas recovery system can help reduce overall quantities of CO_2.

All proposed projects will require a combination of hardware (solar infrastructure, tanks, pumps piping etc) software (automation, programmes etc) for access to operating technology and the incorporation of the orgware[4] elements of consultation, sensitization, capacity building and training.

The proposed projects fall into various technology market categories. Predominantly adaptation projects such as Drip and Sub-canopy Sprinkler Irrigation, and the use of rainwater harvesting in the agriculture sector which would be accessed by farmers as a commodity from retail suppliers as consumer goods; while a related community-based water project in the water sector such as Community Scale Rainwater Harvesting Systems or repair of Minor Water Tank Networks for Communities would be publicly provided goods, supplied (at least initially) through the State. Likewise coastal protection adaptation projects which equitably benefit citizens and the environment would also be publicly provided goods. Mitigation projects in the agricultural sector such as Concentrated Solar Power, and proposed projects in the energy sector such as Waste to Energy and Biogas generation would be implemented as capital goods, requiring state interventions to support private sector or as a PPP venture, due to their high capital costs but overall benefit for society. Mitigation in the agricultural sector using Composting would be implemented as a

[4] Hardware referring to capital infrastructure, materials and equipment; software referring to technology and interface; and orgware referring to organizational and human behavioural perspectives.

consumer good if undertaken at commercial farms but could also be a capital good is undertaken using the state agro park infrastructure.

Part I Introduction

1 Purpose

This document presents the Technology Action Plan (TAP), for the Adaptation and Mitigation Technologies selected for Jamaica in the areas of Agriculture, Water, Coastal Resources and Energy. The TAP represents the third stage of the Technology Needs Assessment (TNA) process. The plan has been crafted in keeping with the UNFCCC/UNEP DTU document '*Enhancing Implementation of Technology Needs Assessments – Guidance for Preparing a Technology Action Plan'*. Described as the "keystone" between the Technology Needs Analysis (TNA) and technology Implementation, the TAP presents a set of concrete actions as part of the implementation process, as well as associated indicative investment proposals that can be advanced for funding consideration.

1.1 Overview of the TNA Project

The Global TNA project is a strategic programme on technology transfer, designed to support countries to carry out Technology Needs Assessments within the framework of the United Nations Framework Convention on Climate Change (UNFCCC) and under the Paris Agreement. Its main aim is to avert the risks and impacts of climate change and to reduce national greenhouse gas (GHG) emissions. In that regard, the TNA is intended to assist developing countries to identify and analyse priority technology needs, which can form the basis for a portfolio of environmentally sound technology (EST) projects and programmes to facilitate the transfer of, and access to the ESTs and know-how in the implementation of Article 4.5 of the UNFCCC Convention. TNAs are central to the tracking of an evolving need for new equipment, techniques, practical knowledge, and skills, which are necessary to mitigate GHG emissions and/or reduce the vulnerability of sectors and livelihoods to the adverse impacts of climate change.

The TNA Project is funded by the Global Environment Facility (GEF) and executed by the United Nations Environment Programme (UNEP) through the UNEP DTU (Technical University of Denmark) Partnership on Energy, Climate and Sustainable Development.

1.2 Objectives of the TNA

The main objectives of the TNA Project are:

1. To identify and prioritize, through country-driven participatory processes, technologies that can contribute to the adaptation and mitigation goals of the participating countries, while meeting the national sustainable development goals and priorities.
2. To identify barriers hindering the acquisition, deployment, and diffusion of prioritized technologies, followed by the identification of enabling frameworks to overcome these barriers.
3. To develop Technology Action Plans (TAPs) specifying activities and enabling frameworks to overcome the barriers and facilitate the transfer, adoption, and diffusion of selected technologies in the participating countries.

Further, the TNA process will develop concept notes for attracting funding to implement selected technologies as prioritized by the respective sector groups and the TNA Project Steering Committee in country.

1.3 Prioritized Technologies for Jamaica

The first deliverable of the TNA Project for Jamaica was completed in February 2020. The report identified and prioritized technologies for diffusion and implementation for adaptation to and mitigation of climate change. Prioritization was done through a process of stakeholder and working group consultations and document review. Gender balance was considered during the stakeholder mapping and the selection of the working groups for each sector. This was guided by the TNA Guidance for Gender-Responsiveness (De Groot, 2018).

A long list of technologies was first developed from research, and this was shortened based on stakeholder consultations via an online survey. Technology Fact Sheets were then prepared for each shortlisted technology, incorporating findings from consultations with respective technology-savvy professionals within each sector; through review of Technology Fact Sheets from other countries; and additional research of technology options.

The prioritization of climate technologies was completed by the working groups using the TNA Multi-Criteria Analysis process. Members of the respective groups undertook the following:

1. Discussed the Technology Fact Sheets for all the short-listed technology options, including capital and operational costs, benefits, status of the use of the technologies, disadvantages of the technology options and how the technology can assist the sector in adapting to the effects of climate change. Some adjustments were made based on stakeholders' recommendations.
2. Developed criteria based on cost, economic, social, environmental, and climatic benefits. The approved criteria were then used for rating the technology options from the short-list of technologies.
3. Developed weights for each criterion, for each technology.
4. Rated/scored each technology option based on the criteria and weighting using the Multi-Criteria Analysis (MCA) worksheet template provided.

Ten technologies for climate change adaptation and mitigation for Jamaica were prioritized using this process. The identification of climate technologies in each sector were aligned with Vision 2030 national development objectives and the sustainable development goals of Jamaica. The prioritized technologies are presented in Table 1.1. Below.

Table 1.1: Prioritized technologies for climate change adaptation and mitigation for Jamaica

Technologies for Adaptation	
Agriculture Sector	Sub-canopy Sprinkler and Drip Irrigation for Crop Farmers
	Rainwater Harvesting Systems and water storage for irrigation
Coastal Resources	Wetland Restoration (mangrove)
	Artificial Coral Reef and Coral Reef Ecosystem Restoration

Water Resources	Rainwater Harvesting and Restoring of Barbeque Catchments
	Creation and Restoration of Minor Tank Networks
Technologies for Mitigation	
Agriculture Sector	Concentrating Solar Power Systems
	Aerobic Biological Treatment (Composting)
Energy Sector	Refuse-Derived Fuel Production (Waste to Energy)
	Biogas (Waste to Energy)

2 Preparation of the TAP

The development of the TAP began with a review of the targets set by the project implementation team and sector stakeholders for each prioritized technology from the Barrier Analysis and Enabling Framework (BAEF). These were then updated and included in the TAP as the **Ambition**. The team conducted 'brainstorming' exercises and further prioritization of proposed measures from the BAEF considering the effectiveness, efficiency, and suitability of these measures for the sector. Accepted measures were then brought into the TAP as the main **Actions** required for overcoming barriers to the wide scale use of the prioritized technologies across Jamaica.

The **Activities** to be implemented were developed based on the Actions identified. Capacity was considered by the consulting team as a key consideration for selection of activities. This process was done in consultation with the sector experts, as these stakeholders had considerable experience in the implementation of similar technologies and activities across Jamaica and the wider Caribbean. A similar process was used for the development of the other components of the TAP, that is, identification of sources of funding, responsible focal points, identification of risk, determination of success criteria, indicators for monitoring of implementation, and the proposed Budget.

Several key documents were reviewed to underpin the recommended approaches to technology diffusion. Of particular note was the Third Nationally Determined Contributions (NDCs), and the Nationally Appropriate Mitigation Action (NAMA) for the water and energy sectors. Vision 2030 - Jamaica's National Development Plan and the United Nations Sustainable Development Goals (SDGs) also formed part of the reference framework for the TAP.

Part II. Technologies for Adaptation

3 Technology Action Plan for the Agriculture Sector

3.1 Sector Overview

The agriculture sector in Jamaica traditionally consisted of export-driven large-scale monoculture commercial plantations (estates) which produced mainly sugar and bananas on the coastal plains and inland basins, and coffee and cocoa in the upland areas; and small-scale mixed farms which produced for household subsistence, the domestic market and also limited export. Farming occurs throughout the rural areas on hilly terrain as well as on coastal plains depending on the specific requirements of the crop being grown and the availability of land. More recently, several of the large estates are being converted into alternate land use, and there has been increasing encouragement of diversified agricultural production for both the local and export markets.

One of the biggest challenges facing the agriculture sector in Jamaica is the availability of water. The sector accounts for up to 75% of the local water demand (CSGM, 2016) with most small and medium-sized farmers in Jamaica depending on rainfall as their primary source of water for irrigation (Young, 2020). The effects of climate change are already being felt across the sector as rainfall variability and longer dry periods have become more frequent. Climate projections indicate that change in rainfall during the rainy season will be the primary driver of drying trends, and Increases in dry spell length are expected to be greater in March and October by midcentury. Water management practices and technologies are therefore imperative for current and future use.

The challenge of praedial larceny which affects over 90% of farmers in Jamaica is yet another challenge facing the sector. The compounding impact exacerbates the issues being faced by climate change and further affects profit margins. As such, the cost of appropriate security systems should be included in the financing package for the capital costs of the drip and sprinkler irrigation systems and would be calculated on a site-specific basis. However, likely disparities in the implementation of systems are anticipated since it is usually difficult to install effective security systems in rural areas.

Jamaican farmers have developed various strategies to deal with the effects of climate change on their farms. These strategies have emerged through traditional knowledge and experimentation as well as through special training initiatives such as those implemented by RADA and other agencies. One example is the Agriculture Disaster Risk Management (ADRM) initiative which has strengthened the understanding of several Jamaican farmers regarding disaster risk reduction and resilience in the process of adapting to climate change across the island (FAO, 2019). Several projects have trained farmers in how to utilise climate-smart techniques including drought mitigation strategies like the drip-irrigation technique, water harvesting, green or shade house production and various soil husbandry operations (JIS, 2015). Farmers already use improved informal irrigation, mulching for retention of soil moisture, crop diversification and

changes in crop planting seasons while also creating water storage options (ODPEM, 2011). In Southern St. Elizabeth, for example, farmers have implemented a variety of adaptation measures to manage drought, including planting quick crops (e.g., escallion); planting drought-resistant crops (e.g., escallion, cassava); scaling down production during dry season; installing edging (e.g., perimeter planting with guinea grass); careful timing of water application; sacrificing portions of crops; sharing water; using trucked water; and installing water storage "black tanks" to increase availability (Campbell, Barker, & McGregor, 2011). In the 2021 – 2022 budget presentation, the Government of Jamaica has allocated some JM$1.1 billion to support the development and the expansion of irrigation.

In addition, improved soil and crop management (e.g., use of organic materials), community risk mapping, reforestation, establishment of boundaries/reserves to regulate the forest cover, agroforestry, engagement of the community, data gathering and use, public awareness, training of farmers in climate-resilient best practices and mangrove replanting are all considered suitable practices to help combat the impacts of climate change (PPCR, 2011).

More advanced science and technology-based techniques such as crop suitability modelling are also required. In agriculture, this may take the form of crop modelling which could include determining the successes that would be achieved if one crop variety were transplanted from one location to another without having to invest in cultivating the plant itself. In addition, data for agricultural-resilience projects are needed. This can incorporate data on the best crops for extremes in particular areas, soil types, the best animal feed in particular climate extremes (e.g., using local materials in the absence of water and grass), and climate information more specific to agriculture (e.g., agricultural drought information specific to areas being included in weather reports, rather than vague evaluations of general rainfall distribution across the island).

3.1.1 Action Plan for Drip and Sprinkler Irrigation

Sector	Agriculture
Sub-sector	Irrigation
Technology	Drip and Sub-canopy /Micro Sprinkler Irrigation with Rainwater Harvesting Infrastructure: Install rainwater harvesting systems integrated with drip and sprinkler irrigation systems powered by smart sensor integrated solar PV panels, controllers, DC motors and pumps.
Ambition	Provide grant support to install "starter" drip and sprinkler irrigation systems for farmers operating ¼ acre farms and implement capacity building programmes across farming districts. The roll out would be at a rate of twenty farms per year from 2022–2024 in the small category. The program would be expanded to include twenty larger farms (¼ – 5 acres) per year from 2023 – 2025. Vulnerable farms in need of support would be identified through the Rural Agricultural Development Agency (RADA) and other agricultural support entities. Implement SPV systems up to 10 kW each at ten (10) small farms (≤1/4 acre) per year from 2021–2023. Expand the project to implement 10-100kW SPV systems at five (5) larger farms (¼ – 5 acres) per year from 2023 – 2025. The intervention is estimated to avoid 753.6 metric tons of CO_2 equivalent[5] from 74,056 gallons of diesel fuel for pumps; and generate 1,063.76 MWh from renewable energy over the project period (4 years) for pumping.
Benefits	• Rainwater harvesting infrastructure secures water resources to be used during periods of water stress, lowers the demand on treated water for domestic and other uses and incorporates nutrients such as nitrates from rainfall for farming. • RWHS also reduces the cost for delivering water, thus improving the economics of operations. • Subcanopy Sprinkler and drip irrigation technology is a more efficient distribution system for irrigation water • Addition of smart sensors for detecting crop root/soil moisture will activate pumps when needed to efficiently deliver irrigation volumes specific to the crop and appropriate for real-time weather conditions. • Solar pumping avoids the resulting emissions from diesel water pumps and have lower operating costs. • Eliminates use of open water conveyance channels therefore reducing water loss. • Distributes water more evenly across crops, thus helping to avoid wastage and increases crop/farm yields. • Most suitable for rows, field and tree crops that are grown closely together. These include sugarcane, groundnut, cotton, vegetables, fruits, flowers, spices and condiments.

[5] https://www.epa.gov/energy/greenhouse-gas-equivalencies-calculator

Table 3.1: Detailed Action Plan for Drip and Sprinkler Irrigation

	Action (Measures)	Activities to be implemented	Sources of funding	Responsible body and focal point	Time Frame	Risks	Success criteria	Indicators for monitoring of implementation	Budget per activity
1	Provision of special grants or subsidy to fund initial cost of installation of *Sprinkler and Drip Irrigation Systems* with solar PV and smart sensors for ¼ acre of properties (small and medium-sized farmers).	Identification of possible sources of funding for the grant.	Ministry of Finance and Public Service IADB FAO World Bank IICA	RADA	0.5 years	Entities may not be willing to provide Funding for individual scaled projects.	Identification of funding for the provision of special grants to fund initial cost of installation of Sprinkler and Drip Irrigation Systems and solar PV systems with sensors.	Number of grants awarded	Administrative activities for preparing, executing grant system has been estimated to be US$200,000.00 over the 4-year period.
		Assessment of the number of registered farmers in Jamaica who may be eligible for grant.	-	RADA	0.5 years	Many small farmers may not be registered and will therefore not be able to benefit from this interventio n.	Identification of small and medium sized farmers who are eligible for grant funding for sprinkler and drip Irrigation systems, and solar PV with smart sensors .	-	

	Action (Measures)	Activities to be implemented	Sources of funding	Responsible body and focal point	Time Frame	Risks	Success criteria	Indicators for monitoring of implementation	Budget per activity
		Identify suitable providers of drip and sprinkler irrigation systems and solar PV with smart sensors in Jamaica.	-	RADA MSET	0.5 years	Few local suppliers for sprinkler and drip irrigation systems available in Jamaica. Adequate suppliers of solar PV systems.	List of suitable providers of drip and sprinkler and irrigation systems in Jamaica	-	
		Develop and implement criteria and application process for accessing grants.	-	RADA	2 years	Slow uptake from farmers for grants due to other challenges, such as no documentation, etc.	Grants awarded and installation of irrigation systems and solar PV for plots ¼ to 5 acres for 15 farmers by end of 2025. Increase productivity per acre/unit of farmland	Number of grants awarded per quarter per type of irrigation system. Total Number of applications received per year per type of irrigation system.	• **Micro-Sprinkler** Cost for purchase and installation of a micro-sprinkler irrigation system for a ¼ acre property is US$150 to US$400. • **Drip Irrigation System** Cost for purchase and installation of a drip irrigation system for a ¼ acre farm is US$200 to US$500. Cost for 10 kW solar PV system approximately US$30,000 and US$250,000 for a 100-kW system. • **Training and Development**

	Action (Measures)	Activities to be implemented	Sources of funding	Responsible body and focal point	Time Frame	Risks	Success criteria	Indicators for monitoring of implementation	Budget per activity
									Cost for farmers to use rainwater harvesting and sprinkler and drip irrigation systems is estimated at US$200 per farmer.
2	Provision of low-interest or interest-free loans for the expansion of irrigation systems to improve efficiencies above ¼ acre.	Identification of institutions willing to provide small loans to farmers.	-	Ministry of Agriculture and Fisheries RADA	0.5 years	Institutions may see farming as high risk and may not want to provide an appropriat e loan facility	List of institutions willing to provide small loans to farmers.	-	Administrative activities for preparing, executing grant system has been estimated to be US$200,000.00 over the 4-year period.
		Identify suitable providers of drip and irrigation systems in Jamaica. Identify suitable providers of solar PV systems.	Development Bank of Jamaica (DBJ)	RADA MSET	1 year	Few local suppliers for sprinkler and drip irrigation systems available in Jamaica. Adequate number of suppliers of solar PV systems.	List of suitable providers of drip and sprinkler and irrigation systems in Jamaica	-	
		Development of criteria and payback terms for accessing loans for small farmers.	World Bank DBJ FAO IICA	Development Bank of Jamaica	0.5 Years	Small farmers lack proper credentials and collateral for	Suitable criteria for small farmers to access loans	-	

	Action (Measures)	Activities to be implemented	Sources of funding	Responsible body and focal point	Time Frame	Risks	Success criteria	Indicators for monitoring of implementation	Budget per activity
						accessing loans.			
		Provision of loan facility for small and medium sized farmers	World Bank DBJ FAO IICA		1 Year	Farmers default on loan payments	Loans awarded and installation of irrigation systems and solar power for plots ¼ to 5 acres for 15 medium sized farmers by end of 2025. Increase productivity per acre/unit of farmland.	Total Number of loans received per year type of irrigation system. Total number of loans awarded per year per type of irrigation system.	
3	Provision of tax incentives on capital costs for the installation of efficient irrigation systems from 2021-2025.	Categorize and gazette items which registered farmers will be able to access tax incentives for.	Ministry of Finance and Public Service	Ministry of Finance and Public Service Ministry of Agriculture and Fisheries Jamaica Customs Agency	1 year	Government of Jamaica maybe adverse to offering new tax incentives.	Approved and advertised tax incentives for small and medium size farmers.	-	Administrative activities for preparing, executing grant system has estimated to be US$200,000.00 over the 4-year period.

	Action (Measures)	Activities to be implemented	Sources of funding	Responsible body and focal point	Time Frame	Risks	Success criteria	Indicators for monitoring of implementation	Budget per activity
		Develop approval process for registered farmers to access tax incentive.	Ministry of Finance and Public Service	Ministry of Agriculture and Fisheries RADA	3 years	Government of Jamaica maybe adverse to offering new tax incentives	Grants awarded and installation of irrigation systems and solar PV for ¼ acre size plots for 10 small farmers per year from 2021 to 2023. Grants awarded and installation of irrigation systems solar PV for plots ¼ to 5 acres for 5 medium sized farmers by end of 2025. Increase productivity per acre/unit of farmland.	Total Number of applications received per year type of irrigation system. Total number of grants awarded per year per type of irrigation system.	

	Action (Measures)	Activities to be implemented	Sources of funding	Responsible body and focal point	Time Frame	Risks	Success criteria	Indicators for monitoring of implementation	Budget per activity
4	Establishment of a funding policy/financial framework that would enable the Government of Jamaica through RADA or the Ministry of Agriculture to provide guarantees to selected lending institutions for providing credit to private entities to supply sprinkler and drip irrigation systems to local farmers who meet the determined criteria.	Consultancy (project) for the development of the appropriate funding framework.	Ministry of Agriculture and Fisheries	Ministry of Agriculture and Fisheries	1 year	Small farmers lack proper credentials and collateral for accessing loans. Farmers default on loan payments. Lending institutions may deem financing small agriculture farmers too risky.	Grants awarded and installation of irrigation systems and solar PV for ¼ acre size plots for 10 small farmers per year from 2021 to 2023. Grants awarded and installation of irrigation systems and solar PV for plots ¼ to 5 acres for 5 medium sized farmers by end of 2025. Increase productivity per acre/unit of farmland.	Number of grant applications received per quarter per type of irrigation system. Number of grants awarded per quarter per type of irrigation system. Total Number of applications received per year type of irrigation system. Total number of grants awarded per year per type of irrigation system.	**Consultant fees for the development of the appropriate funding framework –** Estimated lump sum cost: US$50,000.

	Action (Measures)	Activities to be implemented	Sources of funding	Responsible body and focal point	Time Frame	Risks	Success criteria	Indicators for monitoring of implementation	Budget per activity
5		Determine the cost for purchase and installation of security equipment.		Praedial Larceny Prevention Unit of the Jamaica Constabulary Force. RADA			Grants awarded for the installation of irrigation systems with security systems and solar PV systems for plots ¼ to 5 acres for 15 medium sized farmers by end of 2025. Increase productivity per acre/unit of farmland.		
		Consultancy to develop and execute capacity building workshop/ field schools.	FAO IICA GCF	Ministry of Agriculture and Fisheries RADA	1 Year	-	Workshop material, guidelines and framework which encompasses key instruments for building capacity among small and medium sized farmers	-	**Capacity building workshops for small and medium farmers** Estimated cost: US$30,000 to develop workshop content and material for workshops and for workshop delivery Across Jamaica

	Action (Measures)	Activities to be implemented	Sources of funding	Responsible body and focal point	Time Frame	Risks	Success criteria	Indicators for monitoring of implementation	Budget per activity
6	Establish ongoing capacity building programmes including farmer-field schools to include: - • Business planning and project financing. • Introduction to new technologies for climate change adaptation. • Accessing and interpreting weather, climate, and soil data/information. • Water management strategies for climate resilience.	Host at least 2 Capacity building workshops in each parish for small and medium size farmers.	FAO IICA GCF	RADA	0 – 2 years	Lack of participation by farmers Difficult to reach majority of farmers	After the first year, 40% of small to medium size farmers should have attended at capacity building workshop	Number of farmers who have used or implemented strategies learned from the capacity building workshops.	US$2,000 per workshop for 28 workshops. Total Estimated US$56,000

3.1.2 Action Plan for Rainwater Harvesting for Irrigation

Sector	Agriculture
Sub-sector	Water Supply and Storage
Technology	Rainwater Harvesting for Irrigation
Ambition	Implement sensitization and awareness programme in farming districts across Jamaica through the establishment of 3 selected pilot areas per year from 2021–2023 and install sustainable harvesting systems.
Benefits	The technology can help to collect and store water for use during low water periods.

Table 3.2: Detailed Action Plan for Rainwater Harvesting for Irrigation

	Action (Measures)	Activities to be implemented	Sources of funding	Responsible body and focal point	Time Frame	Risks	Success criteria	Indicators for monitoring of implementation	Budget per activity
1	Provision of special grants or subsidy to fund initial cost of installation of *Rainwater Harvesting Systems* for water collection and storage for irrigation use by small and medium sized farmers.	Identification of possible sources of funding for the grant and assist with proposal development.	Ministry of Finance and Public Service IADB FAO World Bank IICA	RADA	0.5 years	Entities may not be willing to provide Funding for individual scaled projects.	Identification of funding for the provision of special grants to fund initial cost of installation of RWH systems	Number of grant opportunities identified.	Administrative activities for project planning and administration have been estimated to be US$200,000.00 over the 2-year period.
		Determine the number of registered farmers in Jamaica who may be eligible for grant.	-	RADA	0.5 year	Many small farmers may not be registered and will therefore not be able to benefit from this intervention.	Identification of small and medium sized farmers who are eligible for grant funding for RWH systems.		
		Identify suitable providers of drip and sprinkler irrigation systems in Jamaica.	-	RADA	0.5 year	Few local suppliers for sprinkler and drip irrigation systems available in Jamaica.	List of suitable providers of drip and sprinkler and irrigation systems in Jamaica	-	

	Action (Measures)	Activities to be implemented	Sources of funding	Responsible body and focal point	Time Frame	Risks	Success criteria	Indicators for monitoring of implementation	Budget per activity
		Develop and implement criteria and application process for accessing grants.	-	RADA	2 years	Slow uptake from farmers for grants due to other challenges, such as no documentation, etc.	Grants awarded and installation of RWH systems. Increase productivity per acre/unit of farmland	Number of grants awarded per quarter per for RWH systems. Total Number of applications received for RWH systems.	**Rainwater Harvesting System** Requires roof area for water collection, water tank for storage, guttering and accessories. Average cost ranges from US$1,000 to US$2,000 to collect and store 600 gallons to 2,000 gallons of water.
2	Establish ongoing capacity building programmes some of which can be implemented through farmer-field schools: - • Rainwater harvesting techniques, opportunities and challenges. • Business planning and project financing. • Introduction to new technologies for climate change adaptation. • Accessing and interpreting weather, climate, rainfall and soil data/information.	Design programmes and source expertise for delivery	FAO IICA	RADA			Grants awarded for the installation of irrigation systems with security systems for plots ¼ to 5 acres for 20 medium sized farmers by end of 2025. Increase productivity per acre/unit of farmland.		

	Action (Measures)	Activities to be implemented	Sources of funding	Responsible body and focal point	Time Frame	Risks	Success criteria	Indicators for monitoring of implementation	Budget per activity
	• Water management strategies for climate resilience. Setup of model system for RWH for irrigation uses.	Consultancy to develop and execute capacity building workshop/ field schools.	FAO IICA GCF	Ministry of Agriculture and Fisheries RADA	0 - 0.5 Years			-	**Capacity building workshops for small and medium farmers** Estimated cost: US$30,000 to develop workshop content and material for workshops and for workshop delivery across Jamaica.
3	Establish ongoing capacity building programmes some of which can be implemented through farmer-field schools Rainwater harvesting techniques, opportunities and challenges. • Business planning and project financing. • Introduction to new technologies for climate change adaptation. • Accessing and interpreting weather,	Host at least 2 Capacity building workshops in each parish for small and medium size farmers.	FAO IICA GCF	RADA	0.5 – 2 Years	Lack of participation by farmers Difficult to reach majority of farmers	After the first year, 40% of small to medium size farmers should have attended at capacity building workshop. After two years 80% of farmers should have attended capacity	Number of farmers who have used or implemented strategies learned from the capacity building workshops.	US$2,000 per workshop for 28 workshops. Total Estimated US$56,000

	Action (Measures)	Activities to be implemented	Sources of funding	Responsible body and focal point	Time Frame	Risks	Success criteria	Indicators for monitoring of implementation	Budget per activity
	climate, rainfall and soil data/information. • Water management strategies for climate resilience. • Setup of model system for RWH for irrigation uses.						building workshop.		
		Assessment and determination of locations for rainwater harvesting systems for irrigation across Jamaica.	FAO IADB IICA	RADA	0.5 years	Technology may not be suitable in areas with limited rainfall.	Approved locations for rainwater harvesting systems for irrigation uses	-	**Rainwater Harvesting System** Requires roof area for water collection, water tank for storage, guttering and accessories. Average cost ranges from US$1,000 to US$2,000 to collect and store 600 gallons to 2,000 gallons of water.
		Design and financial considerations for rainwater harvesting systems for irrigation.	FAO IADB IICA	RADA	0.5 years	Financial models may indicate negative NPV	Completed and approved designs for rainwater harvesting systems for irrigation.	-	**Rainwater Harvesting System** Requires roof area for water collection, water tank for storage, guttering and accessories. Average cost ranges from US$1,000 to US$2,000 to collect and store 600 gallons to 2,000 gallons of water.
		Installation of rainwater harvesting pilot locations for irrigation.	FAO IADB IICA	RADA	1 Year	-	Commissioning of Pilot Rainwater Harvesting Systems for irrigation		

3.2 Project Ideas for Agriculture

3.2.1 Brief Summary of the Project Ideas for Agriculture Sector

Given the climate related challenges faced by Jamaican farmers each year, projects identified are associated with water use efficiency and storage and facilitating the increased access to such technology while incorporating elements of capacity building.

1. ***Drip and Sub-canopy /Micro Sprinkler Irrigation with Rainwater Harvesting Infrastructure*** – Under this project, farmers will be provided with rainwater harvesting systems integrated with drip and sprinkler irrigation systems powered by smart sensor integrated solar PV panels, controllers, DC motors and pumps to irrigate ¼ - 5 acre farm. This would be made available through the Ministry of Agriculture. Additional systems required for remaining areas of the farm plot (or additional lots) can be purchased with the help of a low-interest or interest-free loan/grant. This offer would be accessible to small and medium-sized farmers from all genders and age groups. This is in an effort to encourage the use of climate-smart technologies which maximize the use of scarce water resources, particularly during the dry season. It is understood that many farmers are unable to finance this investment on their own and are therefore unable to improve their efficiency. Overall, this project would help to increase the resilience of agricultural production systems to climate impacts on the water availability.

2. ***Development of Funding policy/financial framework*** – Establish a funding policy/financial framework that would enable the Government of Jamaica through RADA or the Ministry of Agriculture to provide guarantees to selected lending institutions for providing credit to private entities to supply sprinkler and drip irrigation systems to local farmers who meet the determined criteria. A three year program through the FAO or IICA could perhaps help to garner best practice and lessons for replication as the farmers who receive support demonstrate successful risk management and improved production. This would help to mitigate the risk averse position of the lending institutions as it relates to agricultural enterprise.

3. ***Rainwater Harvesting Systems for Irrigation Water Collection and Storage*** – under this project farmers would be able to access special grants or subsidy to fund the initial cost of installation of rainwater harvesting systems for water collection and storage for irrigation use by small and medium sized farmers. The project would also include the establishment of ongoing capacity building programmes including farmer-field schools for farmers to include: -
    - Rainwater harvesting techniques, opportunities, and challenges.
    - Business planning and project financing.
    - Introduction to new technologies for climate change adaptation.
    - Accessing and interpreting weather, climate, rainfall, and soil data/information.
    - Water management strategies for climate resilience.

    Overall, the main aim of this project would be to ensure the supply and availability of water for agricultural use in a scenario of increasing climate change-induced water scarcity. By targeting a

climate vulnerable resource key to sustain agriculture, the project will contribute to meeting food security and livelihood objectives that are undermined by the effects of climate change.

3.2.2 Specific Project Idea

A.8. Project size category (total investment, million USD)	Micro (≤10) ☐ Small (10<x≤50) ☒ Medium (50<x≤250) ☐ Large (>250) ☐
A.9. Mitigation / adaptation focus	Mitigation ☐ Adaptation ☒ Cross-cutting ☐

1) Summary of the Idea

a) Project Goal

To provide small and medium sized farmers in Jamaica with rainwater harvesting systems integrated with drip and sprinkler irrigation systems powered by smart sensor integrated solar PV panels, controllers, DC motors and pumps.

b) Rationale

Small and medium sized farmers in Jamaica often lack the start-up capital required for the acquisition and installation of irrigation systems, thus limiting their potential for maximum productivity and increased profit margins. Efficient irrigation systems can be expensive for these small farmers. The Government of Jamaica through RADA can provide registered farmers with an integrated system that incorporates the capture and storage of water for future use, sustainable use of scarce water resources and green energy through the use of solar power. This system would cover an area of ¼ - 5 acres with the farmer given the option to expand further at own cost through loans or grants. Such a project seeks to wholistically improve the production potential of farmers that are generally at risk.

c) Implementation Narrative

Key steps for the implementation of this project would include:

1. *Identifying target farmer population through partnership with RADA and by assessing the number of registered farmers in Jamaica who may be eligible for the programme.*
2. *Developing criteria and application process for accessing system*
3. *Developing an approval process for registered farmers who apply for the programme*
4. *Partnering with local plumbers, masons, electricians, for support in the procurement of equipment and services to help install the systems.*
5. *During execution, the project will implement SPV systems up to 10 kW each at ten (10) small farms (≤1/4 acre) per year from 2021–2023.*
6. *Implementing and executing capacity building programmes across farming districts to improve technical know-how, inclusive of set-up and efficient use of the irrigation system*
7. *Monitoring buy-in and gage improvement through feedback from farmers who received the system*

2) Climate impact potential

Adaptation: In providing improved irrigation systems farmers become less vulnerable to the longer, harsher drought conditions associated with climate change and resulting inconsistencies in water availability. Increases in evapotranspiration rates induced by rising temperatures can also be alleviated through the implementation of these irrigation systems. This technology is overall a more efficient use of water as it uses less water while distributing water more evenly across crops, thus helping to avoid wastage and increases crop/farm yields.

Mitigation: the incorporation of the solar PV pump will decrease the need for diesel fuelled pumps thereby reducing GHG emissions and providing lower operating costs. More specifically, the intervention is estimated to avoid 753.6 metric tons of CO_2 equivalent[6] from 74,056 gallons of diesel fuel for pumps; and generate 1,063.76 MWh from renewable energy over the project period (4 years) for pumping.

3) Paradigm shift potential

Such a project may be expanded to implement 10-100kW SPV systems at five (5) larger farms (¼ – 5 acres) per year from 2023 – 2025. It can be replicated by large farmers of a wide variety of crops since most are planted in rows. It is also suitable for a variety of soil types and across different terrain.

Further continuity of this project can be facilitated through:

- *Training of farmers, agricultural MDA and support services in merits of the technology and sustainability.*
- *Financing through local entities e.g. Commercial banks, credit unions, DBJ etc.*
- *Personal investment by farmers after seeing the benefits and increase in yields and profits.*
- *Promotion of the project successes among farmers to encourage replication*

4) Sustainable development potential

This will likely:

- *Increase water use efficiency which also saves time and money since rainwater harvesting infrastructure secures water resources to be used during periods of water stress and lowers the demand on treated water while making use of nutrients such as nitrates from rainfall for farming. The combined sub-canopy Sprinkler and drip irrigation technology further improves the efficiency of distribution system for irrigation water.*
- *Prevent disease by minimizing water contact with the leaves, stems, and fruit of plants.*
- *Eliminates use of open water conveyance channels therefore reducing water loss and allows the rows between plants to remain dry, improving access and reducing weed growth. This also distributes water more evenly across crops, thus helping to avoid wastage while increasing crop/farm yields.*
- *Decreases labour.*

[6] https://www.epa.gov/energy/greenhouse-gas-equivalencies-calculator

- *RWHS also reduces the cost for delivering water, thus improving the economics of operations.*
- *Addition of smart sensors for detecting crop root/soil moisture will activate pumps when needed to efficiently deliver irrigation volumes specific to the crop and appropriate for real-time weather conditions.*

5) Country ownership

- *Ministry of Agriculture and Fisheries,* supported by:
  - *RADA*
  - *NIC*

6) Type of Finance

Provision of special grants or subsidy to fund the expansion of the Sprinkler and Drip Irrigation Systems received. Potential local sources of funding for these systems would be through the Ministry of Finance and Public Service and the Development Bank of Jamaica.

7) Risks

- *Many small farmers may not be registered and will therefore not be able to benefit from this intervention.*
- *Small farmers lack proper credentials and collateral for accessing loans.*
- *Farmers default on loan payments.*
- *Praedial larceny may discourage farmers from continuing or replicating on other farms across Jamaica.*

4 Technology Action Plan for Water Resources

4.1 Sector Overview

Jamaica's water resources are derived from rainfall which feeds limestone and alluvial aquifers and surface flows in rivers. Approximately 50% of incoming rainfall is lost to evapotranspiration, leaving 50% to feed ground and surface storage, (MEGJC, 2019).a significant consideration with respect to warming temperatures. 84% of national water supply is obtained from groundwater, and surface flow supplies the remaining 16%.

Agriculture is the major user of the island's water resources, accounting for 75 percent of annual water consumption, compared to 15 percent for urban domestic water supply, and 10 percent for other uses, including industrial use, rural domestic water supply and tourism. (MEGJC, 2019). Approximately 10 percent of cultivated lands is currently irrigated, and 50 percent of those lands is served by public irrigation systems managed by the NIC; the other half are on commercial estates, such as banana, papaya and sugarcane, as well as individual private systems.

More recently, outbreak of the Covid-19 pandemic has stressed the need for clean and safe water for sanitation and hygienic purposes across all sectors of Jamaica. Demand has certainly increased but no analysis has been undertaken to date.

It has been acknowledged that Jamaica is not currently water stressed in terms of the existence of the resource, but rather, one of the challenges to water availability is the incongruence of the location of the major resource on the north and interior of the island and the major demand of growing population and urban centres located mainly on the south. Of additional concern is inadequate storage, aging infrastructure, and the impact of climate change which is already being experienced across the island as rainfall variability and extended dry periods challenge supply and storage in many areas.

Over the coming decades climate change is expected to bring increasing temperatures and more frequent and longer drought periods across Jamaica. Jamaica's *State of the Climate (2015) Report* articulates the projected change in parameters and increasing variability in rainfall occurrence to 2030, 2050 and the end of the century. This will exacerbate the existing challenges of reduced water availability, groundwater quality, and saltwater intrusion along over abstracted coastal areas. Projected increases in storm events will contaminate water from storm-water runoff during heavy rainfall periods, and storm surge and rising sea level will infiltrate and increase salinity in coastal aquifers. Scarcity of freshwater sources could limit Jamaica's social and economic development, food security, health and sanitation, and biodiversity.

To adapt to the water insecurity, water storage has been increased particularly with the use of tanks in domestic and commercial settings as well as on farms. There has also been an increased push and use of rainwater harvesting, particularly in rural communities (Witter, 2007). However, the GOJ has embraced the need for an integrated approach to management of the water sector to meet the needs of the growing population, increasing urbanisation and expanding economic sectors. An updated National Water Sector Policy (2018) was endorsed and accepted in 2019. The Plan outlines the current situation in the water and wastewater sector, and ensures that the principles, objectives, and policy directions for the management

of the country's water resources are in line with Vision 2030- Jamaica's National Development Plan. Key additions to the previous policy include a strong commitment to Integrated Water Resources Management (IWRM), drought mitigation, and efforts to ensure adaptation and resilience to climate change and climate variability across the water resources sector (MEGJC, 2019).

The Goal of the Policy is "*To ensure that Jamaica's water resources are effectively managed so as to provide for our nation's social, economic, and environmental well-being, now and in the future*" (MEGJC, 2019).

In keeping with the goal the Objectives include: To improve institutional arrangements for integrated water resources management. 2. To protect watershed areas, ecosystems, catchments and networks, and promote effective programmes for water conservation and protection. 3. To include research, adaptation and implementation of scientific and technological innovation to sustain ecosystems services of water. 4. To put in place the policy, programmes and physical structures for climate adaptation and energy efficiency in the water sector. 5. To allow for private sector participation in the water sector. 6. To facilitate and increase investments in the water sector. 7. To ensure economic efficiency by considering pricing and other economic incentives. 8. To effectively manage water supply in Utility and Non-Utility Service Areas by ensuring equitable sharing of the water resources in the twenty-six (26) Watershed Management Units (WMUs). 9. To increase resilience to climatic shocks, such as drought. 10. To encourage rainwater harvesting, both as a primary source of access and as a drought management mechanism. 11. To ensure effective management of wastewater. 12. To provide sufficient water for achieving food security by improving irrigation services. 13. To ensure effective flood water control. (MEGJC, 2019)

Stakeholder consultations highlighted technological interventions that would help to satisfy access to water particularly in rural areas and in areas with limited access to the Utility -

4.1.1 Action Plan for Community Scale Rainwater Harvesting Systems

Sector	Water
Sub-sector	Water Supply and Storage
Technology	Community-Scale Rainwater Harvesting System. Elevated systems will utilise gravity for water delivery in communities. Solar driven water pumps will be used for areas which are flat or have varying elevations.
Ambition	Currently, there are 353 community-scale rainwater harvesting systems across Jamaica. The target to increase rainwater harvesting, and storage systems in non-utility supplied rural communities by approximately 20% of existing number of communities with RWHSS (71 systems) over a three-year period, 2021–2024. Each RWHSS will be assigned 1 x 10 kW solar driven pumping system where required. The intervention could therefore avoid an estimated 1,036.2 metric tons of CO_2 equivalent[7] from 9,258 gallons of diesel fuel for pumps; while generating 1,101.43 MWh from solar energy over the project period (3 years) for pumping.
Benefits	Rainwater harvesting can help to adapt to effects by climate change as it allows for the: - • Diversification of potable water supply • Creation of new sources of water • Increase in storm-water control and capture. • Increase in water storage. • Technologies with low setup cost for simple systems, however, this can vary with more complex systems, • The use of a system which is easily scalable, and components can be added over time. Use of technology which can be simple and easily maintained without specialised persons.

Table 4.1: Detailed Action Plan for Community Scale Rainwater Harvesting System

	Action (Measures)	Activities to be implemented	Sources of funding	Responsible body and focal point	Time Frame	Risks	Success criteria	Indicators for monitoring of implementation	Budget per activity
1	Financial support for community scale rainwater supply systems for non-utility supplied communities	Identification of non-utility supplied communities for the installation of rainwater harvesting systems.	MEGJC	Rural Water Limited Municipal Corporations	0 – 0.5 years		List of non-utility number of communities supplied	-	**Rainwater Harvesting System with a 24,000-gallon water storage and water treatment system.** Estimated capital cost: US$50,000 per system.

[7] https://www.epa.gov/energy/greenhouse-gas-equivalencies-calculator

	Action (Measures)	Activities to be implemented	Sources of funding	Responsible body and focal point	Time Frame	Risks	Success criteria	Indicators for monitoring of implementation	Budget per activity
		Determine approximate area/location for community scaled rainwater harvesting and storage system	-	Rural Water Limited Municipal Corporations	0.5 – 1 year	Limited locations in communities for large scale rainwater harvesting and storage systems. Requires suitable land area (tree and building clearances, solid ground formation, centrality to community etc.).	Details and locations for community scale rainwater harvesting systems within non-utilities supplied communities	Long list of locations identified within communities. Short list of locations. Approved location for community scale rainwater harvesting system	
		Identify suppliers for the construction and installation of rainwater harvesting and storage system.	-	Rural Water Limited Municipal Corporations	0.5-1 year		List of contractors for the installation of community scaled rainwater harvesting systems	List of suitable contractors with experience in rainwater harvesting systems Shot list of approved contractors for the supply of rainwater harvesting systems List of approved contractors.	

	Action (Measures)	Activities to be implemented	Sources of funding	Responsible body and focal point	Time Frame	Risks	Success criteria	Indicators for monitoring of implementation	Budget per activity
		Design and Determine cost for installation/construction of rainwater harvesting and storage systems.	Private Contractors: Civil engineer and Quantity Surveyor:	Rural Water Limited Municipal Corporations	0.5 – 1 year	-	Completed designs and cost for each community rainwater harvesting system		
		Implementation/construction of rainwater harvesting and storage system.	Rural Water Limited Municipal Corporations Private Entities	Rural Water Limited Municipal Corporations	1 – 3 years	Delays in construction Cost overruns	Number of community scale rainwater harvesting systems installed after 3 years	Number of community scale rainwater harvesting constructed and commission every year over a 3 year period.	
2	Rainwater harvesting systems should have a financing component for operations and maintenance to ensure the continuity and sustainability of the system.	Identification of fund for the maintenance and operational cost associated with rainwater harvesting systems.	Municipal Corporations Rural Water Limited Private Entities Community Organizations IADB	Municipal Corporations Community Organizations	1-3 years	Municipal Corporations do not have the required financial resources to continuously find operational expenses. Little return on investment on community scale rainwater harvesting systems.	Funds allocated for operational and maintenance activities for community scale rainwater harvesting systems	Amount of funds available for operation and maintenance of rainwater harvesting systems each year. Number of community scale rainwater harvesting systems with budget for operational and maintenance expenses.	Operational and maintenance: US$2,000 per year (average) per system

	Action (Measures)	Activities to be implemented	Sources of funding	Responsible body and focal point	Time Frame	Risks	Success criteria	Indicators for monitoring of implementation	Budget per activity
3	Community organizations can be responsible for the management and operation for the community rainwater harvesting systems, however, they may require financial and professional support.	Identification of capable community organizations for the management and operation of rainwater harvesting systems.	Municipal Corporations Rural Water Supply JN Foundation	Municipal Corporations	-	Community groups change over time and there might be loss of knowledge or interest.	50% of community scale rainwater harvesting systems managed by community groups by 2024.	Number of community groups trained in operation and maintenance of rainwater harvesting systems.	**Training and capacity building for community group organizations.** Estimated Cost: US$3,000 for training session per community group
		Training of community organization in operating and management of rainwater harvesting system.	Municipal Corporations Rural Water Supply JN Foundation Private Entities	Municipal Corporations	1 - 3 years	Community members may not be interested. High turn-over of persons within community organizations.	Number of community scale rainwater harvesting systems managed by community groups	Number of persons trained per year.	
4	Development of national standards and guidelines for rainwater harvesting.	Setup multi-agency team for the development of standards and guidelines for Rainwater Harvesting in Jamaica. Agencies to be included: - • WRA • MOHW • NWC • NEPA • Rural Water Limited	JN Foundation PAHO GCF Ministry of Finance and the Public Service	WRA MOHW NEPA	0-2 years		Development and approval of rainwater harvesting standards and guidelines for Jamaica	Number of meetings for the multi-agency team. Progress reports from the multi-agency team	**Fees to support multi - agency team in research and development.** Estimated lump sum cost: US$20,000.

	Action (Measures)	Activities to be implemented	Sources of funding	Responsible body and focal point	Time Frame	Risks	Success criteria	Indicators for monitoring of implementation	Budget per activity
		• Private Sector Entities							
5	Government to create a department in an existing agency with related portfolio (NWC, WRA) with the sole responsibility of rainwater harvesting research and development. This should include conducting research into rainfall and watershed analysis, catchment dynamics and rainwater quality.	Setup department with responsibility of research and development into rainwater harvesting.	GOJ= MEGJC	WRA	0-2 years	Rainwater harvesting not in-line with the history of main core business of the agency.	Increased research and development into rainwater harvesting in Jamaica.	Establishment of the Rainwater harvesting Unit	Estimated cost for staff and administration: US$100,000 per annum

4.1.2 Action Plan for Minor Water Tank Networks for Communities

Sector	Water
Sub-sector	Water Storage and Distribution
Technology	Minor Water Tank Networks for communities. Solar driven water pumps will be used for areas which are flat or have varying elevations and where pressured systems are necessary for extensive piping within communities.
Ambition	The target for minor tank networks is to increase water storage and distribution systems for potable uses by 20% in non-utility supplied rural communities by 2024. This target is in keeping with the National Water Sector Policy and Implementation Plan 2019 which outlines the GoJ's goal to provide potable water access to everyone by 2030 (GoJ, 2019).
Benefits	Creation and Restoration of tanks which harvest water from surface water bodies, runoff and from direct rainfall. Restoration of tanks that have been damaged or silted. These tanks can provide water for domestic, agricultural and livestock needs.

	These tanks are large and usually gravity feed to houses or to a communal pipe. They are large enough to support small communities. For densely populated communities, or communities where extensive piping is needed to supply homes, solar water pumping will alleviate the need for diesel pumps and avoidance of emissions. Water will require some treatment for potable uses. Diversification of water supply Control and capture of storm water

Table 4.2: Detailed Action Plan for Minor Water Tank Networks for Communities

	Action (Measures)	Activities to be implemented	Sources of funding	Responsible body and focal point	Time Frame	Risks	Success criteria	Indicators for monitoring of implementation	Budget per activity
1	Financial support for community scale minor tank systems for non-utility supplied communities	Identification of non-utility supplied communities for the installation of minor tank network systems.	-	Rural Water Limited Municipal Corporations	0 – 0.5 years	Limited locations in communities for location minor water tank systems.	List of non-utility supplied communities for minor tank networks	-	**Minor Tank Networks system with a 24,000-gallon water storage capacity.** Estimated capital cost: US$50,000 to US$200,000.
		Determine approximate area/location for community scaled minor tank network system.	-	Rural Water Limited Municipal Corporations	0 – 0.5 years	Requires large areas of land space for water storage.	Details and locations for minor tank networks for non-utility supplied communities	-	
		Identify suppliers for the construction and installation of minor tank network system.	-	Rural Water Limited Municipal Corporations	0 – 0.5 years	Inadequate water supply for minor tanks in some communities with high water demand.	List of contractors /suppliers for minor tank network systems	-	

	Action (Measures)	Activities to be implemented	Sources of funding	Responsible body and focal point	Time Frame	Risks	Success criteria	Indicators for monitoring of implementation	Budget per activity
		Design and Determine cost for installation/construction of minor tank network systems.	-	Rural Water Limited Municipal Corporations	0.5 – 1 year	-	Design and cost with approximate financial model for the minor tank network systems.	-	
		Implementation/construction of minor tank network system.	IADB PAHO Private Entities	Rural Water Limited Municipal Corporations	1 – 3 years	Delays in construction activities. Cost over-runs	Construction and commissioning of minor tank network systems in non-utility supplied rural communities	Number of minor tank networks systems constructed and commissioned per year.	
2	Develop minor tank network systems .	Identification of funds for the maintenance and operational cost associated with sustainability of the network systems.	Municipal Corporations Rural Water Limited Private Entities Community Organizations IADB	Municipal Corporations Community Organizations	1-3 years	Municipal Corporations do not have the required financial resources to continuously find operational expenses. Little return on investment on community scaled minor tank	Funds allocated for operational and maintenance activities for minor tank network systems.	Amount of funds available for operation and maintenance of minor tank network systems each year. Number of minor tank network systems with budget for operational and maintenance expenses.	Operational and maintenance: US$2,000 per year (average) per system

	Action (Measures)	Activities to be implemented	Sources of funding	Responsible body and focal point	Time Frame	Risks	Success criteria	Indicators for monitoring of implementation	Budget per activity
						network systems.			
3	Facilitate the management and operation of community rainwater harvesting systems	Identification of capable community organizations for the management and operation of minor tank network systems.	Municipal Corporations Rural Water Supply JN Foundation	Municipal Corporations	-	Community groups change over time and there might be loss of knowledge or interest.	50% of community scale minor tank network systems managed by community groups by 2024.	Number of community groups trained in operation and maintenance of minor tank network systems.	**Training and capacity building for commute organizations.** Estimated Cost: US$3,000 for training session per community group.
		Training of community organization in operating and management of minor tank network system.	Municipal Corporations Rural Water Supply NWC Private Entities	Municipal Corporations	1 - 3 years	Community members may not be interested. High turn-over of persons within community organizations.	Number of community scaled rainwater harvesting systems managed by community groups	Number of persons trained per year.	

4.2 Project ideas for Water Resources

4.2.1 Brief Summary of the Project Ideas for Water Resources

1. ***Community Scale Rainwater Harvesting for Rural Communities*** – A number of rural communities in Jamaica do not have access to utility water. This project therefore aims to increase the resilience of rural community members who are without access to water supply from a utility provider by installing large-scale rainwater harvesting systems. Large rainwater harvesting and storage system would be placed in these communities at central locations for the collection of water by community members or the setup of minor water distribution networks within the community. Additionally, these facilities can house filters and the water treatment equipment for potable water supply. Potential area of focus would be three communities in St. Thomas where rainfall is received regularly.
2. ***Digital Maps (DEM) of Watersheds*** – Watersheds across Jamaica are consistently being degraded. However, the extent of this in several areas is unknown due to the limited data available. Under this project, satellite imagery with the appropriate resolution would be used to capture the required data. This would ultimately be processed and used to update watershed zones across the island and the 2003 Watershed Policy, viz. to identify threats to the watershed (e.g. factories farming), determine the state of the watershed, determine how it has changed overtime, as well as decide interventions for conservation, restoration and protection, particularly with the advent of climate change and human-based impacts.
3. ***Basin level modelling and seasonal forecasting for water allocation of the Rio Cobre -*** Under this project, basin level modelling of the Rio Cobre would help to determine how to best optimize available resources among competing users, and to assess potential trade-offs, while ensuring that enough water is left for the environment given the varied competing uses of the river and the changing dynamics and water availability between the wet and dry seasons in Jamaica. Various scenarios including predictions on available seasonal water supply, sustainable extraction rates, and estimations of the minimum amount of water required for irrigation can help in improving the management of this very important water resource, thus striking a balance between economic, residential and sustainable use. Additionally, these models can be used to project the implications of future climate change on availability of water resources and help inform both infrastructure development and land use planning decisions.
4. ***Restoration of Community Tanks*** – This project involves the restoration of tanks which harvest water from surface water bodies, runoff and from direct rainfall, as well as those that have been damaged or silted. These tanks are large and usually gravity feed to houses or to a communal pipe and can provide water for domestic, agricultural and livestock needs.

4.2.2 Specific Project Idea

A.8. Project size category (total investment, million USD)	Micro (≤10) ☐ Small (10<x≤50) ☒ Medium (50<x≤250) ☐ Large (>250) ☐
A.9. Mitigation / adaptation focus	Mitigation ☐ Adaptation ☒ Cross-cutting ☐

1) Summary of the Idea

a) Project Goal

To increase rainwater harvesting and storage systems by approximately 20% of existing coverage over a three-year period, 2021–2024, in three rural communities that are not supplied with utility water.

b) Rationale

Many rural communities across Jamaica are not supplied with domestic water from the National Water Commission or Municipal Corporation. This is partly because the capital and operational cost to provide utility water is very high and the hilly terrain makes it difficult for the installation and maintenance of these systems. However, many of these rural communities have high quantities of rainfall which can be harvested and stored for potable and non-potable uses. Providing the infrastructure to undergo rainwater harvesting in these communities can also help members to adapt to effects by climate change.

c) Implementation Narrative

These include:

1. *Identifying suitable non-utility supplied communities for the installation of rainwater harvesting systems in St. Thomas.*
2. *Determining the approximate area/location within the community to install rainwater harvesting and storage system based on the existing landscape.*
3. *Identifying suppliers for the construction and installation of the rainwater harvesting and storage system.*
4. *Determining the cost for installation/construction of rainwater harvesting and storage systems.*
5. *Implementing/constructing rainwater harvesting and storage system.*

2) Climate impact potential

a) Adaptation: By implementing RWH systems in the selected communities in St. Thomas, residents will have greater access to water to serve their domestic needs year-round.

3) Paradigm shift potential

There is potential for replicating this system in other similar rural communities across Jamaica where rainfall is relatively consistent, but utility water supply is unavailable.

The main requirements for functional continuity of this rainwater harvesting, storage, and treatment system after the project has been completed, is dependent on training persons for regular maintenance of the system. Also, maintenance cost ranges, and therefore, the water could be supplied at a minimal cost to cover and sustain these operational and maintenance expenses.

4) Sustainable development potential

Increased water security and availability of other sources of water in areas where reliance would have previously been primarily on sources like rivers or springs. This target is in keeping with the policy goals to provide potable water access to everyone by 2030.

5) Country ownership

- *Rural Water Limited*
- *Municipal Corporations*

The National Water Sector Policy and Implementation Plan 2018 strongly encourages the implementation of RWH systems in residential areas to help in adapting to intensifying and longer drought conditions associated with climate change.

6) Type of Finance

The installation of the system may be funded through the Rural Water Limited and the St. Thomas Municipal Corporation to assist with covering the cost of some materials and the skilled labour needed, i.e. plumber, masons etc. The private sector may also be engaged to help provide support with tanks and other plumbing supplies which would be required. Payment collected from supplying water can help to cover operational expenses associated with consistent maintenance, necessary repairs or replacement of defunct parts.

7) Risks

- *Limited locations in communities for large scale rainwater harvesting and storage systems.*
- *Requires large areas of land space.*
- *Community groups change over time and there might be loss of knowledge or interest.*
- *Municipal Corporations do not have the required financial resources to continuously fund operational expenses. Also, cultural assertion that water is free, and should be provided by the Government.*

- *Wastage of water through leaks in homes, or lack of sufficient care when accessing water at community stand-pipes.*
- *Installing the system at a location in the community that is accessible to all those who need to use it (use not restricted by gang feuds)*
- *Rainwater harvesting not in-line with the history of main core business of the agency.*
- *Vandalization of the system.*

5 Technology Action Plan for Coastal Resources

5.1 TAP for Coastal Resources

5.1.1 Sector Overview

Jamaica's coastal resources have environmental, social, and economic significance. With an estimated 70% of the population and 75% of economic assets, including air and seaport facilities, urban centres, industrial production, energy generation and tourism infrastructure, being concentrated in coastal areas. Coastal resources are responsible for generating approximately 90% of the island's gross domestic product (GDP) (Met Office, 2010). Jamaica has, however, been experiencing several effects that are attributed to climate change. These include coastal erosion due to sea level rise; reduced fish production, and coral bleaching due to increases in sea surface temperatures; reduction of reefs and calcareous species due to ocean acidification and storm damage; and the destruction of coastal ecosystems, marine habitats and spawning grounds by hurricanes and tropical storms (CSGM, 2016). Additionally, the removal of mangroves, seagrass beds, and coral reefs occasioned by this multi-purpose use of the coastal zone has increased Jamaica's vulnerability to hurricanes and storm surges and has posed a major threat to coastal ecosystems and marine life. Therefore, the impacts of climate change on an already deteriorating ecosystem are likely to become more severe and worsen problems that coastal areas experience.

To combat the challenges associated with coastal resources across Jamaica and adapt to the impacts of climate change, Jamaica has generally sought to employ various hard engineering techniques. Wave attenuation devices (WADs) are one of several hard engineering structures widely used in Jamaica. Whilst carrying out their primary function of protecting the coastline and reducing the effects of coastal erosion, these structures have simultaneously provided a habitat for fish and marine life, as is observed along the coastal communities of Old Harbour Bay in St. Catherine, Long Bay in Westmoreland, Alligator Pond in Manchester and Annotto Bay in St. Mary. Shoreline revetment projects have been carried out on several locations on Jamaica's southern coast (GoJ, 2018). These include Roselle in St. Thomas, the windward side of the Palisadoes Peninsula, Gordon Cay, Kingston Harbour, and Bluefields in Westmoreland. The placement of groynes along the seashore is an ongoing protective measure that is being carried out at various locations to dissipate wave energy and the impact of currents and protect the shoreline from erosion. Other coastal protection works have included installation of geo-textile tubing in Portmore to prevent erosion (MEGJC, 2018); the installation of breakwaters at various locations on the south coast; and embankments in some low-lying coastal areas.

In more recent times, the need for more soft approaches to coastal protection has gained attention. In recognizing this, the restoration and protection of mangrove, seagrass and coral reef ecosystems have been identified as key outputs for climate change adaptation, as the ecosystem services they provide can help to minimize coastal erosion as well as reduce the risk of damage and loss to industries, communities, key infrastructure, and economic lifelines. Mangrove replanting programmes have been carried out along the Palisadoes Strip in Kingston, Portland Cottage in Clarendon and along the Portmore Causeway in St. Catherine. These measures have helped to stabilise the coast and restore the protective function of coastal ecosystems. Coral restoration programmes have also been established in Jamaica, like that

implemented by the Sandals Foundation in partnership with the Coral Restoration Foundation and the Bluefields Bay Fishermen's Friendly Society.

A community-centred approach was used by the Caribbean Fish Sanctuary Partnership Initiative (C–FISH), a four-year project implemented by the Caribbean Community Climate Change Centre (CCCCC) and CARIBSAVE, that helped with improving the management of 7 fish sanctuaries across Jamaica. C–FISH was successful because it focused on building the capacity and engagement of the local communities. The most prominent sanctuaries include the fish sanctuaries in Portland Bight in Clarendon, Bluefields Bay in Westmoreland and San San in Portland (GoJ, 2018).

5.1.2 Action Plan for Wetland (Mangrove and Seagrass) Restoration

Sector	Coastal Resources
Sub-sector	Coastal Protection
Technology	Wetland (mangrove) Restoration
Ambition	Over a five-year period, 2021–2026, complete the enhancement and/or replacement of 20% of critical wetland (mangrove) areas across Jamaica, based on a list of critical areas identified in consultation with NEPA
Benefits	Wetland habitats are important because they perform essential functions in terms of coastal flood and erosion management. They induce wave and tidal energy dissipation (Brampton, 1992) and act as a sediment trap for materials, thus helping to build land seawards. The dense root mats of wetland plants also help to stabilise shore sediments, thus reducing erosion (USACE, 1989). Wetland restoration re-establishes these advantageous functions for the benefits of coastal flood and erosion protection. Techniques have been developed to reintroduce coastal wetlands to areas where they previously existed and to areas where they did not if conditions will allow. The diversity of wetland types means there are numerous methods for restoring wetlands. The method adopted will depend on the habitat which is being restored. Mangroves can be restored by growing types of saline grass in a nursery and transplant to areas which have been prepared for wetland rehabilitation.

Table 5.1: Detailed Action Plan for Wetland (Mangrove and Seagrass) Restoration

	Actions	Activities to be implemented	Sources of funding	Responsible body and focal point	Time frame	Risks	Success criteria	Indicators for monitoring of implementation	Budget per activity
1	Create incentives at all levels for the restoration of mangroves. This may include making coastal land space available for restoration and providing financial and legislative support.	Develop suitable suite of incentives. Co-design incentive scheme with relevant stakeholders	NEPA GCF GEF UNEP TNC IDB World Bank	MHURECC	6 years	No consensus on incentive programs Incentive is inaccessible or unrealistic. Low/no uptake of incentives	Number of projects that have access to the incentives.	Number of applications for incentives Ratio of cleared/degraded mangroves to restored areas	**Consultant fees for the economic valuation of coral reefs across Jamaica.** Estimated lump sum cost: US$150,000.

Actions		Activities to be implemented	Sources of funding	Responsible body and focal point	Time frame	Risks	Success criteria	Indicators for monitoring of implementation	Budget per activity
2	Restoration projects should be valued and have insurance coverage to allow for finances to be recovered for the project in the event of a storm or hurricane.	Identify resources for valuation of restoration projects.	CCRIF	NEPA	3 years	Insurance plans are unattainable. No mandate in place to insure projects.	Financial institutions offering insurance plans for restoration projects.	% of restoration projects valued. % of restoration projects with insurance in place.	Average lump sum cost per project valuation (consultant fees) USD40,000
		Develop and implement insurance options/ plans for restoration projects	CCRIF	NEPA	3 years	Cost to value projects is unattainable.	Regulation/ policy stipulating conditions for valuation of restoration projects	Number of insurance pay outs.	
3	Funding needs to also be placed largely into research and development of these technologies and not only into the restoration project itself. The technologies require research, modelling, and simulation to understand how the environments can adapt to future climate conditions.	Identify funding sources.	-	NEPA	1 year	Funding reallocated to other priorities.	Dedicated R&D funding mechanism in place	% of Restoration R&D projects funded.	**Consulting fees to develop investment mechanism.** Estimated Lump Sum: USD49,500
		Implement investment mechanism for restoration R&D.	IADB GCF	NEPA	5 years	R&D yields inconclusive results.	-	% of Restoration R&D projects executed.	**-**
		Partner with research institutions regionally and internationally.	TNC IDB World Bank GCF UWI	NEPA UWI	5 Years	Limited partnership opportunities for research and development.	Parentship Agreements.	Development of new ideas, methods and technologies for restoration activities. Increased research activities and publications centred around coastal restoration activities.	**-**

Actions		Activities to be implemented	Sources of funding	Responsible body and focal point	Time frame	Risks	Success criteria	Indicators for monitoring of implementation	Budget per activity
4	There is a need for a more holistic approach to the technologies that allow for not only rehabilitation, but to address other factors within the watershed that affect mangroves and coral reef systems.	Strengthen the existing National Water Sector Policy (2018) and action the recommended programmes and projects.	UNEP TNC IDB World Bank GCF	NEPA	6 years	Delays in implementation of IWRM policy	IWRM Policy implemented	-	
		Implement sensitization and awareness programmes for relevant stakeholders (e.g., farmers, commercial developers, communities etc).	UNEP TNC IDB World Bank GCF	NEPA	6 years	Stakeholders may not be interested.	-	# of sensitization programs implemented # of participants across sectors in sensitization programs	Consulting fees to develop policy and sensitization programs. USD350,000
		Create capacity building strategic plan for ecological restoration.	NEPA GCF GEF	NEPA	6-years	Staff turnover resulting in loss of technical and institutional knowledge.	Capacity building framework in place	Capacity building plan implemented. Number of persons trained per quarter.	**Training and capacity building for NEPA in new concepts, technologies, and methodologies for wetland restoration. This may take the form of workshops, conferences, and research activities.** Estimated Cost: US$20,000 per annum

Actions		Activities to be implemented	Sources of funding	Responsible body and focal point	Time frame	Risks	Success criteria	Indicators for monitoring of implementation	Budget per activity
		Consistent training and sensitization events for appropriate resource personnel within NEPA.	UNEP TNC IDB World Bank			Low/no availability of training resources		Number of capacity building sessions held per quarter	
5	Develop stronger regulation and provide better stakeholder support for the incorporation of mangroves into the design of coastal developments, e.g. integrating mangroves into coastal design as part of the growing trend to green tourism which can serve as eco-tourism attractions for the hotels.	Develop policy/ regulation that mandates 'no net loss' or 2:1 compensation of functional mangroves (to include penalties for breaches)	-	NEPA	6-years	Limited available areas for mangrove restoration/ compensation	Number of coastal developments with no net loss/2:1 permit conditions	Ratio of cleared/degraded mangroves to restored. % change in total mangrove cover island wide	NA
6	The guideline which allows for mangrove restoration on a 1:1 ratio should be adjusted to a higher ratio.	Develop policy/ regulation that mandates 'no net loss' or 2:1 compensation of functional mangroves (to include	No funding required	NEPA	6- years	Limited available areas for mangrove restoration/ compensation	Number of coastal developments with no net loss/2:1 permit conditions	Ratio of cleared/degraded mangroves to restored. % change in total mangrove cover island wide	NA

Actions		Activities to be implemented	Sources of funding	Responsible body and focal point	Time frame	Risks	Success criteria	Indicators for monitoring of implementation	Budget per activity
		penalties for breaches)							

5.1.3 Action Plan for Coral Reef Restoration

Sector	Coastal resources
Sub-sector	Coastal Protection
Technology	Wetland Restoration
Ambition	Over a five-year period, 2021–2026, complete coral reef restoration at two sites. Site selection, method, implementation, and monitoring should be done in consultation with NEPA.
Benefits	Coastal erosion is being exacerbated by climate change and areas with existing coral reefs are seeing coral reef degradation due to high sea temperatures. Therefore, creating and restoring coral reefs with different varieties of corals which can withstand higher temperatures can help to decrease coastal erosion and create marine coral reef environments. The coral reefs will play an important role in the protection of coastal areas and wetlands as they are threatened by increasing sea level rise and storm surge. The reefs form a more effective barrier with respect to wave action and erosion along the coastline, therefore, providing shelter for other marine organisms and improving the overall stability of the reef and ecosystems and preserving biodiversity.

Table 5.2: Detailed Action Plan for Coral Reef Restoration

Actions		Activities to be implemented	Sources of funding	Responsible body and focal point	Time frame	Risks	Success criteria	Indicators for monitoring of implementation	Budget per activity
1	Create incentives at all levels for the restoration of mangroves. This may include making coastal land space available for restoration and providing financial and legislative support.	Integrate mangrove restoration into insurance scheme for coastal developments. Identify areas for mangrove restoration where there is great need for coastal protection.	NEPA GCF GEF UNEP TNC IDB World Bank	MHURECC	6-years	No consensus on incentive programs. Incentives are inaccessible or unrealistic.	Number of projects that have accessed incentives.	Number of applications for incentives.	**Consultant fees for the economic valuation of mangroves across Jamaica.** Estimated lump sum cost: US$150,000.
		Co-design incentive scheme with relevant stakeholders	NEPA GCF GEF UNEP TNC IDB World Bank	MHURECC	6-years	Low/no uptake of incentives	Number of projects that have accessed incentives.	% wetlands in fair condition and above (according to Reef Health Index)	
2	Restoration projects should be valued and have insurance coverage to allow for finances to be recovered for the project in the	Identify resources for valuation of restoration projects.	CCRIF	NEPA	6 years	Insurance plans are unattainable. No mandate in place to insure projects.	Financial institutions offering insurance plans for restoration projects.	% of restoration projects valued % of restoration projects with insurance in place # of insurance pay outs	Average lump sum cost per project valuation (consultant fees) USD40,000

Actions		Activities to be implemented	Sources of funding	Responsible body and focal point	Time frame	Risks	Success criteria	Indicators for monitoring of implementation	Budget per activity
	event of a storm or hurricane.	Develop and implement insurance options/ plans for restoration projects				Cost to value projects is unattainable	Regulation/ policy stipulating conditions for valuation of restoration projects		
3	Funding needs to also be placed largely into research and development of these technologies and not only into the restoration project itself. The technologies require research, modelling, and simulation to understand how the environments can adapt to future climate conditions.	Identify funding sources. Implement investment mechanism for restoration R&D. Partner with research institutions regionally and internationally	NEPA GCF GEF UNEP TNC IDB World Bank	NEPA	6 years	Funding reallocated to other priorities. R&D yields inconclusive results.	Dedicated R&D funding mechanism in place	% of Restoration R&D projects funded % of Restoration R&D projects executed Number of partnerships established or signed agreements	Consulting fees to develop investment mechanism. USD49,500
4	There is a need for a more holistic approach to the technologies that allow for not only rehabilitation, but to address other factors within the watershed that affect mangroves	Strengthen the existing National Water Sector Policy (2018)and action recommended programmes and projects. Implement sensitization and awareness	WRA NIC NEPA RADA PIOJ RWSL NWC MEGJC MHURECC	WRA NEPA	6 years	Delays in implementation of IWRM policy	IWRM Policy implemented KAP survey completed	# of sensitization programs implemented # of participants across sectors in sensitization programs # of IWRM projects in place # of participants in KAP survey	Consulting fees to develop policy and sensitization programs. USD350,000

Actions		Activities to be implemented	Sources of funding	Responsible body and focal point	Time frame	Risks	Success criteria	Indicators for monitoring of implementation	Budget per activity
	and coral reef systems.	programmes for relevant stakeholders (e.g., farmers, commercial developers, communities etc) KAP survey for water resource management among relevant stakeholders							
5	Develop new ideas, technologies and methodologies for ecological restoration projects, and engage in capacity building	Create capacity building strategic plan for ecological restoration with environmental management agency, NEPA. Consistent training and sensitization events on new technologies and approaches in ecological restoration for appropriate resource personnel within NEPA.	NEPA GCF GEF UNEP TNC IDB World Bank	NEPA	6 years	Staff turnover resulting in loss of technical and institutional knowledge. Low/no availability of training resources	Capacity building framework in place	Capacity building plan implemented. # Of persons trained per quarter # of capacity building sessions held per quarter	**Training and capacity building for NEPA in new concepts, technologies, and methodologies for wetland restoration. This may take the form of workshops, conferences, and research activities.** Estimated Cost: US$20,000 per annum
6	There needs to be stronger regulation and stakeholder	Develop policy/ regulation that mandates 'no net loss' of reefs (to	No funding required	NEPA	6 years	Limited available areas for reef restoration/ Compensation	# coastal developments with no net loss condition	% change in total coral cover island wide	NA

Actions	Activities to be implemented	Sources of funding	Responsible body and focal point	Time frame	Risks	Success criteria	Indicators for monitoring of implementation	Budget per activity
support for the incorporation of mangroves into the design of coastal developments. For example, hotels can integrate mangroves into their design as part of the growing trend to green tourism and to pay attention to the blue economy. These areas can serve as eco-tourism attractions for the hotels.	include penalties for breaches) Develop suitable suite of incentives. Gain consensus from relevant stakeholders on incentives				Low success rate for reef restoration			

5.2 Project Ideas for Coastal Resources

5.2.1 Brief Summary of the Project Ideas

The competition between economic development and ecosystem integrity is widespread across the various coastal and marine ecosystems in Jamaica. These natural resources provide a number of benefits to coastal communities ranging from coastal protection to livelihood sustenance. Nevertheless, ecosystem degradation still occurs from a combination of natural events and anthropogenic influence. As such, there are several coastal ecosystems across the island in need of conservation, restoration and protection initiatives.

This has been corroborated by all the stakeholders consulted, who comprise of experts on each type of marine and coastal ecosystem, experts on reef and mangrove restoration, as well as the national regulatory agency, NEPA, a key focal point of the Government of Jamaica for coastal resource management and collaborator with the Climate Change Division for climate change adaptation and mitigation. All have agreed that a concerted effort will be required to effectively manage these valuable resources. In alignment with these ecosystem needs, NEPA is currently preparing a National Ecosystem Restoration Strategic Action Plan for the next ten years (2021-2031) that will include strategies and specific targets for ecosystem restoration. The development of this action plan is being informed by the Coastal Management and Beach Restoration Guidelines: Jamaica (2017) which was prepared with support from the World Bank. NEPA has already started exploring funding opportunities for some of the restoration activities, e.g. ecosystem restoration of the Hellshire Bay area.

Some suggested project ideas include:

1. ***Dune Restoration in Alligator Pond*** – sand dunes are one of the few environmental features located along the beach in Alligator Pond. Whilst the dunes in some areas are stable and vegetated, a great portion of dunes in other areas along the beach have been cleared of its vegetation causing them to be unstable and unhealthy. Sand dunes help to retain water and dissipate wave energy, thus acting as a buffer against tidal waves, storms, and coastal flooding. Restoration of these dunes can promote these natural functions and will require a combination of beach nourishment and replanting of dune vegetation to restore the functionality of the sand dunes.
2. ***Seagrass Restoration in Hellshire Beach*** – loss of seagrass beds linked to natural and anthropogenic factors influencing the marine and coastal ecosystems surrounding Hellshire have had major direct and indirect ripple effects. The degraded seagrass meadows have resulted in loss of a key habitat that serves as spawning, nursery, feeding grounds and shelter to a variety of marine organisms. The loss has also reduced carbon uptake but more evidently have contributed to a reduction in sand accretion and reef degradation. Seagrass slows down coastal currents which helps stabilise sediments and retain sand, reducing beach erosion, whilst improving the clarity of coastal waters, thus the widespread interrelated impacts associated with their loss, due to the connectivity of marine ecosystems. Under this project, the rhizomes or shoots from healthy donor adult seagrass plants would be harvested for subsequent transplanting into the degraded areas.

3. ***Rehabilitation of the Royal Palm Reserve in the Negril Morass*** – the Negril Morass is a 6000-acre protected area that has been impacted by the encroachment of unsanctioned development and farming. The Royal Palm Reserve within the morass was one of the biggest eco-tourism attractions in Jamaica with an expanse of 300 acres. However, the reserve is currently in a state of disrepair. Under this project, the functionalities of the reserve as a tourist attraction would be restored and effectively maintained. The infrastructure (including the boardwalk, observation tower, and museum) would be refurbished. The money gained from tours can go towards paying tour guides from the surrounding communities as well as the upkeep, maintenance and security of the reserve. Partnerships with hotels, schools and corporate Jamaica can help with the promotion of the tours to visitors, locals and students who are interested in bird watching, fishing, and nature walks. Individuals can also use the area as a wedding destination, an area for scientific research, photoshoots, and for company/group retreats. The museum can also host a gift shop that can also generate revenue and promote self-sustainability. Much of this was previously in place but improved management is required for longevity.
4. ***Coral Reef Restoration*** – the coral reefs across the Palisadoes-Port Royal Protected Area are impacted by a combination of natural (hurricanes, warming temperatures) and anthropogenic (improper solid waste disposal, sediment run-off, nutrient outflow) stressors which have overtime caused a significant decline in the ecosystem health. To regain the community of reef building coral species which has been destroyed, this project recommends the in-situ growth of coral fragments across selected reef sites. This will minimize the need to outplant coral. This new approach is expected to have a higher survival rate of corals as they are expected to grow and adapt into the environment. The reef building species grown will also help increase reef rugosity which further increases the wave breaking capacity of reefs, thereby protecting coastal communities and livelihoods.
5. ***Black River Morass Insurance Policy for Storm Protection*** – the protective benefits of mangroves are significantly more valuable than the costs to restore them. This project therefore seeks to establish partnership with insurance companies and the private sector to develop a policy that covers the restoration of mangroves in the Black River Great Morass after a storm event to cover associated damages. The policy would be parametric based (i.e., based on storm intensity and/or the aerial extent of the area impacted). The model would be the product of strategic collaboration between the local government (Forestry Department as stewards of forests in Jamaica), commercial operators, residents, and coastal-based hoteliers. This policy would have a fast injection of cash for mangrove replanting which is an innovative way to leverage the value of nature to pay for its own conservation. Coupled with this, the community would be leveraged to engage in restoration activities. This intends to incentivize the preservation of the mangroves by raising awareness of its value to the surrounding communities. This can be done through partnership with nearby communities and schools (like the Black River Primary and Infant School, Black River High School) through educational initiatives (following the Jamaica Awareness of Mangroves in Nature (JAMIN) model) and Tourism initiatives (possibly work with Black River Safari company to include an educational component about the mangroves in its offering and optional tree replanting in the area).

6. ***Grow 40 by 2030*** – develop a 'green design policy' that encourages the owners of new coastal hotel developments to cultivate and/or preserve at least five hectares of mangroves as a part of its commitment to sustainability efforts. Hotel managers would be tasked with hiring personnel to monitor, maintain and protect the wetland. When the mangrove wetland matures, visitors could be encouraged to bird watch as a part of the hotel's ecotourism offerings.
7. ***Protect the Bight Project*** – build resilience of the mangroves in the Portland Bight Protected Area by incentivizing its preservation. Include the Portland Cottage Women's Group as stewards of the mangrove area, who could work together with CCAM in monitoring and managing the area, thus promoting gender inclusivity in the area of coastal restoration. The Tourism Product and Development Company could be approached to offer mangrove heritage trail tours, bird watching activities as an ecotourism product with residents of Portland Cottage and surrounding communities who could work as paid guides.

A number of areas are in need of intervention and the above projects may be applied to these areas. These include Hellshire Bay, Negril (the Great Morass), Portland (Hope Bay, St Margaret's Bay, Orange Bay), Alligator Pond, Portland Cottage, Savanna-la-mar, Black River, Morant Bay, Manchioneil, Port Maria, Ocho Rios. Of these, Hellshire Bay, the northern Portland coast and Alligator Pond were identified by NEPA as the agency's priority areas in need of intervention.

	Cost / m^3	Cost / linear m	Cost / Hectare
Relevant Interventions	*D2.1 Natural Beach Protection* *D2.2 Beach Nourishment / Recharge* *D2.3 Beach Recycling* *D3.5 Land Reclamation*	*D3.1 Breakwater* *D3.2 Revetments* *D3.3 Seawalls* *D3.4 Groynes* *D3.6 Gabions* *D3.7 Flood Barriers* *D3.8 Levees* *D3.9 Sand Bag Structures*	*D2.4 Beach Vegetation Planting* *D2.5 Coral Reef Restoration* *D2.6 Mangrove Restoration* *D2.7 Seagrass Restoration* *D2.8 Wetland Management*
	≤ US$ 100	≤ US$ 1k	≤ US$ 100k
	US$ 100 - US$ 500	US$ 1k - US$ 5k	US$ 100k – US$ 1m
	≥ US$ 500	≥ US$ 5k	≥ US$ 1m

Figure 5.1: Indicative cost ranges for coastal restoration interventions (Source: Beach Restoration and Coastal Management Guidelines: Further Recommendations for Research for Jamaica, 2017)

5.2.2 Specific Project Idea

A.8. Project size category (total investment, million USD)	Micro (≤10) ☐ Small (10<x≤50) ☒ Medium (50<x≤250) ☐ Large (>250) ☐
A.9. Mitigation / adaptation focus	Mitigation ☐ Adaptation ☐ Cross-cutting ☐

1) Summary of the Idea

a) Project Goal

To develop an insurance policy that covers the restoration of mangroves in the Black River Morass through the public-private partnerships.

b) **Rationale**

Approximately 60% of Jamaica's population reside within 5km of the coastline (STATIN 2011) and 90% of Jamaica's major commercial facilities and towns (banks, tourism centres, port facilities) are located along the coast. This underscores the vulnerable nature of the Jamaican economy and emphasizes the importance of coastal ecosystems in shoreline protection. Mangroves, more specifically protect coastal communities from storm surge, flooding, sea level rise and coastal erosion. They are also critical nursery habitats that help support local fisheries and ecosystem connectivity across coral reefs. Additionally, mangrove forests store huge quantities of carbon, thereby mitigating further greenhouse gas emissions. Despite this, they are among the most threatened due to their undermined value as they are often destroyed to make way for urban development.

The Black River Great Morass is a vital economic resource for over 20,000 people who depend on the ecosystem for farming, fishing and eco-tourism. It is a Ramsar site and is the largest freshwater wetland ecosystem in Jamaica with high biodiversity that includes plants such as the Red, Black and White Mangrove species, Anchovy Pear (Grias cauliflora), Swamp Cabbage (Roystonea princeps) and Bull Thatch (Sabal jamaicensis). At least 150 vertebrate species have also been recorded, including endangered species. Just below 50% of the island's avian species have been identified in the morass including the West Indian Whistling Duck (Dendrocygna arborea). Given its undeniable value, losing these ecosystems and the services they provide will be especially costly to the surrounding Black River community with increased exposure and potential for greater damage and loss during hurricane/storm events. One way to address the issues surrounding the loss of mangrove ecosystems is the establishment of an insurance product that can fund the protection and restoration of mangroves if damaged. Feasibility studies conducted have indicated that post-storm mangrove restoration can be cost-effective, faster and more efficient. However, insuring ecosystems is still a novel venture across the world, but the Latin America and the Caribbean region has already begun paving the way for others to replicate in an effort to conserve our coastal ecosystems. In Jamaica where wetlands are often viewed as a nuisance, such a project will have a dual impact in broadening the understanding of the importance of the Black River Morass to their safety and livelihood.

c) Implementation Narrative

1. *Stakeholder consultation with potential insurance companies that have or are interested in greening their business portfolio by providing climate risk insurance policies (e.g. Grace*

Kennedy Weather Protect Insurance Policy which provides protection to farmers and fisherfolk from adverse weather events, namely intense rain, drought and wind).

2. *Consultation with Forestry Department and environmental conservation organizations with interests in the conservation of the Black River Morass.*
3. *Consultation with surrounding hoteliers and commercial groups that benefit from the existence of the Morass.*
4. *Determine defined area for protection (likely following the designated boundary outlined under the Natural Resources Conservation Authority (NRCA) Act, 1991). The Order designating the Black River Protected Area has received Cabinet approval and is being prepared by the Chief Parliamentary Counsel.*
5. *Estimate restoration costs which will form the basis to calculate the required amount of insurance coverage.*
6. *Determine the most appropriate trigger point for pay-outs*
7. *Identify collaboration partners (i.e. commercial entities whose livelihoods depend on the Black River Morass, community groups, hotels and other private businesses, NGOs)*
8. *Identify purchaser and primary beneficiary of insurance policy*
9. *Use the above information to develop a suitable parametric-based policy (triggered by wind speed over a particular strength and or areal extent of damage) that is ideal for the area. Essentially, the insurance policy would be parametric-based, and pay-outs would be triggered when wind speed of a particular threshold is met or an area of a particular extent is damaged, thus allowing the release of funds for restoration activities into the account of the Department of Forestry (who will serve as the insurance policy holders) within 10 working days after a storm. The pay-out would be used to repair damage to the mangrove. Swift repair of the mangrove ecosystem enables it to recover more quickly, thus providing local communities with more consistent natural protection from coastal flooding and erosion, among other vital services.*
10. *Link with NEPA regulations and permit conditions associate with the construction of commercial and residential property along coastlines. Include having an up-to-date insurance policy be a part of the requirements for renewal of operational licences.*
11. *Establish restoration efforts following the Jamaica Awareness of Mangroves in Nature (JAMIN) model; a community-based approach that engages local residents/students to outplant and restore damaged mangrove areas and monitor. Being apart of the process increases a sense of ownership and the likelihood of protection against anthropogenic degradation.*

2) Climate impact potential

This policy will ensure the quick restoration of damaged mangroves within the Black River Morass, thus improving their resilience as natural barriers to storms and sea level rise. Given the wide range of protection that these mangroves provide, consistent maintenance and restoration would boost their contribution to coastal protection and reduce the risks to residential communities, commercial facilities, infrastructure and livelihoods along the coast.

3) Paradigm shift potential

Once this project has been successfully implemented and lessons learnt have been incorporated, the project can be extended to include other RAMSAR sites. This type of ecosystem insurance can also be applied to protected coastal ecosystems (wetlands and coral reefs) across the islands with payouts going to the organization that is mandated to manage the area. This can help to address shortfalls in areas that have been neglected. Additionally, individual residential homeowners,

schemes, local hoteliers, commercial business operators who live and/or operate directly on the coastline can also find value in such a policy and seek to purchase it to insure the area of mangrove (or other coastal ecosystem like coral reefs) that is directly in line with their property.

4) Sustainable development potential

- *help provide restoration jobs in local communities which could be socially beneficial and have indirect and long-term benefits for ecological recovery*
- *increased awareness of the value of ecosystem,*
- *increased area of mangrove forests overtime which can store huge quantities of carbon thereby mitigating further greenhouse gas emissions*
- *community protection and increased social responsibility*

5) Country ownership

- *National Environment and Planning Agency. Supported by:*
    - *Climate Change Division*
    - *Financial services commission of Jamaica*
    - *Forestry Department*
    - *Individual insurance agencies*
    - *Environmental Foundation of Jamaica*
    - *St. Elizabeth Municipal Corporation*
    - *The Nature Conservancy*
    - *CANARI Caribbean* (training support and capacity building)

The Order designating the Black River Protected Area has received Cabinet approval and is being prepared by the Chief Parliamentary Counsel. Mangrove interventions are guided by the Beach Policy for Jamaica (NEPA, 2000).

6) Type of Finance

Purchasing a mangrove insurance is a cost-effective means of ensuring that mangrove forests within a given area are maintained sufficiently to maximize protection to inland communities from storms. The national (through the Forestry Department) or local government (through the Ministry of Local Government/St. Elizabeth Municipal Corporation) would purchase a single mangrove insurance plan that covers the impact of storm damage. Collaboration through public-private partnerships with businesses that benefit from the Morass will also play a major role in financing the policy. Additionally, considerations would be made for companies that engage in this initiative and contributes to the restoration and/or maintenance of the Black River Morass, in that they would qualify for a reduction in insurance premiums (as an incentive).

7) Risks

- *Limited stakeholder buy-in or lack of interest by potential private sector investors and community members*
- *The uncertainties surrounding the actual cost of restoration post-disaster particularly if there is both mangrove loss and extensive hydrological alteration (like extensive erosion or sedimentation).*

- *It is likely that restoration costs may increase non-linearly with wind speed because of these hydrological/topographical impacts*
- *Delinquencies in payment towards the mangrove policy overtime*
- *Inability to control and predict cumulative stressors*

Part II Technologies for Mitigation

6 Technology Action Plan for the Agriculture Sector

6.1 TAP for the Agriculture Sector

6.1.1 Sector Overview

In Jamaica, the agriculture sector is the second highest contributor to greenhouse gas (GHG) emissions which influence global climate change. In 2012, the sector contributed to 11% (1.6 Mt CO_2e or 4,336 Gg CO_2e) of the total emissions released by all industries and sectors across the island (Aether Consultancy, 2015). Overall, Jamaica's GHG emissions increased by 0.63 $MtCO_2e$ from 1990 to 2013, with an average annual change in total emissions of 0.5%. Average annual change within the agricultural sector was estimated to be −1.6%, indicating a decrease in emissions between that period (IDB, 2017). Sources of GHG in agriculture and the gases released vary mainly between nitrite and methane with nitrite from manure management accounting for 43% of total crop and livestock emissions (Table 6.1). Other major contributions came from nitrite emissions from organic fertilizer and soil leaching.

Table 6.1: Source and Types of GHG emitted from Agriculture in Jamaica with their respective Quantities.

Source and Type of GHG Emitted	Quantity
Synthetic N Fertilizer	35.7 Gg NO_2/year, CO_2e
Organic N Fertilizer	1390.7 Gg NO_2/year, CO_2e
Crop Residues	6.6 Gg NO_2/year, CO_2e
Drained/Managed organic Soils	64.4 Gg NO_2/year, CO_2e
Indirect N_2O Emissions: Soils Deposition	4.1 Gg NO_2/year, CO_2e
Soils Leaching/Runoff	459.5 Gg NO_2/year, CO_2e
Emissions of CO_2 from Lime	0.2 Gg CO_2
Emissions of CO_2 from Urea Application	1.5 Gg CO_2
Emissions of CH_4 from Rice Cultivation	0.2 Gg CH_4/year, CO_2e
Emissions of CH_4 from Field Burning	6.0 Gg CH_4/year, CO_2e
Emissions of N_2O from Field Burning	1.9 Gg NO_2/year, CO_2e
TOTAL	**1970.9 Gg CO_2e**
GHG Emissions from Livestock: Grazing Animals	304.3 Gg NO_2/year, CO_2e
Enteric Fermentation (CH_4)	139.9 Gg CH_4/year, CO_2eq
Manure Management (CH_4)	106.9 Gg CH_4/year, CO_2eq
Manure Management (N_2O)	1613.7 Gg NO_2/year, CO_2e
TOTAL	**2104.5 Gg CO_2e**
TOTAL CROPS AND LIVESTOCK	**4075.4 Gg CO_2e**

Source: (IDB, 2017)

Currently, Jamaica does not monitor its own greenhouse gas emissions and progress to develop a centralised database has been slow due to limited capacity and resources. However, with the establishment of a government operated Climate Change Division, this process is expected to be accelerated.

The relationship between the tourism and agricultural sectors in Jamaica has been long-standing, with a number of large farms being solely reliant on the sector as a market source. Whilst this is typically a desired and mutually beneficial relationship due to the reliability and consistency in food/crop supply and markets, the approach is not sustainable. Downturns in the tourism sector can trigger significant declines in the quantity of goods required. This ripple effect, if prolonged, can lead to reduction in crop production and overall scaling back on farming operations. Nevertheless, there are environmental benefits to be gained in the resultant decrease in emissions that is likely to occur.

6.1.2 Action Plan for Concentrated Solar Power for Small and Medium Sized Farms

Sector	Agriculture
Sub-sector	Energy
Technology	Concentrated Solar Power (CSP) for small and medium sized farms
Ambition	To reduce GHG emissions from the multi-dimensional agricultural sector through implementation of Concentrated Solar Power where there is demand for electricity. CSP systems up to 5 MW may be applicable for large commercial farms with large power demands for water pumping, electrical equipment (e.g., cold storage), conveyors, external security lighting and offices, etc. Due to the cost for the CSP technology focus will be placed on 3 opportunities: • A 100kW CSP Stirling engine system (4 x 25 kWe) at one (1) of the 9 Agro Parks[8]. Agro Parks operate under a cooperative structure with multiple users so power demand within the park boundary will be continuous throughout various crop cycles therefore improving commercial viability of the investment. • 100kW CSP Stirling engine system each at 2 private sector farms in Jamaica. • Potential avoidance of 7 metric tons of CO_2/annum (700 gallons of diesel/annum).
Benefits	The main benefits are the production of clean electricity onsite, reduction of electricity costs and GHG emissions avoidance. The CSP energy can be stored before or while powering a steam generator and therefore can be used either as a flexible provider of electricity, as a "peaker" plant, or as a base load source of electricity similar to a traditional power plant, however, without the GHG emissions.

[8] *An Agro Park is an area of intensive, contiguous, parcel of land for agricultural production which seeks to integrate all facets of the agricultural value chain from pre-production to production, post harvesting and marketing.*

Table 6.1: Detailed Action Plan for Concentrated Solar Power for Small and Medium Sized Farms

Actions		Activities to be implemented	Sources of funding	Responsible body and focal point	Time frame	Risks	Success criteria	Indicators for monitoring of implementation	Budget per activity
1	The Ministry of Industry Commercial, Agriculture and Fisheries (MICAF) should provide the capital costs for the installation and connectivity of Stirling Engines at Agro Parks. Operation and maintenance should be allocated to the Agro Park.	Identify suitable Agro-Parks for the installation of CSP technology.	JEF DBJ	MICAF	2 years	Legal challenges for power distribution Insufficient sources of financing Cost recovery (billing and receivables) mechanism	Installation of 1-100kW CSP at one Agro Park.	Confirmation of financial support from funding sources.	Capital cost of approximately US$950,000 for 3 x 100kW CSP systems.
		Consultations with stakeholders (JPS, OUR, MSET, Agro Parks, etc.) about CSP technology, supply, and distribution.	Ministry of Finance and Public Services					Financial agreements for funding.	The capital cost of CSP is about USD 2,500/kW (but could decrease to USD 1,000/kW in the near future with economies of scale) for options without storage equipment.
		Application for the requisite grid license.						Successful RFP for 100KW CSP at 3 locations and award of contracts.	Construction and planning with generation costs of approximately USD 0.11/kWh without storage.

Actions		Activities to be implemented	Sources of funding	Responsible body and focal point	Time frame	Risks	Success criteria	Indicators for monitoring of implementation	Budget per activity
		Source green financing for the CSP technology.						Approval of licenses and standard offer contract.	Most developers estimate operation and maintenance cost of the CSP plant of USD 0.5-1¢/kWh over a useful product lifetime of 5,000–10,000 hours.
		Procurement process for the CSP technology to be provided to the Agro Parks.						Recovery for electricity supply ($ per kWh).	
2	Private farms should access duty exemptions for renewable technology and apply for the Net Billing Regulations for commercial entities (up to 100kW) to facilitate grid interconnection.	Stakeholder consultation with MOFPS, MICAF, MSET and JCA on the importation of CSP technology and associated accessories.	Commercial Banks IFC DBJ IDB Self-funded	MICAF	2 years	Limited uptake by private farmers due to risk-aversion towards new technologies.	Installation of 100kw CSP at least two private farms	Number of CSP systems imported and given Duty Exemption. Number of CSP systems installed. Number of successful Net Billing license granted to Private Farmers.	-
		Promotion/Consultation with private farmers on the benefits of CSP Technology.							
		Sensitization and provide support to private farmers on the process to apply for net billing.							
3	Utilize stakeholder consultations and capacity development to promote CSP for the agriculture sector.	Plan and execute stakeholder consultation.	MICAF	MICAF	1 year		Execution of 3 CSP consultations	3 main consultations. At least 30% of agro park farmers attendance over	**Consultations to promote awareness of CSP.** Estimated cost: US$20,000 per consultation x 3.

Actions		Activities to be implemented	Sources of funding	Responsible body and focal point	Time frame	Risks	Success criteria	Indicators for monitoring of implementation	Budget per activity
							Execution of 1 CSP Capacity building workshops.	the 3 consultations. At least 5 large private sector farms in attendance over the 3 consultations.	**Training and capacity development for technology application and maintenance** Estimated Cost: US$50,000.
		Plan and execute capacity building workshop.							

6.1.3 Action Plan for Aerobic Biological Treatment (Composting)

Sector	Agriculture
Sub-sector	Soil Management
Technology	Aerobic Biological Treatment (Composting)
Ambition	To allow for an effective system for handling agricultural waste while contributing to the reduction of greenhouse gases from decomposition of the organic matter. Small farmers are already composting in small containers, used barrels and wooden troughs at a subsistence level. It is recommended that at least a 1-acre commercial composting operation be established in each of the 3 counties of Jamaica (Cornwall, Middlesex, and Surrey, i.e., 3 in total) to demonstrate the feasibility of commercial composting and give easier access to visits and observation for interested parties across the island. Agro Parks, with their mixed cropping, could be ideally used as various crops mature at different times, hence the possibility of year-round organic material based on crop cycles. Also, the compost can be utilized at the same location by the farmers, or the excess sold.
Benefits	Waste composting can result in economic, social, and environmental benefits for Jamaica. It can reduce the overall need for waste collection in rural areas which therefore has an impact on economics, and this is generally expensive. The sorting and reuse of bio-degradable waste will mean that waste management authorities can focus more efforts and resources on the management of non-biodegradable waste, therefore contributing to an overall cleaner environment.

	Natural decomposition which takes place under anaerobic conditions results in the emissions of methane gas. Composting however, results in the emissions of carbon dioxide instead of methane. Carbon dioxide is thirty times less potent as a greenhouse gas than methane. Therefore, composting contributes overall to climate change mitigation Additionally, the use of compost as a 'fertilizer' in the agriculture sector has additional benefits, particularly the reduction in the use of chemical fertilizers which contribute to GHG emissions.

Table 6.2: Detailed Action Plan for Aerobic Biological Treatment (Composting)

	Actions	Activities to be implemented	Sources of funding	Responsible body and focal point	Time frame	Risks	Success criteria	Indicators for monitoring of implementation	Budget per activity
1	Ministry of Agriculture and Fisheries, and Ministry of Industry, Investment and Commerce (and their respective agencies) should develop a strategy/policy and capacity building for compositing focused sustainable land management and waste management for the agriculture sector. The policy/strategy should focus on reduced use of chemical fertilization, reduce importation of inorganic fertilizers	Plan and execute promotion campaign for composting.	MICAF RADA	MICAF RADA	1.5 years	Low interest due to limited financial expectations	10% increase application/ use of composting among farmers	Number of composting promotional events (road show, advertisement, etc).	**National campaign to demonstrate, promote and encourage composting within the agricultural sector.** Estimated cost: US$100,000.

	Actions	Activities to be implemented	Sources of funding	Responsible body and focal point	Time frame	Risks	Success criteria	Indicators for monitoring of implementation	Budget per activity
	and to increase soil health.								
2	Bureau of Standards should establish standards for composted materials to enable incremental pricing for products of the technology and for access to export markets.	Bureau of Standards (BSJ) to develop composting standards through their approved process.	MOFPS FAO BSJ MSET	BSJ MSET MICAF	1.5 year	Lack of financing to support the technology.	Development of Composting Standards	Progress on the BSJ process for developing standards.	**Standards Development by BSJ:** US$35,000
		BSJ to promote composting standards to the agriculture sector and other stakeholders. NCRA to regulate and enforce standard.				High cost for testing and certification for compliance may deter farmers from implementing or use of the technology			**Promotion of Composting Standards to Agriculture Sector and other Stakeholders:** Estimated Cost: US$20,000.
3	Establish commercial (large-scale) composting demonstration site at an Agro Park. This can also be done through PPP.	Develop commercial model for composting site. Determine suitable location for composting site.	FAO IICA JEF MOFPS MICAF	MICAF RADA	2 years	Short- to medium-term financial viability (high operational cost, low financial returns).	Establishment of commercial composting demonstration site.	Development of commercial model within 6 months. Selection of suitable site within 3 months.	**Setup of large-scale composting demonstration sites across Jamaica.** • US$254,358 per ha for site preparation and construction.

Actions		Activities to be implemented	Sources of funding	Responsible body and focal point	Time frame	Risks	Success criteria	Indicators for monitoring of implementation	Budget per activity
		Acquire and setup equipment/ location for composting.	RADA			Vagaries of the agricultural sector affecting feedstock supply	Positive ROI for commercial composting.	Acquisition and setup of equipment at composting site within 1 year. Coordination of logistics and composting through three crop cycles.	• US$850,000 to 1.5 M per ha for mechanization/equipment.
		Coordination of logistics for composting	DBJ					Quantity of compost utilized on farms or sold to market.	
4	Utilize stakeholder consultations and capacity development to train farmers/composters and promote aerobic biological treatment for the agriculture sector.	Development of content and training material for capacity building exercise for farmers.	IICA CARDI MICAF FAO	RADA MICAF	9 months	Farmers may lack interest in the use of composting.	3 major capacity building exercise (1 in each county)	Development of Training content and material. Promotion and advertising of the capacity building exercises.	**Development of content and training material (including necessary stakeholder consultations).** Estimated cost: US$15,000 for consultant.
		Execution of capacity building sessions for farmers.				Farmers may be unwilling to commit time to learning the technology.		Implementation of the 3-capacity building session.	**Training and capacity building exercise for aerobic biological treatment application.** Estimated Cost: US$20,000 for each capacity building exercise.
5	Secure green financing for loans and grants to reduce initial capital costs. Utilize special low interest	Development of financial product for loans specific to composting.	DBJ JBA	MFPS MICAF	1 year	Unfavourable terms for debt financing. Small farmers may be averse to debt financing.	Development of the loan facility. Uptake of the loan facility.	Development of the loan facility. Uptake of the loan facility.	

Actions	Activities to be implemented	Sources of funding	Responsible body and focal point	Time frame	Risks	Success criteria	Indicators for monitoring of implementation	Budget per activity
rates from the Development Bank of Jamaica to finance project.	Promotion of loan facility for composting to farmers.				Small farmers may not have the resources and documentation required for accessing loan facility.			

6.2 Project Ideas for the Agriculture Sector

6.2.1 Brief Summary of the Project Ideas

Aerobic Biological Treatment (Composting) – The agricultural sector generates large volumes of underutilised and valuable waste which are often disposed untreated. The unutilised wastes accumulate and decompose in anaerobic conditions in the environment, releasing methane (30 times more potent than CO_2 as a GHG). Where wastes are high in nitrogen and decompose anaerobically in moist conditions, nitrous oxide (N_2O) (>300 times more potent than CO_2) is also produced in the decomposition process.

This practice therefore does not maximise environmental and economic values of climate change mitigation, reduction, recycling and monetizing wastes.

Small scale subsistence composting efforts are inefficient, inconsistent in outcomes, not commercially viable and time and labour intensive therefore not attractive for farmers, however composting can produce positive gains as demonstrated in other jurisdictions.

This project will therefore entail the following: :

1. **Climate change mitigation** – can be achieved by reducing the production of methane and nitrous oxide through a commercially controlled decomposition process of mixing and aeration for the agricultural wastes, which reduces the emissions of GHGs and fixes carbon in complex organic molecules (compost) which can then be sold as natural fertilizers and soil ameliorant. Success of the project will ultimately result in scaled up operations island wide, increased mitigation of GHG production.
2. **Augmentation of agricultural income streams** – when a large-scale agricultural technology elevates composting to a scale of operation, mechanisation and commercialization which is new and profitable (for Jamaica). Compost is proven internationally as a valuable organic fertilizer and soil ameliorant in the green agriculture and health commodity markets. Commercial composting operations will produce economic volumes and add value and revenue to the core agricultural endeavour from predictable local sale and export of organic compost for a green and health-conscious market. As a value-added benefit, local eco-tourism markets, cottage industries and SMEs in the health sector would benefit from marketing organically grown produce.
3. **Agricultural waste management** – can be improved as historically organic wastes from the sugar, coffee and citrus sectors have adversely impacted waterways and land, in addition to the GHG emissions, due to improper disposal of plant wastes. Commercial composting will avoid land-based and environmental impacts through the recycling of carbon and nitrogen rich wastes into a marketable commercial product.
4. **Inter-governmental cooperation** - as various Ministries Departments and Agencies (MDA) of government including agriculture, commerce, solid waste management, hospitality, standards and compliance and local government have in isolation, encouraged small scale composting, however the focus has been on solid waste management and organic farming at subsistence scales. Corporation within the agroparks, and support of the various MDAs will create synergies and efficiencies in the national efforts to improve livelihoods and macro-economic growth while achieving climate change ambitions.

Specific Project Idea

The proposed technology is **Aerobic Biological Treatment (Composting)** for the agricultural sector.

A.8. Project size category (total investment, million USD)	Micro (≤10) ☒ Small (10<x≤50) ☐ Medium (50<x≤250) ☐ Large (>250) ☐
A.9. Mitigation / adaptation focus	Mitigation ☒ Adaptation ☐ Cross-cutting ☐

1) Summary of the Idea

a) Project Goal:
The utilisation of aerobic bio digestion (composting) technology on three (3) small 1-acre commercial agro-farms as models for commercial composting, and to reduce the emission of greenhouse gases (methane in particular) from the decomposition of organic matter.

b) Rationale
Small farmers are already composting in small containers at a subsistence level, for own-consumption, as there are no mandatory market standards, lucrative market appetite, or funding to expand to commercial scales of composting.

By establishing successful visible and accessible models of commercial composting operations the project will;

- *Provide sensitization and training to farmers regarding the commercial potentials for composting.*
- *Prove to the Government of Jamaica (GoJ), the rationale for developing quality standards for uptake of the organic compost in the local and export markets.*
- *Provide data for the GoJ to include composting as a suitable technology for GHG mitigation in the agriculture sector, and for inclusion in the National Determined Contributions for the mitigation of climate change.*
- *Provide a sustainable and commercial outlet for reuse of existing agricultural wastes instead of disposal and contribution to GHG emissions.*

c) Implementation Narrative
For implementation, the following actions will be required:

i. *The Ministry of Industry Commerce Agriculture and Fisheries (MICAF) and their respective agencies should develop a strategy/policy to support composting as a sustainable land management and waste management strategy. The strategy/policy will also signal the Government's short and long-term goals, stimulating market confidence for foreign direct investments, green financing and private sector investments.*
ii. *The Bureau of Standards Jamaica should establish standards for compost materials to enable incremental pricing for products of the technology and for access to export markets.*
iii. *Secure green financing for loans and grants to reduce initial capital costs. Utilize special low interest rates from the Development Bank of Jamaica to finance the project.*
iv. *Establish the commercial (large-scale) composting demonstration sites at three (3) Agro Parks in a public private partnership arrangement.*

v. *Utilize stakeholder consultations, and training institutions for capacity development to train farmers/composters and promote aerobic biological treatment for the agriculture sector.*

2) Climate Impact Potential

Current decomposition of agricultural wastes under anaerobic conditions results in the emissions of methane gas. Composting will result in the emissions of carbon dioxide instead of methane, the former which is thirty times less potent as a greenhouse gas than methane. Therefore, composting contributes overall to climate change mitigation.

The anticipated reduction of methane will be a factor of;

- *Composition and volumes of farm wastes.*
- *Baseline for current methane emissions.*
- *Specific methodology for composting operations (i.e., mechanical, manual, mixed) and retention days).*
- *Composting temperatures are specific farm locations (e.g., cooler humid high elevations vs warmer dryer lower elevations).*

Regarding adaptation benefits, the target group of small farmers (1-acre) are vulnerable and dependent on natural rainfall, so have unpredictable income levels. Reduced rainfall and droughts in particular, adversely affect their livelihoods, however the use of compost can improve soil water retention and may buffer crop losses in drier periods.

Compost is a soil ameliorant so improves overall soil ecosystem health and nutrients in areas where dry weather due to climate change has contributed to top soil loss and saline intrusion. Also, compost will reduce the cost required for inorganic fertilizer required for production.

As a marketable commodity, compost will provide an additional income stream, thus improving the farmer's revenue stream.

3) Paradigm Shift Potential

The proposed technology is suitable for a sustainable shift towards the continued use of composting as it is scaled to satisfy small farmers, however larger farmers can scale up the model for commercialization.

With GoJ policy and support, capacity development and a successful project commercial outcome the project can be self-sustaining in a competitive market setting.

4) Sustainable Development Potential

Besides the climate change mitigation (and adaptation) benefits, over time, a compost market will also;

- *Improve quality of food production.*
- *Encourage the current trajectory of more healthy diets (e.g., low salt, low sugar etc), and specifically to eat more 'organically grown' foods as per eco-tourism cottage industry, and for export.*
- *Improve overall farming techniques.*

- *Support green practices (reduce, reuse, recycle) in the agricultural sector.*

The project success may have unintended negative effects on the livestock sector where farms export plant-based wastes to small farmers to supplement livestock feed.

5) Country Ownership

Whereas the GoJ does not have a formal policy for developing a compost industry, it has enunciated the interest and commitment for utilizing composting as a waste management option for the sanitation and agricultural sector. The intent has been expressed in discrete capacity building events with the support of international development agencies such as Institute for International Corporation in Agriculture (IICA) and the Food and Agriculture Organisation (FAO), through the National Solid Waste Management Authority (NSWMA) and in interagency collaborations.

It is expected that MICAF will be the lead agent of the State.

This project could consolidate, structure and advance the Government's policy intentions above.

6) Type of Finance

In general, the project finance would have two main components:

- *Soft costs related to policy development, standards development, promotions, and capacity development of approximately US$190,000.*
- *Capital and other project costs to establish and operate the model sites of approximately US$1.8 M.*

Approximately 80% of the projected soft costs will be initially expended within the first year of the project, and the remainder of approximately 20% at the close of the project. Capital costs would be utilised for operations over a 2-year period to establish the 3 composting sites and for their operations over at least 2 crop cycles. The composting locations would be commissioned within 6 months of the GoJ policy and standards development.

Project income may be marginal within the 2 years of operation as revenues may be limited while the market appetite develops and also as the learning curve at the composting locations may require reinjection of the revenues to sustain the project.

It will be critical to secure green financing for partial loans, and grants to reduce initial capital costs. The project will utilize special low interest rates from the Development Bank of Jamaica to finance project.

7) Risks

Since the project will depend on transfers and accumulation of farm waste to produce a commercial mass, there may be logistical challenges for consistent delivery of feedstock and at the volumes required per each composting stage.

The process will require sustaining some moisture and therefore droughts during the project period may affect production of the compost. Conversely, excessive rainfall (storms and hurricanes) could threaten production.

Successful development of a formal national strategy/policy and standards will be critical for ascribing value and price to the compost produced. Without these the product will not be competitive against inorganic fertilizers or imported compost materials.

If the above-mentioned outcomes are not achieved it may be difficult to encourage large farms and agro-parks with smaller farms to adopt and sustain the technology, hence subsistence composting activities could continue.

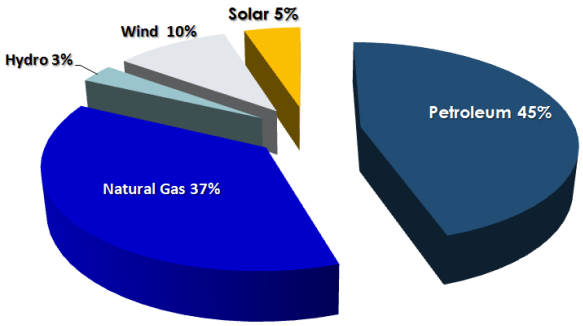
7 Technology Action Plan for the Energy Sector

7.1 TAP for the Energy Sector

7.1.1 Sector Overview

Jamaica is a net importer of fossil fuel energy resources principally for electricity, heat and transport applications. From Jamaica's overall energy balance in 2019, imported fossil sources contributed 24,859 kBOE (91%) for which approximately 83.6% of the fossil sources were from crude oil and derivatives, 12.7% from natural gas and 3.7% from coal. Local renewable energy sources contributed 2,046 kBOE (9%), being primarily biomass sources (85.2%), wind (8.5%), hydro (4.8%) and solar (1.5%).

Transportation was the largest energy consumer at 45% (primarily fossil sources), manufacturing at 35% (bauxite being dominant at 26%), residential at 10%, followed by commercial and other activities at 9%[9]. In the transformation sector, electricity generation, transmission, distribution and losses consumed over 5,000 kBOE (20.5%) of all energy resources, both imported fossil fuel and local renewables, for all sectors. A further breakdown of types of energy resources in the generation subsector indicates that the electricity grid is supplied by petroleum (45%), natural gas (37%) and renewables (18%), which include solar, wind and hydropower (Figure 7.1)



Source: MSET Sectoral Presentation, 2019

Figure 7.1: Installed Electricity Capacity in Jamaica by 2020

The high proportion of old (>30 years) and inefficient fossil-based plants directly and adversely influences Jamaica's high GHG emission levels. Electricity and heat generation alone contributes over 70% of Jamaica's total emissions over multiple years. Against this background, Jamaica's Third National Communication (TNC) under the United Nations Framework Convention on Climate Change (UNFCCC) indicates that Jamaica's GHGs are significant compared to other small states. In 2013, Jamaica's total GHG emissions were 10.3 Mt CO2e, amounting to 0.02% of global GHG emissions (USAID, n.d.) and the main sources of harmful emissions were from the combustion of fossil fuels from the electricity sector, transportation, and the industrial sector. The aluminium/bauxite industry, in particular, is responsible for the high energy intensity in Jamaica being comparable on that of most developing countries. This is reflected in the country's carbon emissions statistics.

[9] Source: Ministry of Science, Energy & Technology, Energy Division, Energy Economics & Planning Unit, May 2021.

Emissions data show that the energy sector in particular is responsible for over 86% of CO_2 emissions released into the atmosphere, with the remainder coming from land use changes that remove trees and other vegetation (National Policy for the Trading of Carbon Credits 2010–2030 – Proposed Strategic Framework, October 2010). In a BAU scenario, Jamaica will generate emissions of 14.5 Mt (CO_2e) in 2030, however, with interventions, Quantified Emission Targets with Unconditional Contributions, Jamaica is expected to achieve emissions of 13.4 Mt (CO_2e), a 7.8% improvement on reduction from the BAU 2030 scenario. With international support in regard to the Quantified Emission Targets with Conditional Contributions, Jamaica is expected to achieve a 10% improvement on reduction in emissions below the BAU 2030 scenario of 13.0 Mt (CO_2e) (Figure 7.2).

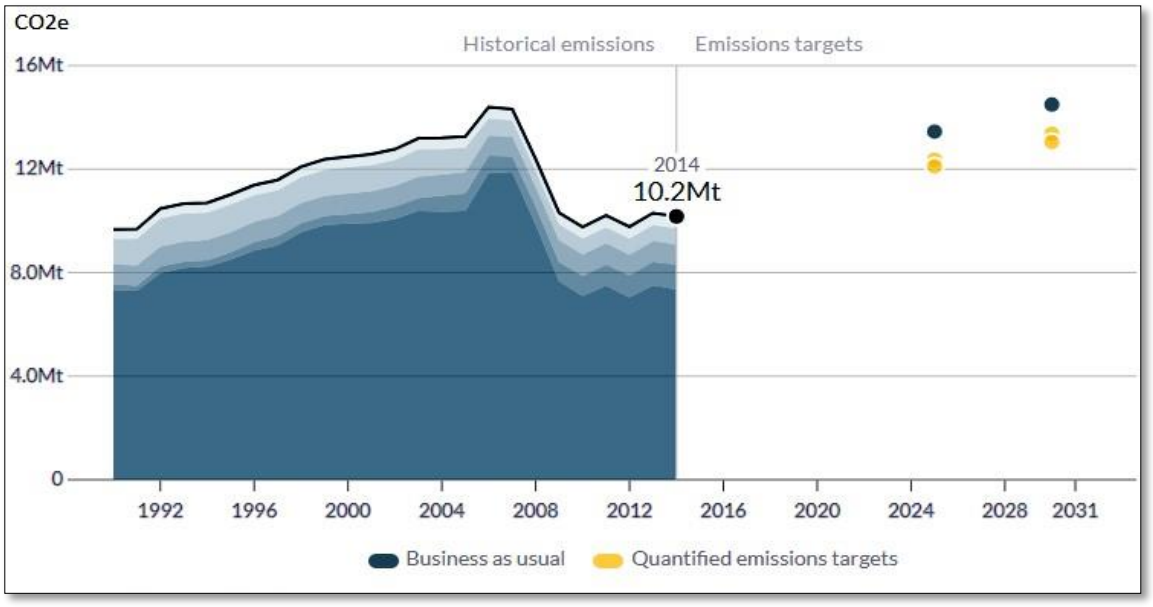


Figure 7.2: GHG emissions and emissions targets (Climate Watch, 2019)

The success of the Nationally Determined Contributions (NDCs) Table 7.1) is predicated on the level of implementation of the National Energy Policy, the Climate Change Policy Framework and the existing pipeline of renewable energy projects under the IRP since at this time Jamaica does not have climate change-related laws to drive actions.

Table 7.1: Jamaica's Nationally Determined Contribution Targets

Year	BAU	NDC (unconditional) (7.8% reduction)	NDC (conditional on international support) (10% reduction)
2025	13,443 kT CO_{2e}	12,370 kT CO_{2e}	12,099 kT CO_{2e}
2030	14,401 kT CO_{2e} (5.1 metric tonnes CO_2 per person)	13,368 kT CO_{2e} (1.1 million metric tonnes of CO_2 per year or 4.7 metric tonnes CO_2 per person)	13,043 kT CO_{2e}

The Integrated Resource Plan (IRP) will be critical for including 32% of electricity generation from renewables by 2030 and approximately 49% from renewables by 2037 with the commensurate reduction in CO_2 emissions to 2030. This is in keeping with the Office of the Prime Minister's mandate to increase renewables in the energy mix from 20% to a more ambitious target of 50% by 2030. Besides more than 200 MW wind, solar and hydropower generation currently on the grid, new generation under the IRP will include solar, wind, hydroelectric, biomass and waste to energy for the first time.

7.1.2 Action Plan for Refuse Derived Fuel (Waste-to-Energy)

Sector	Energy
Sub-sector	Waste-to-Energy
Technology	Refuse Derived Fuel (Waste-to-Energy)
Ambition	One (1) power 10 MW plant at a waste facility is proposed for this mitigation technology, producing lower GHG emissions than a typical fossil fuel plant. RDF/WTE will be included in the next generation Request for Proposals (RFP) based on the 2019 Integrated Resource Plan.
Benefits	Reduction of vermin and improvement of health locations by reducing breeding environment. Reduce pollution to waterways and the marine environment. Production of useful clean energy Reduction in GHG emissions (to be determined from updated and detailed waste characterization studies at the project location).

Table 7.2: Detailed Action Plan for Refuse Derived Fuel (Waste-to-Energy)

Actions		Activities to be implemented	Sources of funding	Responsible body and focal point	Time frame	Risks	Success criteria	Indicators for monitoring of implementation	Budget per activity
1	The Ministry of Science Energy and Technology should successfully execute procurement for WTE technology under the existing IRP and energy policy.	Preparation of public procurement documents for WTE and publishing RFP. Negotiate for agreement with successful bidder for commissioning of WTE.	MFPS MSET	Generation Procurement Entity (GPE) MSET OUR	3 years	Low number of responding bids for WTE. Terms for procurement may be deemed unfavourable. Resolution of lead national agency for bids.	Successful bid for WTE.	Announcement of the procurement within 1 year. Selection of preferred bidder and successful negotiation with bidder within 1.5 years. WTE plant commissioned within 3 years.	US$35,000 for procurement exercise.

Actions		Activities to be implemented	Sources of funding	Responsible body and focal point	Time frame	Risks	Success criteria	Indicators for monitoring of implementation	Budget per activity
2	Government of Jamaica to create enabling environment to promote uptake of the technology. This may include: • Concessional land lease for the life of technology (20 – 25 years). • Duty, tax, and other benefits for clean energy technology.	Development and implementation of suitable terms and conditions.	MFPS MSET US Government	MFPS MSET NSWMA	9 months	Intra-governmental agreement for the jurisdiction/authority for WTE terms and conditions	Establish responsible authority for WTE. Designation of plant location at acceptable cost. Defined and promulgated incentives.	Development of suitable terms and conditions within 9 months. Lead agency for WTE approvals affirmed with 5 months.	-
3	Secure green financing for loans and grants to reduce initial capital costs. Inclusive of opportunities for financing PPP. Reassign tipping fees charged to waste haulers (both public	Engage local and international financiers to secure green financing.	MOFPS DBJ GEF IFC IDB CABEF CDB JBA	MOFPS DBJ NSWMA	1.5 yrs.	Global focus on RE and low carbon technologies may reduce available funding. Insufficient funding. Resistance of NSWMA to allow tipping fees to be reassigned.	Adequate funding secures.	Secure financier within 1 year. Terms and conditions for funding, financing portfolios and financing framework confirmed in 1.5 years. Adequate financing to cover state share of debt.	US$15,000 Tipping fees range US$52 - 110/ton dependent on jurisdiction. Maintenance costs approximate 5 – 10% of CAPEX annually.

Actions		Activities to be implemented	Sources of funding	Responsible body and focal point	Time frame	Risks	Success criteria	Indicators for monitoring of implementation	Budget per activity
	and private); and sales of scrap metals or other recyclable materials sorted from feedstock to RDF generators to offset operating costs.	Develop green financing portfolios/framework/instruments for channelling funding.							
4	Government to deliver sensitization seminars on the technology to generate interest in the financial sector and private sector organizations (e.g., Jamaica Chamber of Commerce, and Private Sector Organization of Jamaica, other).	Develop financial and scientific technology briefings (research). Logistical and administrative preparation for and delivery of events. Collaboration with PSOs to deliver events.	MSET MOFPS DBJ USAID IDB	MSET	9 months	PSO and investor fatigue from bidding past experiences leading to low participation.	70% attendance of prospective local and international investor.	Delivery of 2 well attended seminars within 1 year (virtual or face-to-face).	US$40,000 (US$20,000 grants) for research, consultancies and 2 events.
		Solicit support from reputable international development partners to provide evidence or desktop analysis of WTE successes globally and with applications for the Jamaican context.				Attractiveness of less complex grid-integrated generation technologies.	Various forms of EOI for future participation in RFP.	Preliminary EOIs from a minimum of 2 participants within 2 months from the sensitization events.	
5	Ensure clear government policy directives in support of WTE technology, consistent with	Review of National Energy Policy and IRP and confirm WTE goals and strategies. Publicly re-enforce Government WTE goals and strategies.	MSET	MSET	6 months	None.	Publicizing GoJ goals and strategies in all media and forums.	Public statements and announcements of WTE goals and strategies.	

Actions		Activities to be implemented	Sources of funding	Responsible body and focal point	Time frame	Risks	Success criteria	Indicators for monitoring of implementation	Budget per activity
	the *Energy from Waste Draft* sub-Policy 2010 – 2030 and IRP implementation scenario for REN technologies including WTE in 2023.								
6	Educate decision-makers on environmental accounting principles, macro-economic, social, socio-economic and environmental benefits of WTE.	Development of information package for media and sensitization events.	MSET MOFPS	MSET	6 months	None	Information packages developed; information shared during events.	2 educational/ sensitization events within 3 months. 1 public/private sector education workshop on WTE technology within 6 months.	Education campaign = US$15,000.

7.1.3 Action Plan for Biogas

Sector	Energy
Sub-sector	Waste to Energy
Technology	Biogas (Anaerobic Biodigestion)
Ambition	At least one (1) medium commercial scale biodigester facility producing electricity and secondary or tertiary stage treated water for irrigation, is being targeted as a catalyst for development at other sewerage sites island wide. A system this scale could be tested at any of the nearly 100 sewerage (wastewater) treatment plants operated by the National Water Commission Island wide. The largest single sewerage treatment plant is in Greater Portmore (18,180 m^3/day).

	The proposed system should receive approximately 100,000 – 200,000 m^3 of wastewater/annum, with potential to generate enough biogas for power generation of approximately 4,000 MWh_e/annum[10]. A system such as this has the potential to save 2,500t CO_{2e}/annum. A continuous digester may be best suited for sewage operations, where the organic material can be constantly or regularly fed into the enclosed digester. Of special interest for immediate intervention would be the Soapberry Wastewater Treatment Plant (SWTP) and associated sewerage infrastructure (i.e., Pumping Stations and Transmission mains), for which NWC has an 85% shareholding, and is now required to expand its current treatment capacity from 75,000 m^3/day to 150,000 m^3/day, in order to meet the medium-term requirement for treatment of wastewater collected by NWC in the Kingston Metropolitan Area (KMA). In the expansion, it is envisaged that the output from SWTP be reused for agricultural purposes to offset the current use of potable water sourced from the Rio Cobre. Electricity will also be produced to offset high electricity costs for pumping (majority of which are electrical motors island-wide). Irrigation water will provide an additional revenue source for economic viability. It is mandated that in privatization, the SWTP should have the climate change mitigation and adaptation designs via new technologies and renewable energy solutions.
Benefits	The technology avoids the emission of methane as the fuel is combusted for heat or electricity. Several economic development benefits arise from the energy production of the technology. National energy self-sufficiency is increased due to the local energy production. This also would reduce Jamaica's dependency on other countries for fossil fuel imports, which in turn would lead to an improved economic balance sheet of the country and a higher level of energy security. Large amounts of animal waste can create serious environmental concerns. When animal manure enters rivers, streams or groundwater supplies it can have environmentally detrimental effects. In addition, decomposing manure causes air quality concerns associated with ammonia emissions, and the contribution of methane emissions to global climate change. The implementation of an anaerobic digestion offers a number of air and water quality benefits. Digester systems isolate and destroy disease causing organisms that might otherwise enter surface waters and pose a risk to animal and human health. Moreover, anaerobic digesters help protect ground water. Synthetic liners provide a high level of groundwater protection for manure management systems (EPA, 2002). The concrete or steel in plug flow and complete mix digesters also effectively prevent untreated manure from reaching the ground water. Biological treatment of waste, such as composting and anaerobic digestion reduces volume of waste and therefore the lowers landfill requirements. Recycling of the residual solids as fertilizer further reduces waste volume. Climate change mitigation benefits of this technology is the prevention of methane emissions associated with conventional manure management practices. In addition, the energy produced by the biogas facility offsets energy derived from fossil fuels. Therefore, anaerobic digesters with a biogas recovery system can help reduce overall quantities of CO_2.

[10]Bio-engineering Installations - HoSt Holding B.V. 2020. https://www.host.nl/en/biogas-plants/sludge-biogas-plants/?gclid=CjwKCAiArIH_BRB2EiwALfbH1NadycAC4sewP7buB0XA3_lgfd4Wqh4vjYGlSEaTx5cc3E8KN8bZixoCe5EQAvD_BwE

Table 7.3: Detailed Action Plan for Biogas

Actions		Activities to be implemented	Sources of funding	Responsible body and focal point	Time frame	Risks	Success criteria	Indicators for monitoring of implementation	Budget per activity
1	Incorporation of the technology into the Government Procurement Plans to achieve climate change and renewable energy goals.	Develop technology briefing for procurement. Develop RFP documents for procurement.	MOFPS	Parent Ministry MEGJC	9 months	Lower priority versus competing lower cost and proven RE technologies. Cultural barriers to the use of products from recycled human waste.	1 successful bid process. Contract (s) for wastewater offtake.	Procurement documents ready for bid process in 1.5 years. 1 preferred bidder and agreement for development of technology (private or PPP) in 2nd year) Contract(s) for treated water offtake in 2nd year.	Internal costs of Procuring Entity, advertising and negotiation meetings. estimated at US$ $20,000.
2	Application for permit/licenses to generate electricity and provide irrigation water (utility and/or PPP).	Application to relevant government ministry(ies) for permits/ licenses.	Parent Ministry (OPM)??	Parent Ministry MEGJC MSET NIC	1 year	Protracted delays	Power generation license. Irrigation license.	Applications for generation and irrigation licenses in 3 months. Power generation license in 1 year. Irrigation license in 1 year.	
3	Application of Environmental Accounting and traditional accounting methodologies to compare BAU fossil fuel energy sources, versus exploitation of	Secure expertise in environmental economics for analysis of the technology. Conduct analysis to inform procurement and other decision-making activities.	Parent Ministry (OPM)?? MOPFS	Parent Ministry MEGJC	4 months		Report on economic feasibility of technology.	Report on economic feasibility of technology within 6 months.	Consultancy estimated at US$ 15,000

Actions		Activities to be implemented	Sources of funding	Responsible body and focal point	Time frame	Risks	Success criteria	Indicators for monitoring of implementation	Budget per activity
	this renewable energy source.	Engage key stakeholder consultations.						2 Stakeholder consultations in 3 months.	
4	Empower national agencies as the leads for government PPP representatives to facilitate the technology development.	Capacity development for lead agencies. Framework for lead agencies to operate.	Parent Ministry MEGJC		6 months	None.	Capacity development sessions.	2 capacity development sessions for lead agency(ies) in months 2 and 6.	
5	Develop short-term incentives enable importation of equipment as with renewable energy source with similar incentives; and for power generation (if power is exported).	Develop short term category for incentives (duty/ taxes/electricity tariffs other) for WTE renewable energy technology options.	MOFPS	Parent ministry MEGJC JCA OUR MSET MOFPS	1 year	Government is currently averse to additional incentive schemes.	Portfolio of incentives.	Portfolio of incentives within 1 year.	Internal budget.
		Develop PPA or Power Wheeling Agreement if power is to be exported or wheeled on the grid.		JPS.		Next tariff review in 2025 may be late for technology implementation. Also, Power Wheeling implementation has been stalled in negotiations of financial terms.	PPA or Wheeling contract with utility.	PPA or Wheeling contract with utility in 2nd year.	

Actions		Activities to be implemented	Sources of funding	Responsible body and focal point	Time frame	Risks	Success criteria	Indicators for monitoring of implementation	Budget per activity
6	Access development grants and green financing for PPP initiative.	Application for grant funding from international development agencies, inclusive of project proposal.	IDB UNDP GEF UNFCCC ????	MSET MOFPS PIOJ MEGJC	9 Months	Window, categories, and allocations for call for proposals.	Approval of grant funding.	Development of project proposal in 3 months. Completed application for grant funding in 6 months. Final negotiations and disbursement in 1 year.	Consulting fee for project proposal development US$20,000. Administrative costs US$5,000
		Engage negotiations/discussions for financing.							

7.2 Project Ideas for the Energy Sector

7.2.1 Brief Summary of the Project Ideas

Biogas Waste to Energy – The NWC is the single largest consumer of electricity among government agencies and is in need of options for reducing its electricity costs to become more self-sustainable. Water scarcity is threatening farm productivity and viability as climate change occurs, so additional sources of water are needed to sustain existing farms and additional agricultural endeavours. Additionally, in the capital city of Kingston there has been an increase in the construction of apartments and townhouses. As the demand for wastewater treatment increases with densification of urban residential and commercial spaces, there will be greater need to treat more wastewater. NWC is also actively centralizing wastewater treatment in preference to absorption pits which can have an adverse impact on ground water resources. As such, the main aim of this project would be to implement one (1) medium commercial scale biodigester facility to produce electricity, and also secondary or tertiary stage treated water for irrigation, located at a large sewerage facility of the National Water Commission (NWC). Furthermore, the technology will assist in additional wastewater disposal while producing the energy required to meet high energy demands for pumping and treatment. Wastewater which decomposes anaerobically, produces methane (CH_4) which is 30 times more potent as a GHG relative to carbon dioxide (CO_2). The proposed system would receive approximately 100,000 – 200,000 m^3 of wastewater/annum, with potential to generate enough biogas (>60% CH_4) for power generation of approximately 4,000 MWh_e/annum. A system such as this has the potential to save 2,500t CO_{2e}/annum. Power generation from biogas also reduces the demand for increasing the importation of fossil fuels for generation expansion and therefore also reduces the production of CO_2 from fossil sources. An additional benefit of the project is the production of tertiary treated discharge water suitable for irrigation. This facilitates adaptation to future periods of droughts and water scarcity which adversely impacts the agricultural sector in particular.

7.2.2 Specific Project Idea

The proposed technology is **Refuse Derived Fuel (Waste-to-Energy)** for the energy sector.

A.8. Project size category (total investment, million USD)	Micro (≤10) ☐ Small (10<x≤50) ☒ Medium (50<x≤250) ☐ Large (>250) ☐
A.9. Mitigation / adaptation focus	Mitigation ☒ Adaptation ☐ Cross-cutting ☐

1) **Summary of the Idea**
   a) **Project Goal**:
   Implement one (1) 10 MW waste to energy (WTE) power plant at a waste facility for power generation, disposal/destruction of solid waste and mitigation of GHG emissions in the electricity sector.

b) **Rationale**:

Jamaica has a growing challenge for effective disposal of commercial and domestic wastes. Other challenges at the waste disposal sites include spontaneous fires, ground water pollution and an annually increasing footprint as waste collections increase.

Also, from 2018 – 2037 over 1,600 MW of new or replacement generation will be required on the national grid. Solid waste to energy provides an excellent nexus technology in response to both needs. For that reason, the integrated resource plan (IRP) 2018 (revised 2020) allocates 74 MW for new generation from hydro, WTE or biomass.

Barriers to the technology include;

- *Resistance by environmental lobby.*
- *The need to provide a comprehensive national solid waste management strategy/policy inclusive of WTE.*
- *Collaboration/coordination of various ministries, departments and agencies of government regarding the energy resources, disposal strategy, funding and leadership pertaining to WTE and waste disposal.*
- *Funding for WTE projects.*

The project would be a catalyst for the Government of Jamaica (GoJ) to create an enabling environment in terms of strategy, legislation and procurement procedure to promote the uptake of the technology. Through a transparent procurement process for WTE, external investments will come from local private sector or foreign direct investments (FDI) on a build, own and operate (BOO) basis.

c) Implementation Narrative

Waste to energy project implementation will require State collaboration, creation of an enabling environment and attracting investment. The critical activities needed are as follows:

i. *The Government to conduct a comprehensive and up to date evaluation of the solid waste disposal sector and waste characterisation analysis to determine the technical feasibility for WTE generation. Support from reputable international development partners may be needed to conduct the evaluation and analysis.*
ii. *The Government to create an enabling environment to promote confidence in the electricity market for uptake of the technology, including;*
    - *Developing a comprehensive national solid waste management strategy inclusive of WTE for disposal.*
    - *Ensure there are clear government policy directives in support of WTE technology, consistent with the Energy from Waste Draft sub-Policy 2010 – 2030 or revised energy policy thereof, and in support of the IRP implementation scenario for REN technologies including WTE in 2023.*

- *Providing a concessional land lease at the waste disposal sites if required, for the life of the technology (20 – 25 years).*
- *Provision of duty, tax, and other benefits for implementation of the technology.*

iii. *Encourage innovative financing suitable for WTE inclusive of the following;*
- *Secure low interest green financing for loans and/or grants to reduce initial capital costs to investors.*
- *Develop a framework for public private partnership as a capital financing mechanism.*
- *Reassign tipping fees charged to waste haulers (both public and private) to RDF generators to offset WTE operating costs, and allow the sales of scrap metals or other recyclable materials sorted from feedstock as additional operational revenue.*

iv. *The Ministry of Science Energy and Technology should prepare and execute procurement for WTE technology under the existing IRP implementation schedule and the current or revised energy policy.*

v. *Overcome objections to the technology with strategies such as the following;*
- *Sensitization workshops/seminars on the technology to generate interest in the financial sector and private sector organizations for investment (e.g., Jamaica Chamber of Commerce, and Private Sector Organization of Jamaica, Jamaica Bankers Association, other).*
- *Special sensitization workshops/seminars with environmental associations, social activist groups, academia, and non-governmental organisations on the merits of the technology to address Jamaica's environmental and energy challenges.*
- *Educate decision-makers on environmental accounting principles, macro-economic, social, socio-economic and environmental benefits of WTE.*

2) Climate Impact Potential

The project will reduce GHG emission by avoiding the increase of fossil fuel importation for power generation and the concomitant emissions. While combustion of solid wastes will release some GHG the quantum will be reduced relative to fossil fuels.

An efficient WTE facility will also reduce the volume of organic materials which would decompose naturally and release methane, which is 30 times more potent as a GHG than carbon dioxide (CO_2) from combustion. Currently, landfill gas is responsible for some of the annual spontaneous fires at waste facilities.

Modern WTE plants include high temperature incineration and waste flue gas emissions controls, therefore lowering the CO_2 equivalent released per MWh of energy.

The reduction in GHG emissions is to be determined from updated and detailed waste characterization studies for a specified project location (to be determined).

3) Paradigm Shift Potential

Jamaica has had 2 unsuccessful efforts for implementation of WTE projects. This project proposes to address two main causes for failure, challenging financial requirements and lack of an enabling environment to engender confidence in the electricity sector for investments.

Jamaica will benefit from 1 to 2 small scale WTE plants for the long-term energy mix. Small WTE power plants are preferred in order to maximise the available solid waste, without a need to depend on cofiring using fossil fuels.

The establishment and successful operation of the first project in the south-east of Jamaica, as in this project proposal, will enable a second WTE plant for either central or western areas of Jamaica which also have solid waste management issues and increasing electricity demand.

Project(s) will be implemented as commercial BOO from private sector investments, foreign direct investment or PPP. Procurement will be done according to international standards as has been done for past renewable energy RFPs, and interconnection with the national grid will follow the national electricity codes and legislation for IPPS, hence will not require continuing international financial support.

4) Sustainable Development Potential

The project will have critical and sustainable benefits including:

- *Social and health benefits by reducing vermin and disease vectors and reducing air pollution from occasional fires.*
- *Reduction of pollution to waterways and the marine environment due to leachates and surface runoff.*
- *Elevation of living standards as persons accessing the waste facilities will have an opportunity for gaining transferable skills and reduced exposure to health and safety risks in a controlled and regulated environment.*
- *Continuity (or improvements) in livelihood activities related to recyclable materials which cannot be combusted (e.g. scrap metals).*

There may be some livelihood changes including the possible unavailability of traditional recycling of materials such as cloths, plastics and tires. Possibly also some persons cannot be upskilled and there may be some resulting unemployment. The Government will have to consider training persons for alternative livelihoods.

5) Country Ownership

The main government ministry is to be determined, however in the past an inter-ministerial council was formed to address WTE, composed of local government, environment, and energy ministries.

A lead ministry will have to be determined and a national solid waste strategy/policy developed.

6) Type of Finance

The project finances may be estimated at > US$100,000 exclusive of the actual capital cost for the technology[11].

Over a period of 9 – 12 months up to 50% of this amount will be used to conduct a detailed waste characterisation study on the waste sector, develop the enabling environment for procurement including review of existing energy policy and the IRP and developing a national solid waste strategy/policy, initiate procurement preparation and any legislative or regulatory amendments, and finally securing innovative financing.

The remainder of project funds are to be used for stakeholder consultations, publicity campaigns and research throughout that 9 – 12 month period.

Funding will need to be a mixture of grant funds and state co-financing. If a PPP is to be developed, then a low interest loan may be required.

7) Risks

The development the enabling environment to create confidence in the electricity sector to invest in the technology will be critical for project success. The availability of fiscal incentives to lower capital costs and the tipping fee for operations will also be critical for investors to commit to a project.

In the past the lack of clear leadership between the government ministries for a WTE project adversely affected the advancement of this technology even though there was general interest from local and overseas private sector. This clarity will be important for project success.

There are now competing commercial and non-commercial interests in disposal of plastics and tyres which could reduce the energy value and volumes of feedstock for a successful WTE project. This may be a project risk, to be determined by the comprehensive evaluation of the solid waste disposal sector and waste characterisation analysis.

Once successfully implemented, the project will - with high probability - continue for its estimated lifetime, unless future solid waste management strategies cause an increase in the need for

[11] Capital cost >US$25 M will be secured from investors in the technology for a BOO procurement mechanism.

cofiring with fossil fuels or if the energy policy mandates significant shifts in the energy mix which make the WTE plant non-viable.

8 Cross-cutting Issues

Cross cutting Issues identified in the TNA Process for Jamaica relate primarily to adaptation and mitigation in the Agriculture and Water sectors. Sustainability of water supply for irrigation is an increasing challenge given the exacerbation triggered by climate change parameters on an already stressed situation of water resource availability. The technologies recommended have considerable synergies that could be pulled together in an integrated climate smart project that would incorporate demonstration effect for small farmers, as well as application of new approaches to water harvesting, optimisation of energy demand, and efficient distribution.

9 Conclusion and Next Steps

This document presents the Technology Action Plan (TAP), for the Adaptation and Mitigation Technologies selected for Jamaica in the areas of Agriculture, Water, Coastal Resources and Energy. The TAP represents the third stage of the Technology Needs Assessment (TNA) process highlighting Objective 3, which is to develop the Technology Action Plans (TAPs) specifying activities and enabling frameworks to overcome the barriers and facilitate the transfer, adoption, and diffusion of selected technologies in the participating countries. It follows the Technology needs identification and prioritization of potential climate change adaptation and mitigation technologies and the Barrier Analysis and Enabling Framework assessment of those prioritized technologies.

All proposed projects will require a combination of hardware (solar infrastructure, tanks, pumps piping etc) software (automation, programmes etc) for access to operating technology and the incorporation of the orgware[12] elements of consultation, sensitization, capacity building and training.

The proposed projects fall into various technology market categories. Predominantly adaptation projects such as Drip and Sub-canopy Sprinkler Irrigation, and the use of rainwater harvesting in the agriculture sector which would be accessed by farmers as a commodity from retail suppliers as consumer goods; while a related community-based water project in the water sector such as Community Scale Rainwater Harvesting Systems or repair of Minor Water Tank Networks for Communities would be publicly provided goods, supplied (at least initially) through the State. Likewise coastal protection adaptation projects which equitably benefit citizens and the environment would also be publicly provided goods. Mitigation projects in the agricultural sector such as Concentrated Solar Power, and proposed projects in the energy sector

[12] Hardware referring to capital infrastructure, materials and equipment; software referring to technology and interface; and orgware referring to organizational and human behavioural perspectives.

such as Waste to Energy and Biogas generation would be implemented as capital goods, requiring state interventions to support private sector or as a PPP venture, due to their high capital costs but overall benefit for society. Mitigation in the agricultural sector using Composting would be implemented as a consumer good if undertaken at commercial farms, but could also be a capital good if undertaken using the state agropark infrastructure.

The proposed projects include the main selected sectors under the TNA – agriculture, water, coastal resources and energy.

The agriculture sector is the second highest contributor to greenhouse gas (GHG) emissions and is also severely challenged by climate related impacts each year. The projects identified therefore under the TAP have been associated with water use, efficiency and storage (drip irrigation and sub-canopy sprinklers, and rainwater harvesting and storage) for climate change adaptation and the use of renewable energy technology (solar PV) for climate change mitigation.

As an adaptation strategy, the agricultural sector can benefit from water management technologies to reduce water consumption in line with projections of more frequent and severe dry periods, without compromising the water supply for quality crop yields. These technologies identified include drip and sub-canopy /micro sprinkler irrigation systems linked to solar pumping using smart sensor technologies and automation. Additional adaptation features for projected projects include water storage and management provided mainly by rainwater harvesting and storage infrastructure to overcome prolonged droughts. The agricultural sector will also benefit from mitigation strategies, primarily in the form of solar photovoltaic electricity generation for water pumping/circulation. This strategy will avoid the use of fossil fuels on site for pumping, but also reduce the energy demand from the grid which is primarily supplied using fossil fuel plants.

Regarding the water sector, Jamaica is primarily dependent on groundwater for potable water and also irrigation. These do not represent sustainable consumption options. Therefore, the recommended adaptation (Community Rainwater Harvesting and Storage, and installation of Minor Water Tank Restoration) and mitigation (solar water pumping) projects will assist the sector to adapt to future drought which will exacerbate the existing challenges of water stress and reduced water access. In rural areas in particular, there is also the problem of inconsistent water supply or lack of distribution infrastructure, which negatively impacts local communities and business operations. The project recommendations therefore capitalizes on rainwater harvesting and storage technologies, particularly for rural communities, but will also be suitable for agricultural sites and urban areas. Such projects are aligned with various national policies, plans and strategies. Whether restoring dilapidated community tank networks or installing new community-scale rainwater harvesting and storage systems, the proposed projects will increase harvesting of water resources, reduce over-exploitation of ground water and provide water resources more consistently to communities as an adaptive strategy to climate change. Initial external financing of these systems will be critical as it is a capital good which is unaffordable by individual community residents.

As a small and exposed island, Jamaica's coastal resources play multiple significant roles for its economic, social and environmental sustainability and productivity. Climate change has however caused several coastal and marine challenges which now pose a major threat (and likely to become more severe) to coastal and marine ecosystems, and traditional livelihoods. While Jamaica has generally sought to employ various hard engineering techniques, the need for more soft approaches such as restoration and protection of mangrove, seagrass and coral reef ecosystems and coastal protection has had mixed success. The suggested TAP adaptation projects therefore focus on soft approaches which utilise local knowledge and expertise, native species and are more inclusive of the affected communities. Projects have been recommended for protected areas with special economic and environmental value such as coral reef restoration for the Palisadoes-Port Royal protected area, which hosts one of two international airports, a heritage site, an isolated community and fisheries; Black River Morass insurance policy for storm protection, an important source of water purification, biodiversity, ecotourism, fisheries and coastline protection; and protection of the Portland Bight project with economic and environmental values in fisheries, heritage tourism and ecotourism strong community**.**

Jamaica is a net importer of fossil fuel energy resources (91% of the energy mix) principally for electricity, heat and transport applications and the electricity and heat generation alone contributes over 70% of Jamaica's total emissions. The electricity sector is powered primarily from a high proportion of old and inefficient fossil-based plants which adversely influences Jamaica's high GHG emission levels. Local renewable energy sources contribute only 9% of the total energy mix, being primarily biomass, wind, hydro and solar.

The proposed projects are therefore well aligned with Jamaica's National Energy Policy, Third National Communication (TNC), Nationally Determined Contributions (NDCs) and Integrated Resource Plan (IRP) to reduce fossil fuel use. The policy is to increase electricity generation from renewables to 30% by 2030 and approximately 49% from renewables by 2037 with the commensurate reduction in CO_2 emissions by 2030. The proposed mitigation projects targets under-utilized energy resources for electricity in the energy sector (WTE), water sector (biogas) and agricultural sector (composting) for GHG emissions avoidance.

The TNA is critical for these projects to advance and achieve Jamaica's climate change adaptation and mitigation ambitions. Not only are the selected projects not being implemented under current initiatives, but they also would harness benefits in viable niche areas which would otherwise remain untapped. The intervention of the TNA promotes a deviation from the business-as-usual conditions, providing a framework for overcoming existing financial constraints, lack of experience or prior successes with useful innovative technologies and other barriers that stifle green growth in the prioritised sectors. Thus, the TNA acts as a stepping stone for the prioritised sectors and have set a precedence for all productive sectors in the Jamaican economy.

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Appendix I

Consultations completed during the BAEF and TAP exercises

	Name	Organization
Cross Sector		
1	Dr. Theresa Rodrigues	Climate Change Specialist
2	Mrs. Annmarie Goulbourne	Social and Gender Specialist
3	Allison Ramgolam	EFJ
4	Daniel Kitson	JSIF
5	Leanne Roper	CCD
Agricultural Sector		
1	Dr. Gregory Robin	CARDI
2	Annabell Williams	Livestock Farmer Pig Farmers' Association
3	Marianna Young	RADA
4	Everton Parks	Livestock Farmer/ Jamaica Dairy Development Board
5	Janet Lawrence	Consultant
6	Mr. Milton Henry	National Irrigation Commission
Water Resources		
1	Monique Morris	NEPA
2	Desmond Wellington	WRA
3	Ian Gage	ESL
4	Natalia Reid	Rural Water Supply Ltd.
5	Leanne Spence	Instant Save Conservation Solutions
6	Milton Henry	National Irrigation Commission
Coastal Resources		

1	Danielle Nembhard	Marine Ecologist
2	Gabrielle-Jae Watson	NEPA
3	Pierre Diaz	Sea Control Oceanography
4	Dr. David Smith	Smith Warner International
5	Dr. Andrew Ross	Consultant
6	Simone Lee	Environmental Consultant
7	Yohan Rampair	TEF
8	Dr. Camillo Trench	Discovery Bay Marine Laboratory
9	Anthony McKenzie	NEPA
10	Monique Curtis	NEPA
11	Dr. Mona Webber	Centre for Marine Science, UWI
12	Ana Eurice Ebanks Chin	The Nature Conservancy
Energy Sector		
1	Michelle Chin Lenn	Wigton Wind Farm Ltd
2	Horace Buckley	Ministry of Science Energy and Technology
3	Kirk Abbott	Saddle Energy
4	Dionne Nugent	JPS