Government of Belize

Technology Action Plan for Climate Change Adaptation and Mitigation

FINAL REPORT

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Technology Needs Assessment

Climate Change Adaptation & Mitigation

Technology Action Plan

National Climate Change Office

Ministry of Agriculture, Fisheries, Forestry, the Environment, Sustainable Development and Immigration

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FOREWORD

The 2018 summer of fire and swelter looks a lot like the future that scientists have been warning about in the era of climate change, and its revealing in real time how unprepared much of the world remains for life on a hotter planet (Sengupta, August 9, 2018).

It is unequivocal that the earth's climate is warming, and the effects are being felt around the globe, especially among the most vulnerable countries that lack the resources and improved technology to adapt to the changes.

Research and development on improved technologies, diffusion, accessibility, and deployment is critical for the international response to climate change. It is imperative, therefore, that barriers to the acquisition, uptake and use of development technologies to enhance resilience and reduce emissions, in the productive sector especially, are eased or removed, so that such technologies can be procured and put to beneficial use.

The TNA process that culminates with this TAP and subsequent implementation of specific technologies, is a positive step in the right direction to help address the challenges posed by climate change in Belize. As was highlighted in the Adaptation and Mitigation TNA reports and the Barrier Analysis and Enabling Framework assessment, the vulnerable sectors identified by stakeholders and policymakers were: Energy, Transport, Land-Use Change and Forestry, Agriculture, Water and the Coastal and Marine sector. Taken together, these sectors contribute significantly to Belize's GDP and provide jobs and livelihood security for thousands of Belizean workers and families countrywide.

Belize's national policy framework is now focused on strategically transitioning to a low-carbon development pathway, while strengthening the country's resilience to the impacts of Climate Change. To this end, Belize submitted its first Nationally Determined Contribution under the UNFCCC in April 2016 which outlines targeted actions to be implemented in order to address Climate Change. The Technology Action Plan under the TNA process is yet another strategic mechanism that develops project concepts and project ideas for implementation, given that financing for these can be identified and successfully procured.

It is with much optimism, therefore, that Belize supports the effort of the UNFCCC and the Technology Executive Committee (TEC) to provide an effective means for the international community to agree upon how climate-friendly technologies can be further developed, transferred, deployed and disseminated in an equitable and business-friendly manner.

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Chemical Species

CO_2	carbon dioxide
CH_4	methane
N_2O	nitrous oxide

Units of Measure

Gg	giga grams
kW	kilowatt
MW	mega watt

Abbreviations

AC	Alternating current
APEB	Association of Professional Engineers of Belize
ASR	American Sugar Refining Limited
BA	Barrier Analysis
BAEF	Barrier Analysis and Enabling Framework
BAHA	Belize Agricultural Health Authority
BBS	Belize Bureau of Standards
BEL	Belize Electricity Limited
PHB	Public Health Bureau
BLPA	Belize Livestock Producers Association
CARDI	Caribbean Agriculture Research and Development Institute
CCCCC	Caribbean Community Climate Change Centre
CDB	Caribbean Development Bank
CFE	Federal Commission of Electricity (acronym in Spanish)
CRDU	Crop Research and Development Unit
CSA	Climate Smart Agriculture
CZMAI	Coastal Zone Management Authority and Institute
DC	Direct current
DFC	Development Finance Corporation
DOE	Department of the Environment
DOT	Department of Transport
DRR	Disaster Risk Reduction
DRM	Disaster Risk Management
DTU	Technical University of Denmark
ESIA	Environmental & Social Impact Assessment
EU	European Union
EWS	Early Warning System
FAO	Food and Agriculture Organization
FD	Forest Department
FNC	First National Communication
GCF	Green Climate Fund
GDP	Gross Domestic Product
GEF	Global Environmental Facility
GHG	Greenhouse gas
GIS	Geographic Information System
GOB	Government of Belize
Ha	Hectares
IDB	Inter-American Development Bank
IMF	International Monetary Fund
INC	Initial National Communication
IPCC	Inter-Governmental Panel on Climate Change
ITVET	Institute for Technical and Vocational Education and Training
LCDS	Low Carbon Development Strategy
LPG	Liquefied Petroleum Gas
ITVET	Institute for Technical and Vocational Education and Training
MAFFESDI (MOA)	Ministry of Agriculture, Forestry, Fisheries, Environment, Sustainable Development and Immigration
MLLGRD	Ministry of Labour, Local Government and Rural Development
MESTPU	Ministry of Energy, Science & Technology, and Public Utilities
MOF	Ministry of Finance
MOH	Ministry of Health
MOEDC	Ministry of Economic Development and Commerce
NAMAS	Nationally Appropriate Mitigation Actions
NAS	National Adaptation Strategy
NCCC	National Climate Change Committee
NCCO	National Climate Change Office
NDC	Nationally Determined Contributions
NIWRA	National Integrated Water Resources Authority
PACT	Protected Areas Conservation Trust
PV	Photovoltaic
PH	Public Health
PHB	Public Health Bureau
PR	Public Relations
PUC	Public Utilities Commission
RE	Renewable Energy
RWS	Rudimentary Water System
TAP	Technology Action Plan
TNA	Technology Needs Assessment
SIB	Statistical Institute of Belize
SIF	Social Investment Fund
SUV	Sports utility vehicle
USD	American dollar
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
VED	Vehicle Emission Duty
INC	Initial National Communication
WB	World Bank

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Glossary of Terms

Actions	Actions are those measures, which are taken into the TAP through a process of consultation and analysis
Activities	Specific tasks or 'sub-actions' needed to realize an action.
Adaptation	Short for 'climate change adaptation'. An adjustment in the natural or human systems in response to actual or expected climatic stimuli or their effects, which moderate harm or exploit beneficial opportunities (IPCC, 2007). Adaptation is considered a process, not an outcome.
Barrier	Obstruction or impediment that impedes technology transfer; a reason why a target is adversely affected, including any failed or missing countermeasures that could or should have prevented the undesired effect(s).
Biomass	The total mass of living organisms in a given area or of a given species, usually expressed as dry weight. Organic matter consisting of, or recently derived from, living organisms (especially regarded as fuel), excluding peat. Biomass includes products, by-products, and waste derived from such material.
Carbon dioxide	Naturally occurring greenhouse gas, and a by-product of burning fossil fuels or biomass, of land-use changes and of industrial processes. It is the principal anthropogenic greenhouse gas that affects Earth's radiative balance. It is the reference gas against which other greenhouse gases are measured and therefore it has a Global Warming Potential of one.
Climate Change	Climate change refers to a change in the state of the climate that can be identified (e.g., by using statistical tests) by changes in the mean and /or variability of its properties, and that persist for an extended period, typically decades or longer. Climate change may be due to natural internal processes or external forcing, or to persistent anthropogenic changes in the composition of the atmosphere or in land use.
Diffusion	The process by which a technology is spread or disseminated through various channels over time in a society, where the technology is gradually adopted by more and more members of the society (people, institutions, companies, etc.).
Enabling Framework	The set of resources and conditions within which the technology and the target beneficiaries operate. The resources and conditions that are generated by structures and institutions that are beyond the immediate control of the beneficiaries should support and improve the quality and efficiency of the transfer and diffusion of technologies.
Energy	The amount of work or heat delivered. Energy is classified in a variety of types and becomes useful to human ends when it flows from one place to another or is converted from one type to another. Primary energy or energy sources is the energy embodied in natural resources (e.g. coal,

	crude oil, natural gas, uranium) that has not undergone any anthropogenic conversion. Primary energy is transformed into secondary energy by cleaning (natural gas), refining (oil into oil products) or by conversion into electricity or heat. Final energy is secondary energy delivered at the end-use facilities (e.g., electricity at the wall outlet), where it becomes usable energy (e.g. light).
Fertigation	The injection of fertilizers, soil amendments, water amendments and other water-soluble products into an irrigation system.
Land-use	The total of arrangements, activities and inputs undertaken in a certain land-cover type (a set of human actions). The social and economic purposes for which land is managed (e.g., grazing, timber extraction, and conservation). Land-use change occurs when, e.g., forest is converted to agricultural land or to urban areas.
Measures	Measures are technologies, processes, and practices that reduce GHG emissions below anticipated future levels. Examples of measures are renewable energy technologies, waste minimization processes and public transport commuting practices etc. Measures can also be factors (financial or non-financial) that enable or motivate a particular course of action or behavioural change or is a reason for preferring one choice over the alternate. Often the word 'incentive' is used synonymously, sometimes with a slightly different interpretation.
Micro Hydro	Installations with power output of 5 – 100 kW (usually provides power for a small community or rural industry in remote areas away from the grid).
Mitigation	Action to decrease the concentration of greenhouse gasses, either by reducing their sources or by increasing their sinks.
Programme	A programme includes a series of projects with an overarching set of objectives to attain the identified overall ambition for the programme.
Project idea	A project idea presents concrete 'actions' as a project concept note, as a means to deliver the overall ambition indicated in the TAP. A project idea should be formulated so that it can be read and understood as a stand-alone document.
Reforestation	Direct human-induced conversion of non-forested land to forested land through planting, seeding and/or the human-induced promotion of natural seed sources, on land that was previously forested but converted to non-forested land.
Renewable Energy	Renewable energy is energy that is collected from renewable resources, which are naturally replenished on a human timescale, such as sunlight, biomass, wind, rain, tides, waves and geothermal heat.
Silviculture	The practice of controlling the establishment, growth, composition, health, and quality of forests to meet diverse needs and values.

Stakeholder	A person, group, organization or system that affects or can be affected by an organization's actions.
Sustainability	The ability to meet the current needs while considering the carrying capacity of the Earth's supporting eco-systems without compromising the ability of future generations to meet their own needs.
TAP	A Technology Action Plan (TAP) is a concise plan for the transfer and diffusion of prioritised technologies that will contribute to a country's social, environmental and economic development and to climate change adaptation and mitigation. A TAP comprises of numerous specific Actions. Often the TAP is technology-specific, but it can also cover a portfolio of technologies where the same set of Actions benefit all technologies.
Technology	Technology is a piece of equipment, technique, practical knowledge or skill for performing a particular activity. It is common to distinguish between three different elements of technology: the tangible aspect such as equipment and products (hardware); the know-how, experience and practices (software) associated with the production and use of the hardware; and the institutional framework, or organization, involved in the transfer and diffusion of a new piece of equipment or product (orgware).
Technology Transfer	Technology transfer involves vertical technology transfer, whereby transfer is understood as the movement of technologies from the research and development (R&D) stage to the commercialization, and horizontal transfer, which involves the spatial relocation or diffusion of technologies across space.

Executive Summary

The country of Belize is one of 26 participating countries in Phase II of the Technology Needs Assessment (TNA) project, which was proposed in the Strategic Programme on Technology Transfer approved by the GEF in 2008. The TNA as a process, aims to assist developing country parties to the UNFCCC determine their technology priorities, for mitigation of greenhouse gas emissions and adaptation to climate change. The TNA project is being implemented by the United Nations Environmental Programme (UNEP), and executed by a UNEP-Technical University of Denmark (UNEP-DTU) Partnership, on behalf of the Global Environment Facility (GEF).

The National Climate Change Office (NCCO) of Belize is coordinating the TNA Project and a National TNA Steering Committee, comprising of members of the Belize National Climate Change Committee, oversees the implementation of the project. A National Consultant has been recruited to provide technical assistance to the Belize TNA process.

In fulfilling some of its obligations as a signatory to the United Nations Framework Convention on Climate Change (UNFCCC), Belize has moved to develop policies, strategies, and plans that address climate change in the development sectors. The policy framework has evolved to address both mitigation and adaptation to climate change. Some of the key instruments supporting actions to reduce the effects of climate change are: The National Adaptation Strategy and Action Plan to address Climate Change in the Water Sector in Belize (CCCCC, 2010); The National Integrated Water Resource Management Policy (including Climate Change) for Belize (GOB, 2008); The National Integrated Water Resources Act (GOB, 2010); The National Agriculture and Food Policy 2015-2030 (GOB-FAO, 2015); The National Sustainable Tourism Master Plan 2030 (GOB, 2012); The National Climate Change Policy, Strategy and Action Plan 2015 – 2020, (GOB,2015); Horizon 2030 (GOB, 2010); The Growth and Sustainable Development Strategy 2016-2019 (GOB, 2015); The National Agenda for Sustainable Development (GOB, 2015); Belize's Third National Communication to the United Nations Framework Convention on Climate Change (GOB, 2016); Belize Nationally Determined Contribution under the UNFCCC (GOB-NCCO, 2016); Belize Sustainable Energy Action Plan 2014-2033 (GOB-MESTPU, 2015); The National Energy Policy Framework 2014-2030 (GOB, 2014) and the regional strategy, 'Delivering Transformational Change 2011-2021: Implementing the CARICOM "Regional Framework for Achieving Development Resilient to Climate Change" ', (CARICOM-CCCCC, 2012), among others.

The Technology Action Plan (TAP) is the third and final stage of the TNA process. It is a strategic tool for individual country party for the implementation of prioritized technologies and Project Idea Notes, at the desired scale to help achieve the climate and development benefits identified earlier through the TNA process. A TAP is built upon the measures identified earlier in the process of selection and prioritization of technologies in vulnerable sectors, and the analysis of barriers and identification of an enabling framework for the smooth transfer and diffusion of said technologies. In other words, the TAP serves as the bridge or 'keystone' between TNA analysis and technology implementation.

The measures or actions in a TAP can take different forms. These can be technology demonstration projects, with the objective of overcoming public animosity and familiarizing stakeholders of the many benefits such technologies can bring; or technical training of personnel, such as technicians and engineers, to overcome barriers related to the lack of local skills or weak institutional capacity, to establish, operate and manage specific and complex technologies such as a cool storage facility for grains, a micro-hydroelectricity facility, or micro-propagation of plant material. Another action could be aimed at overcoming indirect barrier(s) to technology diffusion, with co-benefits such as improved infrastructure or institutional capacity, for example, a marine monitoring network for provision of an early warning system for fishers and other coastal zone interests.

This final report provides a Technology Action Plan (TAP) for the prioritized technologies analysed during the Technology Needs Assessment (TNA) process conducted in Belize. The aim of the TAP is to facilitate the successful diffusion of the prioritised technologies for climate change adaptation and mitigation. Six adaptation technologies were prioritised and considered in the TAP, and included: four in Agriculture, and one each in the Water and Coastal/Marine sectors. Concurrently, five mitigation technologies were prioritised and further considered in the TAP, including: two in the Energy sector, two in the Transportation sector, and one in the Land Use/Agroforestry sector.

The TAP proposes key actions, related activities, costs and some constraints or risks that may hamper the diffusion of the prioritized technologies analysed earlier in the TNA process, and briefly evaluates some cost-effective and practical project ideas related in one way or the other with these technologies.

Successful technology transfer requires participation and building on indigenous knowledge. Social, economic and environmental indicators, which are clearly selected and measurable, should reveal if goals and objectives are being achieved or were achieved. While hardware has taken centre stage in activities and interventions to reduce greenhouse gas emissions, processes and institutions are central to building capacity and resilience to the impacts of climate change.

This Report comprises of two parts, namely; Part I: TAP for Adaptation Technologies; and Part II: TAP for Mitigation Technologies.

Actions and activities were proposed for each of the prioritized technologies base on the results of the Barrier Analysis and Enabling Framework synthesis. Risks were evaluated for each of the activities outlined based on the recommendations from the guidelines for preparing a TAP (TEC, 2016). Risks associated with activities for technology transfer fall under three categories, namely: costs risks (CR), scheduling risks (SR), performance risks (PR).

In this Report, activity risks were further evaluated using a Risk Index table based on the likelihood of the risks occurring, and its significance. See Table I-1 in Annex I for a summary of the 'activity' risk assessment considered for the TAP. Risk indices scoring '15' or greater were further evaluated for contingency action and estimated costs. Estimated costs were also allocated to other activities and the procurement of the technology itself, for example, the current average market price for installation of one kilowatt of micro-hydroelectric power.

Part I: TAP for Climate Change Adaptation Technologies

In the Agricultural sector the prioritized technologies considered in this TAP are: i) Heat and Drought resistant varieties of open-pollinating corn and beans seeds for reproduction and marketing by four farmers' cooperatives; ii) Improved drip irrigation systems for five farming groups using rainwater harvesting and fertigation for crop nutrient requirement; iii) Establishing an in-country Irish potato clean-stock production unit to produce quality seed-tuber planting material varieties; and iv) Rehabilitation of Seven Protective Covered Structure Cooling Systems.

The technology for the Water sector is: i) Implementation of Water Safety Plans for Strategic Management of Eight Rudimentary Water Systems; and for the Coastal Zone and Marine Ecosystem sector the prioritized technology is: i) Establishing a coastal and marine Environmental Monitoring Network and Early Warning System.

Project Ideas in Adaptation to Climate Change

Four adaptation project ideas are proposed for this TAP. These include:

1) *Enhance the cultivation of climate resilient varieties of open pollinated corn and beans among small and medium-scale farmers*

The technology for improved grain production in Belize is at the top of the MOA's list of crops being promoted in its short and medium term strategic plan to ensure food safety and livelihood security for small farmers and farming communities in Belize (R. Thompson, Project Officer, personal communication, September 2017).

Objective: i) To support the production of corn and beans among rural producers for food security and income generation;

Expected outputs: Increased yields of climate resilient, open pollinated 'quality' corn and beans per season/year, higher sales and profits to the four grain-producing farmer's groups or cooperatives, and incremental yields and profit margins for small farmers participating in the 'quality' grain production programme.

Costs and benefits: The initial cost for this intervention for grain production among four 'quality' seed production groups will be: US$224,804.00. The over-arching benefit is to improve the in-country stock of climate resilient grain varieties and enhance the food and livelihood security of small farmers.

2) *In-country micropropagation, field testing and marketing of 'quality', climate resilient varieties of Irish potato seed tubers*

Bio-technology advances in plant micropropagation is considered for replication of climate resilient varieties of Irish Potato breeder seed tubers. This will enable an increase in national potato production by extending the potato cropping season, and by expanding Irish potato cultivation into other areas where climatic conditions are too warm for cultivating potato using varieties currently available. This will not only reduce the need to import potatoes to supply the national consumer markets, but it will

also save on foreign exchange by eliminating the annual requirement to import expensive, foreign-sourced, seed-tuber planting material.

Objective: i) To supply in-country, 'quality', climate resilient varieties of Irish potato seed-tubers to the local market through an improved bio-technology micropropagation facility at the University of Belize, School of Agriculture.

Costs and benefits: Preliminary estimated initial cost for establishing a production line for Irish potato micropropagation tuber seeds supply at the country level is in the range of US$141,300, which includes institutional strengthening of the plant micropropagation laboratory. The benefits will range from improved Irish potato seed varieties for an expanded growing season, reduction in foreign exchange loss, and enhance food and livelihood security for potato farmers and their communities. The full cycle of initial micropropagation of climate resilient varieties of Irish potato seed-tuber to testing and reproduction in the nurseries, to seed-tuber material for planting is three to four years.

3) *Sustainable soil and land management in Agriculture and Agroforestry in the Greater Belize River Watershed*

Soil conservation and soil fertility are critical for sustainable and eco-friendly agriculture and other land use activities. The target area for this project idea is the Greater Belize River, that has seen an accelerated and unregulated expansion in mechanized, mono-cropping agriculture over the past decade and significant landscape degradation. Almost 22% of the landmass in the Belize River Watershed is under some form of agricultural land use. In 2016 alone, 4,044 hectares or 9,993 acres were put into agriculture use. In the absence of a soil conservation strategy and action plan, the impacts of such intense land use change are: increased release of agrochemicals and other pollutants into surface and groundwater resources, loss of the riparian forest buffer, increased sedimentation and land degradation, and decreased soil fertility.

The project will consist of three main components or actions: i) Development of a strategy and practical field guidelines and work-plan for soil management; ii) Soil testing, soil conservation practices, and soil and water quality monitoring; and iii) Public awareness and capacity building for technicians and farmers in integrated soil conservation. Soil & water quality monitoring will require specialized monitoring equipment.

Objective: i) To introduce a practical soil management strategy for cost-effective good practices in soil conservation and monitoring to improve soil stability and fertility among medium and large farmers in the GBRW.

Costs and benefits: The estimated cost of this intervention is US$520,000, with US$45,000 for operational cost for 3 years. The expected benefits are: i) Improved soil quality and land use good practice to increase land value and crop yields; ii) Introduction of sustainable land management practices; iii) Improved soil and water quality monitoring; and iv) Enhanced eco-friendly and smart agriculture in the watershed.

4) *Establishment of an improved monitoring network and Early Warning System for Belize's Coastal Zone to increase resilience to climate change*

The past three decades have seen rapid economic development and population growth within the coastal zone of Belize. Consequently, this has led to increasing pressures on coastal and marine resources.

Under the TNA-Belize project, the Fisheries Department is proposing the climate change adaptation technology for the Coastal and Marine sector: "Improved Marine Monitoring Network and Early Warning System to increase resilience to Climate Change". The Fisheries Department will spearhead this intervention and the dissemination of information and regular 'early warning' bulletins for key stakeholders, and as a public service.

The technology transfer will consist primarily of the following: i) Eight automatic environmental/marine observation platforms (e.g. YSI EXO 2 Sonde) with sensors to record oceanographic and environmental parameters; ii) Eight data loggers with transmission facility via smart phone technology; iii) Other accessories and hardware for data transmission, retrieval, assimilation, and iv) an updated marine database, increased data analysis capacity, and a marine early warning protocol.

Objective: i) Provide accurate, timely and consistent marine environmental data and information to inform policies, strategies and actions needed for sustainable management and use of marine resources, increase resilience to climate change, and improve the livelihood security of stakeholders.

Timely and reliable environmental data gathering and early warning of impending impacts such as coral reef bleaching alerts, algal bloom and increasing pollution levels will be carried out to inform stakeholders. Marine resource and environmental monitoring and early warning will contribute significantly to climate change adaptation measures in related productive sectors (e.g, Tourism).

Costs and benefits: Total capital cost: 177,965.36 USD for installation of eight only marine environmental monitoring stations at 22,245.67 USD per station. Operational costs to provide project management, monitoring and evaluation of this technology, plus spares, is estimated at 84,491.34 USD for five years of the project cycle (and includes field operation cost at US$8,000.00 per year plus replacement of sensors for two stations over the five-year project cycle).

Part II: TAP for Climate Change Mitigation technologies

Two technologies were prioritized for the Energy Sector. These are: i) Off-grid PV Systems; and ii) On-grid PV Systems. The Transport Sector has prioritised two technologies, namely: i) Production of performance based (CO_2 emission) import duties on motor vehicles [VED – Vehicle Emission Duty]; and ii) Reducing carbon emissions and vehicle operating cost by retrofitting existing vehicles with Liquefied Petroleum Gas (LPG) Systems. The Land Use, Land-Use Change, and Forestry sector has prioritised, "Integrated Landscape Forest Management".

Project Ideas in Mitigation to Climate Change

Two project ideas are suggested for the Energy Sector:

1) *Train technicians to provide services to implement the technologies for PV systems, and*

2) *Installation of seventy-five (75) off-grid solar PV systems in three communities in the Toledo District.*

Off-grid PV System

The Off-grid PV System targets isolated communities, hospitals, and eco-hotels – users that are not connected to the national electrical grid. Three actions have been identified for its diffusion: i) reduce or adjust taxes to create incentive; ii) create awareness of technology and financial support; and iii) increase services offered by certified technicians. These actions are estimated to take 14 months to implement, requiring the Government of Belize to provide an additional 56,640.00 USD from international cooperation.

The success criteria are: i) Within five months of start if the intervention Cabinet will have reviewed tax reform and provide a positive response for adjusting taxes to create incentive; ii) within eighteen months 80% of rural communities are aware of the technology and financial support; and iii) in two years, some 80% of rural communities have access to Off-grid Solar PV services from certified technicians.

On-grid PV system

The On-grid PV system targets residential, commercial and industrial buildings that are connected to the national grid. Four actions have been identified to aid in its diffusion, namely: i) Review taxing scheme on PV components; ii) Create awareness of technology and financial support; iii) Train technicians to increase the offer for services; and iv) Pass regulations on tariffs and market schemes. These actions are estimated to take 18 months to implement, requiring the Government of Belize to seek additional funding of 99,908.00 USD.

The success criteria are: i) Within 6 months Cabinet have reviewed tax reform and have provided a response; ii) Within 18 months 80% of rural communities are aware of technology and financial support; iii) Within 2 years the pool of certified technicians will satisfy the demand for services causing the cost for services to decrease by at least 20%; and iv) Within 1 year regulations on tariffs and market schemes are passed.

The implementation of the Energy Sector technologies could be combined since they share common actions. The only care that must be taken when combining these technologies is that their targets differ, and awareness campaigns will require different approaches.

The project idea for the Transport Sector has to do with the training and certification of mechanics. Ensuring that users of these technologies have reliable technical support within Belize will be vital for the successful uptake and diffusion of the technologies. These interventions will also provide social and economic benefits for locals, such as capacity building, news skills gained, and marketability.

3) *Capacity building through training and certification of mechanics to ensure successful implementation and sustainability of technologies in the transport sector.*

Performance based (CO_2 emission) import duties on motor vehicles (VED – Vehicle Emission Duty)

The Production of performance based (CO_2 emission) import duties on motor vehicles [VED – Vehicle Emission Duty] has changed its focus to performance-based emissions for licensing fees, thus broadening the scope to all vehicles circulating in Belize. The Department of Transport will be the agency responsible for implementing this technology. Four actions have been prioritised for its diffusion, namely: i) Provide tariff incentives based on vehicle carbon emissions; ii) Draft and adopt vehicle regulations dealing with carbon emissions; iii) Acquire emissions testing equipment; and iv) Train local mechanics in new technology. It is estimated that these actions will take twenty-seven months to execute. A sequence or timeline for implementing the actions and activities was used to help improve efficiency of diffusion of the technologies. The Government of Belize will need to seek additional funding of US$223,001.00.

The success criteria are: i) Within two (2) years, vehicle owners have adjusted themselves to new process; ii) Within 18 months, emissions testing is legislated to license vehicles; iii) Within 2 years 100% of districts test for emission and 100% of inspectors are certified; and iv) Within 2 years 80% of mechanics are certified.

Reducing carbon emissions and vehicle operating costs by retrofitting existing vehicles with Petroleum Gas systems

The technology of "Reducing carbon emissions and vehicle operating costs by retrofitting existing vehicles with Liquefied Petroleum Gas" targets light-duty gasoline vehicles circulating in Belize. The Department of Transport will be the agency responsible for implementing this technology. Three actions have been prioritised for its diffusion: i) Regulate market by establishing regulations for LPG Kits; ii) Have public awareness campaigns on technology; and iii) Increase service offerings of certified technicians. It is estimated that these actions will take one year to implement. The Report provides a sequence that is recommended for efficiency of implementation. The Government of Belize will need to seek additional funding of US$91,616.00.

The success criteria for this technology transfer are: i) Within three (3) years market for LPG kits is regulated; ii) Within eighteen (18) months 80% of gasoline vehicle owners are aware of technology; iii) Within two (2) years 80% mechanics are certified. This Report also implies that the implementation of the Transport Sector technologies could be combined with the awareness campaigns and the training and certification of mechanics.

The Land Use, Land-Use Change, and Forestry sector has prioritised, "*Integrated Landscape Forest Management*". This technology targets forest reserves where there are farming activities in the buffer zones such as the Vaca Forest Reserve in western Belize. The Forest Department (FD) and Agriculture Department will be the agencies responsible for the implementation of this technology; along with the University of Belize as a key stakeholder. Five actions were prioritised, namely: i) ensuring access to

funds; ii) amending legislation; iii) strengthening the Forest Department; iv) forming cooperatives or associations to market goods; and v) partnering with the national university and other organisations. It is estimated that the implementation for the diffusion of this technology will take three and-a-half years. The capital investment cost for capacity building is estimated at US$56,354.00. The Government of Belize will need to seek additional funding of US$76,412.00.

The success criteria identified are: i) Within 2.5 years the FD obtains 50% of financing from PACT (Protected Areas Conservation Trust) and other funding agency; ii) Within 1 year the law governing the co-management of national reserves is amended; iii) Within 5 years the FD is in control of the development of the forest reserves; i.e. decreased rate of deforestation; iv) Within 6 months 80% of farmers are members of a cooperative or an association; and v) Within 5 years 80% of farmers have signed up for the programme.

Two project ideas were recommended for the Land Use, Land-Use Change and Forestry sector, namely:

4) *Integrated landscape forest management with farmers in the buffer zone of the Vaca Forest Reserve; and*

5) *Establishment of a micro-hydroelectric power facility on the Rio On in the Mountain Pine Ridge. (Stakeholders favoured the second of these project ideas and recommended it be considered for funding and implementation in the short-term.)*

Project Idea:

Establishment of a micro-hydroelectric power facility on the Rio On in the Mountain Pine Ridge

Micro-hydro power is the small-scale harnessing of energy from falling water, such as steep mountain streams or small rivers. A micro-hydroelectric power facility scheme can generate from 75 to 100 kilowatts of power. This power capacity is sufficient for homes, hospitals, schools, workshops, environmentally friendly tourist destinations, forest station facilities and small farming communities. “Run-of-the-river" systems do not require a dam or storage facility to be constructed, instead water is diverted from the stream or river, channelled into a valley and drop through a turbine via a pipeline called a penstock. Micro-hydro power stations provide poor communities in many rural areas around the world with an affordable, easy to maintain and long-term solution to their energy needs. These systems are designed to operate for a minimum of 20 years, and are a renewable, indigenous, non-polluting energy source.

One of the greatest limiting factor in the transformation of the Douglas D’Silva Forest Station (DDSFS) in the Mountain Pine Forest Reserve in the Cayo District into an Eco-Tourism, Research and Education Facility, is an unreliable source of electrical energy produced by an old Lister diesel generator. Energy is intermittently provided for a three to four-hour period per day. For the DDSFS to be converted into an Eco-tourism and Education/Research Centre, it would be necessary that the system be upgraded, requiring greater output than can be provided by the present generator, and a more reliable source of energy. An assessment of the available alternative sources of energy indicate that the DDSFS complex

needs could best be met through a small hydroelectric plant. The hydrology and topography of the area, with its abundance of creeks and tributaries of the Macal River, is suitable for this renewable technology of minimal environmental impacts.

Objective: To provide a reliable and renewal source of electric power to the Douglas D'Silva Forest Station complex that will have minimal environmental impacts on the forest and water ecosystem in the Reserve.

The Mountain Pine Ridge Micro-Hydroelectric project is projected to generate electric power of 110/220 V, utilizing the waters of the Rio On river by means of a micro hydroelectric power station with a total installed capacity of 75-100 kW. The aim is to improve the supply and quality of the electric power in the Douglas D'Silva Forest Station (DDSFS) and the proposed plan to convert the DDSFS into a model Eco-Tourism, Education and Research facility (MPR Micro-hydro EIA, Tunich Nah, 2004, BET, 2010). It is expected that this improvement in providing a reliable source of affordable electricity will allow this transformation. The estimated capital cost is of the order of US$613,495.00. The intervention is for a three (3) project cycle with an operational cost of 30,000.00 USD per year. Thereafter, the project should be self-sustaining.

Based on the output of the earlier TNA steps this Technology Action Plan was developed, it is aimed at bridging the gap between the TNA analysis and implementation of technology related project ideas. It requires the participation and buy-in of key stakeholders, including policymakers and beneficiaries. The aim is to produce a clearly, articulated strategic plan and a convincing request for financial and technical resources, and to help promote the uptake and/or diffusion of one or more specific, climate technologies. Successfully funded and implemented actions proposed in the TAP can complement Belize's strategic development goals of building resilience to the impacts of climate change, enhance the country's mitigation potentials, and stimulate its pursuance of a low-carbon development pathway.

Introduction

The Technology Action Plan (TAP) is the final stage of the Technology Needs Assessment (TNA) process and is envisioned to serve as the strategic mechanism to facilitate the sourcing of funds at the national, regional and international levels for technology transfer. The availability of the necessary human and material resources; measures/interventions that have already been initiated, complementarity and partnering needs, supportive proposed and/or adopted policies and systems, jurisdiction, improvements and remaining barriers that need to be properly addressed to facilitate the technology transfer will all be considered by the corresponding actors per technology as stipulated in the TAP.

The ambition level for each technology have budgetary implications (Naswa, et al., 2017). Ambition affects scale of measures; for a limited ambition the types of measures are likely to be different from that of an ambition level for wide scale diffusion of the technology. If the ambition is limited to small scale implementation of a technology, then measures could include procuring equipment from foreign markets and providing them directly to the end users at a subsidised cost. The measures then, are directly linked to the technology and are potentially a one-time effort. Such technologies (e.g. monitoring equipment for a marine environmental monitoring network, or a micro-hydroelectric power plant) have high-upfront budgetary allocation. Added to this is the operational and maintenance costs that are critical for sustainability.

On the other hand, if the ambition level is a wide scale diffusion of the technology, then the nature of the measures will be different, and will likely require facilitating players in the market value chain to operate efficiently (e.g. in-country micro-propagation of climate resilient varieties of Irish potato seed-tubers, and/or On-grid/Off-grid Solar PV technology). Measures such as those calling for changing policy structures to have the right incentives for stakeholders or making more financing options available for users to invest in the technology are more expensive, however, they can be spread over a period of time to ease the financial burden. Larger ambitions also necessitate coordination of measures with available financing and budgetary allocation in public finance (Naswa, et al., 2017). The ambition level should also be linked to the status of the technology in the country and available capacity.

Financing for the TAP may come from two sources, namely:

1) Public Finance: Charitable Trusts or Government budget, i) International [Multilaterals, Climate Funds] or ii) National [Budget or Domestic Development Finance Institutions];
2) Private Finance: Private Financial Institutions or Private Investors (Naswa, et al., 2017). See Annex I for details.

Activities for the TAP are of two types, namely:

Type I Activities: ‘Non-Investment’ [Grants for Capacity building; knowledge generation / dissemination; policies, regulations, financing schemes etc.; software/specifications for institutional arrangement to implement programme; Feasibility studies, etc.]; or ‘Investment’ [Soft loans

(International) & Grants; Private Sector funds for Technical Institutions, arrangement for enforcing policy/regulations etc.].

Type II Activities: Equity; Loan; Capital Subsidies; and Risk Management. [Market Loans and Interest Subsidy]. See Annex I for details.

According to Naswa et al., (2017), financing the transfer and diffusion of technology has two areas: i) investment that creates assets, and ii) non-investments to cover incurred costs for services provided such as technical expertise, knowledge products, training, etc. These can also be classified as 'financial' and 'technical' investments.

In Belize, the Ministry of Agriculture, Forestry, Fisheries, the Environment, Sustainable Development, and Immigration (MAFFESDI) is the Ministry responsible for the coordination and implementation of sustainable development and policies related to climate change in Belize. The National Climate Change Office (NCCO) under this Ministry plays a leading role in coordinating the work of the Belize National Climate Change Committee (BNCCC), which has wide representation from the public and private sectors and has the mandate to spearhead climate change actions at the local, regional and international levels on behalf of Belize.

Technology transfer, technology innovation and diffusion in the public and private sector lies under the auspices of the development entities themselves, as there is no national agency or Public Service Department coordinating technology uptake and deployment. Consequently, organizations, ministries and others in the productive sector must have the capacity either within or from external sources to assimilate and operate improved and complex technologies to enhance production and services and build resilience to climatic extremes.

This TAP consists of two parts, namely; Part I: TAP for Adaptation Technologies; and Part II: TAP for Mitigation Technologies. Part I comprises of three chapters that covers TAPs for prioritized technologies in Agriculture, Water and Coastal and Marine Ecosystems. The last section in each chapter presents an overview of Project Idea Notes. Part II of the TAP Report contains another three chapters that cover the prioritized mitigation technologies for the Energy, Transport, and Land Use, Land-use Change and Agroforestry sectors. Three Project Idea Notes are also presented in Part II of the TAP.

The next step after the TNA process is completed is to identify and procure the financing necessary to implement potential project ideas in the form of grants, non-refundable project loans or low interest loans, following the drafting and submission of bankable project concepts to special donor agencies such as the Green Climate Fund (GCF), Global Environment Facility (GEF), the World Bank and others (See Annex I-B (i)-(ii) for Sources of Finance). The aim in the TNA process is to utilize the TAP and Project Idea Notes as a strategic tool to attract funds, both at the local and international levels for implementation of specific technology diffusion related to the prioritized technology actions for each TAP and project ideas.

Part I: TAP for Adaptation Technologies

Chapter 1. Technology Action Plan and Project Ideas for the Agriculture Sector

1.1 TAP for the Agriculture Sector

1.1.1 Sector Overview

The Ministry of Agriculture works closely with farmers and it collaborates with several local, regional and international partners and institutions to promote sustainable and climate smart agriculture in Belize. The agriculture sector policy and institutional framework guides the climate change adaptation strategy and informs decisions to be made and the most suitable entities to implement the proposed TNA prioritized adaptation technologies for the sector.

The Ministry of Agriculture is guided by the National Agriculture and Food Policy (NAFP) 2015-2030, with the strategic objective of increasing agricultural production, productivity, competitiveness, and market opportunities. Emphasis is being placed on innovation, research and development, and partnerships to capitalize on available opportunities that have a comparative advantage.

Strategic objectives of the Agriculture Sector in Belize in the short and medium term are to:

i. Stimulate and facilitate agricultural and fisheries sector growth and reduce rural poverty;
ii. Create the enabling and favourable environment to increase the efficiency, productivity, profitability and competitiveness of the agriculture, fisheries and cooperative sectors;
iii. Accelerate the diversification in production, processing and exports;
iv. Improve and conserve the natural and productive resource base to ensure long-term sustainable productivity and viability;
v. Improve access to productive resources and services and create economic opportunities for small/young farmers, women and indigenous people, particularly in poor, marginal areas;
vi. Strengthen the institutional capacities to provide effective support in marketing and trade, research and extension, as well as relevant education and training;
vii. Increase food production, enhance food security and improve the nutritional status of the population, as well as increasing farm incomes; and
viii. Strengthen inter-sectoral linkages, in particular with the social sectors of health and education, as well as with the strategy and action plan for poverty eradication, (www.agriculture.gov.bz, retrieved June, 2017).

The Technology Action Plan (TAP) for the Agriculture sector focuses on four prioritized technologies namely:

- Heat and Drought resistant varieties of open-pollinating corn and beans seeds for reproduction and marketing for four farmers' cooperatives;
- Improved drip irrigation systems for five farming groups using rainwater harvesting and fertigation for crop nutrient requirement;
- Establish an in-country Irish potato clean-stock production unit to produce quality seed-tuber planting material varieties; and
- Rehabilitation of Seven Protective Covered Structure Cooling Systems.

Agriculture was identified as one of the sectors most vulnerable to the ravages of extreme hydro meteorological events, which have shown a tendency for increased intensity and frequency over the past two decades in connection with climate change. FAO (2018) reports that 80% of the losses due to natural hazards is in the Agriculture sector. In Belize, losses suffered in Agriculture from tropical cyclones, floods, and droughts have often superseded those in other sectors, such as infrastructure, industry, tourism, etc. (CCCCC, 2014; NEMO 2014; GOB/NCCO, 2017).

The selection and prioritization of adaptation technologies in the Agriculture sector were aimed at increasing resilience to climate change among producers and ensuring livelihood and food security, which are fundamental goals endorsed in the National Agriculture and Food Policy (NAFP) 2015-2030. The technology transfer for the Agriculture sector also compliments the call for strengthening the productive sectors and the country's export base, as highlighted in Horizon 2030: National Development Framework for Belize 2010 - 2030 (GOB, 2009), and Belize Growth and Sustainable Development Strategy 2016-2019 (GOB, 2016).

1.1.2 Action Plan for heat and drought resistant varieties of open-pollinating corn and beans seeds

1.1.2.1 Introduction

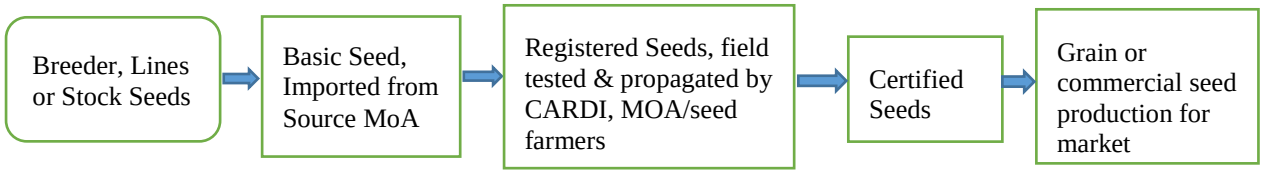
Through the consultative process, stakeholders recommended that crops for technology transfer should be grains; specifically, yellow corn and beans (Small Red, Red Kidney, and Black Beans). The technology for improved grain production in Belize is at the top of the MOA's list of crops being promoted in its strategy to ensure food safety and livelihood security among small farmers and farming communities in Belize (R. Thompson, Agriculture Officer responsible for Projects, personal communication, September 2017). Thus, the technology diffusion should encompass not only the new varieties of open pollinated corn and bean seeds, but also the complete process from land preparation, planting, harvesting, storage of grains, marketing and replanting. Seed production groups will ensure the viability of the seed stock. Seed for planting (quality seeds) and marketing (commercial grain) will be available for famers at a reasonable price.

The proposed technology diffusion to test and produce 'quality' heat and drought resistant varieties of open-pollinated corn and bean seeds for marketing among small farmers in Belize through the

Technology Needs Assessment project is an initiative being promoted by the Ministry of Agriculture to increase the capacity of four farming cooperatives and the MOA's Grain Production Unit at Central Farm in order to expand production and sale. The intervention will run for three years.

Some capacity exists, through a FAO project many farmers have already been exposed to good quality seeds and have seen the results. They have also been introduced to the techniques of planting in rows and on the use of proper storage facilities. This has been transmitted through Farmer Field School methodologies. The Climate Change adaptation intervention will assist to establish plots, threshing equipment, shelling equipment, cold storage bins, procurement of quality seeds, agro-chemicals, drip irrigation and marketing. The target farming cooperatives are: i) Valley of Peace Farmer's Cooperative; ii) Silver Creek Village Farmer's Cooperative; iii) Red Bank Village Farmer's Group; iv) San Carlos Village New River Farmer's Cooperative.

The proposed intervention will have positive impacts on marginalized communities, families and small farmers. Pest incidence on hybrids is much more prevalent than for open pollinated, so additional input to address pest will not be necessary. A simplified production chain for quality corn and black bean seed and other grain is illustrated in the following schematic:



Schematic of production chain for climate resilient varieties of corn and bean seeds

The Ministry of Agriculture Crop Production Unit (Central Farm Group) is involved in seed production of grain crops such as corn, beans and rice. This group will also participate in this intervention. The Crop Unit will be provided with an improved grain storage facility, and other equipment to continue producing seasonal, heat resistant grain during the project cycle. The Unit will also be responsible for coordination of the climate resistant grain seed production programme under the TNA initiative.

The Caribbean Agricultural Research and Development Institute (CARDI Belize) will be the agency responsible for the conservation of seed Germplasm. The objective is to safeguard the quality and integrity of the varieties overtime.

1.1.2.2 Ambition for the TAP

The ambition or scope is to expand the production of open pollinated, climate resilient 'quality' (certified) corn and beans seeds as planting material for small farmers, which will be supplied by four grain-producing farming cooperatives, working in close coordination with the Grain Production Unit of the MOA. The intervention will run for three years, after which the producers will continue on their own as the market for quality grain expands and their profit margins increase. One activity to consider is to encourage farmers cultivating commercial grains for the market to support the 'quality' grain-producing cooperatives and be confident that the planting material is of high quality.

1.1.2.3 Actions and Activities selected for inclusion in the TAP

Summary of barriers and measures to overcome identified barriers

Table 1 is a summary of the barriers and measures connected with the transfer and diffusion of climate resilient corn and beans seed technology. In the barrier analysis and enabling framework process, barriers and measures were listed under categories, namely: economic and financial, market conditions, legal and regulatory, network structures, and others.

Table 1: Barriers and measures considered in relation to the diffusion of climate resilient varieties of grain seeds

Categories	Identified Barriers	Measures to overcome barriers	Intervention		Funding Sources	
			Legal	Other	National	External
Economic and financial	− High initial investment	− Expand and secure access to finance (grants, low interest loans, project funds)		√	√	√
	− Limited subsidies for technology components	− Lobby for reduced import tax on equipment and seeds	√		√	
	− High cost of installation − High cost to obtain external certification (e.g. BAHA) for seed & seed tuber certification	− Provide technology companies & suppliers with concession to service specific areas or groups of clients at reduced service costs − Revert to FAO special, in-country practice of certifying "Quality" seed & seed-tubers		√		e.g. Public-private partnership √
Market conditions	− Gaps in technology value chain	− Set up local assembling industry (small industry, job creation initiative etc.)		√	√	
	− Local hardware stores often low in stocks of spares & components	− Improve access to products and services. Grow the market for new technology		√	√	√
	− Unstable, un-predictable monopoly, special interest groups	− Implement policies & regulations for favourable market climate to help level playing field	√		√	
Legal and regulatory	− Inadequate policy and regulatory framework	− Improve policy and enabling environment (e.g. seed policy, market liberalisation, protectionism, monopoly of incumbent technology)	√		√	

	− No office for testing and certification	− Establish regulatory agency for standards, testing and certification (for equipment, seeds, etc.)	√		√	√
	− Importation of cheaper, inferior-quality equipment/products	− Strengthen regulatory framework (e.g. implement, enforce & penalties)	√		√	
Network structures	− Networking among professionals and agencies weak and ineffective	− Enhance networking for certified seed production/ improved drip irrigation / potato cultivation chain actors. − Strengthen research, development and demonstration of new technology		√	√	√
	− Farmers cooperatives generally work in insolation (crop specific)	− Strengthen Cooperative Department and form an association of farmer's cooperatives	√		√	
	− Limited farmer to farmer visits	− Increase local and regional farmer's networking		√	√	√
Others	− Limited awareness and knowledge of new technology	− Establish management programme and education/awareness campaign among key stakeholders for new technology		√		√
	−Low technical capacity	− Establish effective and on-going training component in technology diffusion programme		√		√
	−Farming communities and farmers suspicious and afraid of change	− Through a technology diffusion programme address social, cultural and behavioural issues; improve KAP* among users of new technologies		√		√

* KAP: Knowledge, Attitude and Perception

1.1.2.4 Actions selected for inclusion in the TAP

Five key actions were prioritized for the diffusion of climate resilient varieties of grain seeds. These are: i) Procure finance to strengthen a certified grain seed production system among farmers' groups and the MOA Seed Production Unit; ii) Organize and run training programme for seed producers; iii) Establish public-private partnership for technical service provision; iv) Strengthen research,

development and demonstration of grain seed production technology; and v) Support the Agriculture infrastructure and management. These actions, as well as other actions listed for the other technologies, were derived directly or indirectly from the measures analysed with key stakeholders in the BA & EF Reports. It must also be noted that during consultative meetings for the TAP, stakeholders were requested to vouch once again on the identified measures to overcome some of the barriers or make recommendations for other measures/actions to facilitate the uptake of the technologies.

Activities identified for implementation of selected actions

Table 2 is a list of the proposed actions and related activities for the implementation of selected actions as discussed in several deliberations with the technology working group in the Agriculture sector. These actions and activities were further analysed for risks, contingencies and costs for inclusion in the TAP overview matrix.

Table 2: Activities for implementation of selected actions to facilitate diffusion of climate resilient varieties of grain seeds

Action 1. Procure finance to strengthen a certified grain seed production system among farmer's groups and MOA Seed Production Unit	**Action 2.** Organize and run training programme for seed producers	**Action 3.** Establish public-private partnership for technical service provision	**Action 4.** Strengthen research, development and demonstration of grain seed production technology	**Action 5.** Support the Agriculture infrastructure and management.
1.1 Conduct a Cost Benefit Analysis for the entire seed production chain.	2.1 Design training programme	3.1 Survey of active agriculture technology service provider by district	4.1 Lobby for and procure finance (or budget line item) for R&D in improved agriculture technologies.	5.1 Assessing the current seed production methodology to identify need and gaps (e.g. agronomic practices)
1.2 Draft and submit bankable project proposal for strengthening resilient grain seed production	2.2 Promote added value to seed production and marketing	3.2 Design and implement adequate mechanism for information dissemination	4.2 Organized Public and Private sector entities for R&D in Agriculture	5.2 Establish a regulating agency for quality seeds and equipment
1.3 Establish incentives for farmers (e.g. give recognition to 'quality' seed producers and favourable market opportunities).	2.3 Promote improved agronomic practices specific for seed production (e.g. soil & water conservation)	3.3 Open a small market for locally designed and manufactured seed cool storage system	4.3 Support R&D at University of Belize School of Agriculture	5.3 Strengthen stock seed source at Central Farm

1.4 Review market policy and make recommendations for improved local market access/opportunity.				
1.5 Revise and implement a national seed policy				

Actions to be implemented as Project Ideas

Action '1': "Procure finance to strengthen a certified grain seed production system among farmers' groups and the MOA Seed Production Unit", was considered as the key action for implementation as a project idea. This 'Action' is further analysed in the Project Ideas section for the Agriculture sector. Climate resilient, "quality" corn and beans seeds production is already being done locally by several farmer's groups, but market demands have been increasing, as recent losses in market grain production are attributed to the delicate hybrid varieties farmers have been cultivating and the lack of dependable rainfall in the normal growing season under local rain-fed agriculture system. Floods and excessive rainfall have also been affecting corn and beans production in many agricultural zones in the country. An expansion of 'quality' grain production for sale to small farmers, who are the most vulnerable, has many economic and social benefits for farming communities, and the grain-producing farmer's cooperatives.

The success criteria for this 3-year intervention are: i) By the end of the first year, all four grain-seed producing cooperatives have harvested, stored and packaged for sale their first crops of corn and beans; ii) Initial series of training on 'value added' and 'marketing' have been completed iii) MoA has recorded a success rate of farmers participation in the programme of around 60% by the end of the first year, with the hope of increasing farmer's participation in the next two years of the intervention.

1.1.2.5 Stakeholders and Timeline for implementation of TAP

Overview of Stakeholders for the implementation of the TAP

Stakeholders for the implementation of TAP for climate resilient varieties of quality grain seeds include:

- Ministry of Agriculture Grain Seed Production Unit, responsible for grain seed production and coordination of selected grain seed production groups;
- Farmer's Grain Production Groups or Cooperatives;
- Grain farmers
- Foreign breeder seed producers or research centres such as: The International Centre for Tropical Agriculture (CIAT), CGIAR International Maize and Wheat Improvement Centre;
- Partners in Agriculture such as: CARDI, SIRDI, IICA, OIRSA, BAHA, UB School of Agriculture, and others;
- Importers and retailors of agriculture equipment and spares.

Scheduling and sequencing of specific activities

Table 3 shows a chronogram of actions and activities identified for the diffusion of grain seed production technology for climate resilient varieties of 'quality' grain as planting material for farmers. The chronogram covers only the first 2.5 years. Grain producers will market and profit from sales of 'quality' registered planting material, while farmers will reduce risks of losses with better seeds and increase their yields and profits.

Table 3: Schedule and sequence of activities for climate resilient varieties of certified grain seeds

Actions	Activities	Timeline (months)																			
		1	2	3	4	5	6	7	8	9	10	11	12	14	16	18	20	24	26	28	30
1. Procure finance to strengthen a certified grain seed production system among farmer's groups	1.1 Conduct a Cost Benefit Analysis for the entire seed production chain																				
	1.2 Draft and submit bankable project proposal for strengthening resilient grain seed production																				
	1.3 Establish incentives for farmers (e.g. recognition of quality seed producers and favourable market opportunities)																				
	1.4 Review market policy and make recommendations for improved local market access/opportunity																				
	1.5 Revise and implement a national seed policy																				
2. Procure finance to organize and run training programme for seed producers	2.1 Design training programme																				
	2.2 Promote added value to seed production and marketing																				
	2.3 Promote improved agronomic practices specific for seed production (e.g. soil conservation)																				
	3.1 Survey of active agriculture technology service provider by district																				

Actions	Activities	Timeline (months)																			
		1	2	3	4	5	6	7	8	9	10	11	12	14	16	18	20	24	26	28	30
3.Public-Private partnership for technical service provision	3.2 Design and implement adequate mechanism for information dissemination																				
	3.3 Open a small market for locally designed and manufactured seed cool storage facility																				
4.Strengthen research, development & demonstration of new technology	4.1 Lobby for and procure finance (or budget line item) for R&D in improved technologies																				
	4.2 Organized Public and Private sector entities for R&D in Agriculture																				
	4.3 Support R&D at University of Belize School of Agriculture																				
Action 5. Support the Agriculture infrastructure and management	5.1 Assessing the current seed production methodology to identify need and gaps (e.g. agronomic practices)																				
	5.2 Establish a regulating agency for quality seeds and equipment																				
	5.3 Strengthen stock seed source at Central Farm																				

Estimation of Resources Needed for Action and Activities

Capacity building needs for the uptake in the production of climate resilient, 'quality' grain by the MOA grain production unit and four (4) farmer's cooperatives include:

1) MOA: Grain Production Unit will require two extra Agronomists and three field personnel; while the Extension Services may require an additional four, trained Extension Officers

2) Increasing farmer's Knowledge, Attitude and Perception (KAP) on improved 'quality' grain varieties and their benefits such as resilience to climate change, increased yields and income, and increase food security.

Estimations of costs of actions and activities: Estimated total cost of proposed actions and activities to facilitate the transfer and diffusion of field-tested, climate resilient varieties of grains is: US$182,000.

1.1.2.6 Management Planning

In the TNA process, risks associated with activities for technology transfer fall under three categories (TEC, 2016), namely: i) Cost risks (CR); ii) Scheduling risks (SR); and iii) Performance risks (PR).

In this Report, activity risks are further evaluated using a Risk Index table base on the likelihood of the risks occurring, and its significance. See Table I-1 in Annex III for an example of the risk assessment for technology activities being considered for the TAP. Risk indices scoring '15' or greater are further evaluated for contingency action and estimated costs.

Risks and Contingency Planning

Table 4 below is a summary of the risk and contingency planning for the diffusion of local production of certified heat and drought resistant varieties of grains by seed-producing farmers groups. As indicated earlier, risk indices scoring 15 and greater are further evaluated for contingency and an estimated cost is provided based on input from stakeholders and the status of the economy.

Table 4: Risk and contingency planning for climate resilient varieties of certified grain seeds

Action	Activities to be Implemented	Risks Type (CR, SR, PR)	Risk Index	Contingency	Cost USD
1. Procure finance to strengthen a certified grain seed production system among farmer's groups	1.1 Conduct a Cost Benefit Analysis for the entire 'quality' seed production chain	CR and PR	12	--	--
	1.2 Draft and submit bankable project proposal for strengthening resilient grain seed production	SR and PR	20	Have project steering committee review proposal and submit to several donors and/or financial institutions	6,000.00
	1.3 Establish incentives for farmers (e.g. recognition of quality seed producers and favourable market opportunities)	CR and PR	12	--	--

	1.4 Review market policy and make recommendation for improved local market access/opportunity	SR and PR	20	Ensure project steering committee brief CEO and Minister on this issue and prepare policy recommendation paper	4,000.00
	1.5 Revise and implement a national seed policy	SC and PR	20	Technical Advisory Group (TAG) in MOA conduct revision, advise PSG. Recommendations forwarded to CEO	6,000.00
2. Procure finance to organize and run training programme for seed producers	2.1 Design training programme	CR and PR	12	---	---
	2.2 Promote added value to seed production and marketing	CR and PR	16	Ensure budget for programme and Added Value trainers available. Organize trainee groups (four training sessions)	24,000.00
	2.3 Promote improved agronomic practices specific for seed production (e.g. soil conservation)	CR and SR	20	Identify experts in the specific agronomic practices long before training/ demonstration programme (6 sessions)	18,000.00
3.Public-Private partnership for technical service provision	3.1 Survey of active agriculture technology service providers by district	SR	12	---	---
	3.2 Design and implement adequate mechanism for information dissemination	CR and SR	12	---	---
	3.3 Open a small market for locally designed and manufactured seed cool storage system	CR and PR	16	Inform farmer's groups or cooperatives of the need and benefit for cool storage facility for quality grain seeds and other crops	15,000.00

4.Strengthen research, development & demonstration of new technology	4.1 Lobby for and procure finance (or budget line item) for R&D in improved technologies	CR	20	Impress on policymakers the importance of an annual budget for R&D	Internal. GOB, in kind
	4.2 Organized Public and Private sector entities for R&D in Agriculture	CR and PR	25	Identify a leader Unit or Entity to champion R&D in Agriculture and organized scientific partners. Provide cost per annum for meetings, seminars, workshops and newsletter.	15,000.00
	4.3 Support R&D at University of Belize School of Agriculture	CR and PR	12	---	---
Action 5. Support the Agriculture infrastructure and management	5.1 Assessing the current seed production methodology to identify need and gaps (e.g. agronomic practices)	CR and PR	12	Contract local consultant to review literature and submit an assessment report	9,000.00
	5.2 Establish a regulating agency for quality seeds and equipment	CR and PR	16	Ensure the recommendation for a regulating agency for 'quality seed' and equipment performance reaches key policymakers. May require a Cabinet paper, cost may be unusually high.	12,000.00
	5.3 Strengthen stock seed source at Central Farm	CR and PR	20	Ensure finance procured for 'stock seed source' facility (e.g. cold storage and packaging and receptacles)	20,000.00

(Source: Adopted from TEC, UNFCCC/UNEP-DTU, 2016)

Next Steps

The MOA Grain Seed Production Unit, as the coordinating entity for this intervention, will draft and submit a bankable project proposal to seek finance to 'strengthen its grain production programme

countrywide". FAO, as well as other local and foreign financing and technical partners in agriculture will be invited as critical actors in this initiative. Members from four 'quality' grain seed-producing farmer's cooperatives will be organized and presented with an updated guideline on grain seed production. Training programmes in 'quality' grain seed production and marketing, and sustainable agronomic practices will be developed and conducted among participating farmers of each of the cooperatives, MOA Extension Service personnel, and personnel of the UB School of Agriculture as part of the expanded grain seed production project.

1.1.2.7 TAP Overview Table for diffusion of improved quality grain seed varieties

Table 5 is the TAP overview for the diffusion of improved quality grain seed variety production. It highlights the actions, activities, ambition, benefits, possible sources of funding, a timeline for implementing the activities, risks, success criteria, indicators for monitoring the implementation and the estimated cost for the successful diffusion of the technology.

The ambition is to expand the production of climate resilient, 'quality' (certified) corn and beans seeds as planting material for small farmers, which will be supplied by four grain-producing farming cooperatives, working in close coordination with MOA. The intervention will run for three years, after which the producers will continue their own work, as the market for quality grain expands.

The benefits are positive economic and social impacts for 'quality' seed producing cooperatives, marginalized communities, families and small farmers involved in grain cultivation. Environmental benefits include decreased deforestation, reduced agro-chemical runoff into surface and groundwater sources, and reduction in emissions arising from improved agronomic practices, and reduced cost inputs for farmers.

Table 5: TAP Overview for improved varieties of certified grain seeds

Sector	Agriculture							
Sub-sector	Crop production							
Technology	In country testing and production of climate resilient varieties of certified grain seeds							
Ambition	To expand the production of climate resilient quality (certified) corn and beans seeds as planting material for small farmers, which will be supplied by four grain-producing farming cooperatives, working in close coordination with MOA. The intervention will run for three years, after which the producers will continue on their own, as the market for quality grain expands.							
Benefits	The proposed intervention will have positive economic and social impacts for 'quality' seed producing cooperatives, marginalized communities, families and small farmers involved in grain cultivation. Pest incidence on hybrid is much more prevalent than for open pollinated, so additional input to address pest will not be necessary. Environmental benefits include decreased deforestation, reduced agro-chemical runoff into surface and groundwater sources, and reduction in emissions arising from improved agronomic practices.							
Actions	**Activities to be implemented**	**Sources of funding**	**Responsible body and focal point**	**Time-frame (Months)**	**Risks**	**Success criteria**	**Indicators for monitoring of implementation**	**Budget per activity (USD)**
Action 1: Procure finance to strengthen a certified grain seed production system among farmers' groups and MOA Seed Production Unit	**Activity 1.1** Conduct a Cost Benefit analysis for entire seed production chain	GOB, GCF, GEF, UNDP,	MOA	0.5	CR & PR 12	High	Cost-Benefit analysis	3,000.00
	Activity 1.2 Draft and submit bankable project proposal for strengthening resilient grain seed production	UNDP, GEF	MOA	1	SR & PR 20	High	Bankable project proposal	6,000.00
	Activity 1.3 Establish incentives for farmers, e.g. recognition of quality seed producers and favourable market opportunities	GEF, GCF, FAO	MOA	1	CR & PR 12	High	Small farmers and farmers cooperatives cognizant of 'quality' seed and seed producers, and seed producers can market their 'quality' grain seeds locally	5,000.00

	Activity 1.4 Review market policy and make recommendations for improved local market access/opportunity	GOB, GEF/UNDP	MOA	1.5	SR & PR 20	Mod	Local market access and opportunities improved for farmers. Policy drafted and adopted	4,000.00
	Activity 1.5 Revise and implement seed policy	GOB, GEF/UNDP	MOA/Trade and Industry	2	CR & PR 20	Mod	Enhance or strengthen the FAO in-country 'quality' seed production protocol	4,000.00
Action 2: Procure finance to organize and run training programme for seed producers	**Activity 2.1** Design training programme	GEF/UNDP, FAO,	MOA Grain Production Unit & Extension Service	0.75	CR & PR 12	High	Training programme adopted and implemented	5,000.00
	Activity 2.2 Promote added value to seeds	FAO, GEF/UNDP	MOA Grain Production Unit & Extension Service	2	CR & PR 16	Mod	Added Value training workshops conducted	24,000.00
	Activity 2.3 Improved agronomic practices specific for seed production (soil conservation)	FAO, GEF/UNDP, WB, IDB	MOA Extension Service	4	CR & SR 20	Mod	Training and demonstration sessions (at least 6 sessions in three-year period)	18,000.00
Action 3. Public-Private partnership for technical service provision	**Activity 3.1** Survey of active agriculture technology service provider by district	FAO, GEF/UNDP	MOA-ARDU	2	CR 12	High	Updated list of active Service Providers	6,000.00
	Activity 3.2 Design and implement adequate mechanism for information dissemination	GOB	MOA Extension Service	3	CR & SR 12	High	Programme or mechanism for information dissemination	6,000.00

	Activity 3.3 Open a small market for locally designed and manufactured seed cool storage system	FAO, GEF/UNDP, GCF	MOA-ARDU/Private partnership	2	CR & PR 16	Low	Local market for cool storage facility for grain seeds	15,000.00
Action 4. Strengthen R&D in quality seed production	**Activity 4.1** Lobby for and procure finance (or budget line item) for R & D in improved technologies	FAO/UNDP, GOB	MOA-ARDU and Grain Production Unit	1	CR 20	Low	Reimbursable finance available for R&D in specific area of Agriculture	30,000.00
	Activity 4.2 Organized Public and Private sector entities for R&D in Agriculture	GOB/MOA	MOA and Partners in Agriculture	1	CR & PR 25	Mod	Active public – private R&D entity in Agriculture	15,000.00
	Activity 4.3 Support R&D at University of Belize School of Agriculture	MOA/UB/FAO	MOA /UB and partners	0.5	CR & PR 12	High	Expansion of Agriculture R&D at UB and affiliate universities	GOB in kind
Action 5. Support the Agriculture infrastructure and management	**Activity 5.1** Assessing the current seed production methodology to identify need and gaps e.g. agronomic practices	MOA-FGPU, FAO/UNDP, GCF	MOA Crop Production Unit	1	CR & PR 12	High	Assessment Report on current 'quality' grain seed methodology	9,000.00
	Activity 5.2 Establish a regulating agency for quality seeds and equipment	GOB/FAO	MOA Policy Unit	2	CR & PR 16	Mod	Regulating Agency recognized and established	12,000.00
	Activity 5.3 Strengthen stock seed source at Central Farm	FAO/UNDP, MOA	MOA Policy Unit and Crop Production Unit	1	CR & PR 20	Mod	Viable seed source being stored	20,000.00
TOTAL								**182,000.00**

1.1.3 Action Plan for improved drip irrigation/fertigation[1] systems

1.1.3.1 Introduction

The Ministry of Agriculture's Agricultural Water Management Investment Plan, Volume 1., Final Report (2015) calls for "cost effective irrigated agriculture contributing to sustainable food security, poverty alleviation and economic growth", and "An irrigated agricultural sector provided with adequate and appropriate irrigation infrastructure" (GOB/FAO/CDB. 2015).

Increased use of drip irrigation for crop production is a national priority (GOB/FAO, 2011; GOB/FAO, 2015); and is a recommended climate change adaptation technology to reduce stress on water resources, soil and forest resources. Some limiting factors include: initial cost per unit for drip/sprinkler irrigation systems; water availability and reliability during the dry season; maintenance costs; availability of spares; energy source for water pumps; import duties on spares; limited; technical capacity of farmers; and inability of small famers to finance the capital cost for procurement and installation of improved, drip irrigation/fertigation system.

In 2015 some 5,427 acres (2196.2 ha) of rice was cultivated with flood irrigation mostly in the Orange Walk District. Less than 50% of the potato crop (107 acres) were cultivated under drip irrigation, mostly in northern Belize (Mr. Jonathan Can, Extension Officer, MOA, personal communication, April 2016). Corn and grain legumes or pulses (beans), and tubers (such as Irish Potato and Sweet Potato) cultivation are mostly rain fed.

Improved drip irrigation system

Improved drip irrigation introduces water directly into the root zone without sprinkling the foliage or wetting the entire soil surface. Such partial-area irrigation methods offer the additional benefit of keeping the greater part of the soil surface (between the rows of crop plants) dry. This discourages the growth of weeds, that would otherwise not only compete with crop plants for nutrients and moisture in the root zone and for light above ground, but also hinder field operations and the control of pests (Perry, 2015). This technology can be used in conjunction with other climate change adaptation measures such as water harvesting, multi-cropping and fertilizer management (fertigation system). Promoting drip irrigation contributes to efficient water use, reduces requirements for broadcasting fertilizers, controls weeds, and increases soil productivity. It is particularly suitable in areas with permanent or seasonal water scarcity, since crop varieties planted can adapt to the local conditions.

Investment is required to build farmer's capacity to efficiently operate and maintain the system and water flow control. Drip irrigation can be used for small or large-scale crop production, and with low cost or more sophisticated components.

[1] Fertigation: Fertigation is the injection of fertilizers, soil amendments, water amendments and other water-soluble products into an irrigation system.

It is very important to consider how the system is operated. Under poor management, even the most sophisticated system can result in water loss and inefficiency. Only knowledgeable, experienced and good management can ensure that irrigation systems achieve their full potential benefits.

1.1.3.2 Ambition for the TAP

The improved drip irrigation systems will be installed at five farming cooperative farming sites, and one at the Ministry of Agriculture field training stations at the Agriculture Showground in Belmopan, Cayo District. The aim is to provide hands-on installation and training in cultivation using improved drip irrigation and fertigation to farmer's cooperatives and individual farmers on a pilot scale initially, then encouraging farmer's groups and individual farmers to purchase and install their own irrigation system at the district level, especially in the drought prone regions.

The target farming groups for the proposed advanced drip irrigation systems installation and initial training will be:

- The San Carlos New River Cooperative consisting of 26 members, engaged in the cultivation of corn, bean, onions and vegetables (Improved irrigation system);
- The Valley of Peace Vegetable producers (mixed cropping under cover structure and small open fields (Improved drip irrigation);
- San Antonio Farmers cooperative engaged in the cultivation of potato, black bean, peanuts and vegetables (Improved drip irrigation);
- Red Bank Village Farmers Cooperative, and
- Silver Creek Farmers Cooperative (Improved drip irrigation).

1.1.3.3 Actions and Activities selected for inclusion in the TAP

Table 6 is a summary of barriers and measures to overcome barriers as presented earlier in the barrier analysis. The category of barriers and corresponding measures are: i) economic and financial; ii) market conditions; iii) legal and regulatory; iii) network structures; and iv) others. It was prudent to select only four or five of the key measures/actions for inclusion and evaluation in the TAP.

Table 6: Barriers and measures for diffusion of improved drip irrigation/fertigation technology among farmer's groups

Categories	Identified Barriers	Measures to overcome barriers	Intervention		Funding Sources	
			Legal	Other	National	External
Economic and financial	− High initial investment of drip irrigation system	− Identify and secure affordable loans and payment plans for farmers		√	-DFC / National Bank, other Banks, Credit Unions	- special project grants, project funds etc.
	− Limited subsidies & tax incentives for import of components	− Lobby for reduced import tax on equipment and irrigation system components	√			√
	− Cost of installation and operation may be beyond the reach of small operators	− Provide technology companies & suppliers with concession to service specific areas/groups of clients at less service costs		√	e.g. Public-private partnership	
Market conditions	− Gaps in technology value chain (supply and demand) - Inadequate grain storage facilities -Market too small	− Set up local assembling industry (small industry, job creation initiative etc.) − Establish demonstration programme to help grow market for drip irrigation. - Procure funds to build or refurbish cool storage facilities		√	√	- Special project grants, project funds etcetera. - Using capital funds, targeting Extension Service & farmer groups.
	− Local hardware stores often low in stocks of irrigation spares & components	− Improve access to products and services through subsidies that may be pass on to farmers. - Expand the market for new technology and crop production in support of drip irrigation		√	√	
	− Inadequate policy and regulatory framework		√		√	

Legal and regulatory	− Incumbent monopoly in some areas; special interest groups; or none use of drip irrigation	− Recommend policy review and actions to improve enabling environment	√		√	
	− No office of testing and certification	− Establish regulatory agency for standards, testing and certification (for equipment, seeds, etc.)	√		√	- special project grants, project funds etc.
	− Import of cheaper, inferior-quality equipment/products	− Strengthen regulatory framework (e.g. implementation & penalty)	√		√	
Network structures	− Networking among professionals and agencies weak and ineffective	− Enhance networking for improved drip irrigation / potato cultivation market chain actors (e.g. importers/retailors, assemblers and clients) − Strengthen research, development and demonstration of new technology		√		Funds for R&D and Demo: CRDU, MOA, Farmer's groups, CARDI
	− Farmers' cooperatives generally work in isolation (crop specific)	− Strengthen Cooperative Department and form a national association of farmer's cooperatives	√		√	
	− Limited farmer-to-farmer visits and interactions	− Increase local and regional farmer's networking. Use ICT and social media.		√	√	√
Others	− Limited awareness and knowledge of new technology	− Promote public awareness and education on technology and related matters.		√		√
	− Low technical capacity	− Develop integrated and on-going, specialized training component in the diffusion programme. - Seek scholarships for specialized external training in drip irrigation (e.g. Nazareth Agricultural Centre, Israel)		√		-use project funds for training, targeting Extension Service & farmer's groups or cooperatives

	− Farming communities and farmers suspicious and afraid of change	− Through technology diffusion programme address social, cultural and behavioural issues; improve KAP*		√		√
	− Water scarcity	Develop and demonstrate guidelines on water management / rainwater harvesting technologies		√	√	

*KAP: Knowledge, Attitude and Perspective of improved technology among farmers' groups

1.1.3.4 Actions selected for inclusion in the TAP

A total of five actions and related activities for the establishment of improved drip irrigation and fertigation systems for five farming cooperatives and the Crop Research and Development Unit of the MOA, are summarized in Table 7 below. The systems will also integrate a rain-water harvesting facility and/or solar PV water pumps to abstract ground water into elevated tanks or an elevated surface ponds. Cost for solar pumps, solar PV systems, piping and tanks will be covered by the capital investment for this pilot project idea.

Table 7: Activities for implementation of selected actions for improved drip irrigation/fertigation

Action 1. Procure finance to introduce improved drip irrigation / fertigation technology	**Action 2.** Organize and run training programme for seed producers	**Action 3.** In coordination with Hydrology Unit, MOA conduct an ongoing awareness programme on water use, conservation and management	**Action 4.** MOA and Partners review, update and implement relevant provisions of the National Water Irrigation Strategy.	**Action 5.** Strengthen research, development & demonstration of new technology
1.1 Conduct a feasibility study and C/B analysis for expansion of drip irrigation countrywide	2.1 Allocate training budget for Training of Trainers programme	3.1 Develop information manuals for extension officers, farmers and public for awareness programme on water management and use in agriculture	4.1 Organize and promote networking with University, private entities and others on implementation of NIWS	5.1 Assess the current use of drip irrigation and identify needs and gaps (e.g. equipment, agronomic practices, water use)

1.2 Draft project proposal for funding to establish seven improved drip irrigation/fertigation systems with water catchment for training and demonstration	2.2 Draft and implement training programme for famers in improved drip irrigation /fertigation and water harvesting in all districts	3.2 Hold series of workshops and field demonstrations on use and water harvesting	4.2 Develop programmes for farmers on activating certain provisions of the NIWS	5.2 Promote network of equipment supplier, importers, & retailors equipment
	2.3 Write, print and disseminate improved drip irrigation guidelines in English and Spanish	3.3 Participate in radio talk shows, expos and visits to farmer's groups		5.3 Strengthen R&D in drip irrigation & best practice at ARDU, University & private entities

Actions to be implemented as Project Ideas

1. Introduce improved drip irrigation / fertigation technology to small farmers.

This Action is the preferred technology for consideration as a Project idea and is further developed in Section 1.2 of Chapter 1. This was a unanimous request from stakeholders during the earlier consultative process.

1.1.3.5 Stakeholders and Timeline for Implementation of TAP

Overview of Stakeholders for the implementation of the TAP

The proposed improved irrigation technology intervention is intended to support the work of the MOA's Crop Research and Development Unit (CRDU) field station in Belmopan, and five district agriculture training/demonstration sub-stations in Belize. The improved drip irrigation/rainwater harvesting & fertigation technology proposed for training and demonstration will target small farmer's groups/cooperatives engaged in vegetable and horticulture cultivation under protected covered structure, which is practiced by farmers in all six districts. Six improved drip irrigation/water harvesting, and fertigation systems are being considered for this adaptation technology transfer; and shall be coordinated, managed and maintained by the CRDU and Extension Services of the Ministry of Agriculture. After the initial training and demonstration phase of the intervention farmers will be encouraged to establish their personal drip irrigation/fertigation systems and commence operation and production. The main stakeholder groups are the MOA CRDU, members of four farmer's cooperatives, Extension Service personnel, CARDI, and importers of drip irrigation/fertigation equipment.

Scheduling and sequencing of specific activities

The schedule and sequence of activities for the diffusion/uptake of improved drip irrigation / fertigation systems among five farmer's cooperatives is presented in Table 8. Procurement of finance, public awareness programme on the benefits of drip irrigation and fertigation, public education on water use

and conservation in agriculture, and R & D in irrigation technology are the key actions considered for the update of this prioritized technology.

Table 8: Schedule and sequence of activities for diffusion of improved drip irrigation / fertigation systems

Actions	Activities	Timeline (months)																			
		1	2	3	4	5	6	7	8	9	10	11	12	14	16	18	20	24	26	28	30
Action 1. Procure finance to introduce improved drip irrigation / fertigation technology	Activity 1.1 Conduct a feasibility study and C/B analysis for expansion of drip irrigation countrywide																				
	Activity 1.2 Draft project proposal for funding to establish seven improved drip irrigation/fertigation system with water catchment for training and demonstration																				
Action 2. Procure finance to organize and run training programme for groups of farmers	Activity 2.1 Allocate training budget for Training of Trainers programme																				
	Activity 2.2 Draft and implement training programme for famers in improved drip irrigation /fertigation and water harvesting in all districts																				
	Activity 2.3 Write, print and disseminate improved drip irrigation guidelines in English and Spanish																				
Action 3.	Activity 3.1 Develop information manuals for extension officers, farmers and public for awareness programme on water management and use in agriculture																				

Actions	Activities	Timeline (months)																			
		1	2	3	4	5	6	7	8	9	10	11	12	14	16	18	20	24	26	28	30
In coordination with Hydrology Unit, MOA to conduct an ongoing awareness programme on water use, conservation and management	Activity 3.2 Hold series of workshops and field demonstrations on efficient water use/conservation, and water harvesting for drip irrigation																				
	Activity 3.3 Participate in radio talk shows, expos and visits to farmers groups																				
Action 4. MOA and Partners review, update and implement relevant provisions of the National Irrigation Strategy	Activity 4.1 Organize and promote networking with University, private entities and others on implementation of NWIS																				
	Activity 4.2 Develop programmes for farmers on activating certain provisions of the NWIS																				
Action 5. Strengthen research, development & demonstration of new technology	Activity 5.1 Assess the current use of drip irrigation and identify need and gaps (e.g. equipment, agronomic practices, water use)																				
	Activity 5.2 Promote network of equipment supplier, importers, & retailors equipment																				
	Activity 5.3 Strengthen R&D in drip irrigation & best practice at ARDU, University & private entities																				

Estimation of Resources Needed for Action and Activities

Estimation of capacity building needs

Training of Extension Service personnel in the operations of improved drip irrigation/fertigation systems is necessary. Extension Service personnel and CRDU officers will conduct a series of demonstrations of the irrigation systems at the locality of the farmers' cooperative, and at the main farm demonstration station at Central Farm or Belmopan, as deemed necessary. Farmers will also be trained in efficient water harvesting, water and soil conservation, and the use of solar pumps. A finance officer

will be available to advise farmers on financing opportunities for purchasing of drip irrigation/fertigation systems.

Estimations of costs of actions and activities

Source of funding: Project funds will be required for solar powered pumps, solar panel components, drip irrigation and fertigation components, as well as water lines and accessories, and for harvesting and storage equipment. The preliminary estimated cost for this technology uptake is US$141,300.00. Operational cost for spares and maintenance is US$45,000.00 for three years (Source: Adaptation Technology Factsheet).

1.1.3.6 Management Planning

Risks and Contingency Planning

Table 9 below is a summary of actions, activities, risks, contingency and costs for improved drip irrigation/ fertigation systems diffusion. Risks of activities based on likelihood of occurrence and consequences are evaluated in Annex I of this Report. Risk indices scoring 15 and greater are further evaluated for contingency and cost.

Table 9: Risk and contingency planning for improved drip irrigation/fertigation systems diffusion

Action	Activities to be implemented	Risks	Risk Index	Contingency	Cost US$
Action 1. Procure finance to introduce improved drip irrigation / fertigation technology	Activity 1.1 Conduct a feasibility study and C/B analysis for expansion of drip irrigation countrywide	CR and PR	12	--	--
	Activity 1.2 Draft project proposal for funding to establish seven improved drip irrigation/fertigation systems with water catchment for training and demonstration	SR and PR	20	Have project steering committee review proposal and submit to several donors and/or financial institutions	15,000.00
Action 2. Procure finance to organize and run training programme for groups of farmers	Activity 2.1 Allocate training budget for Training of Trainers programme	CR	12	---	---
	Activity 2.2. Draft and implement training programme for famers in improved drip irrigation /fertigation and water harvesting in all districts	SR and PR	12	---	---

	Activity 2.3 Write, print and disseminate improved drip irrigation guidelines English and Spanish	SR and PR	9	---	---
Action 3. In coordination with Hydrology Unit, MOA conduct an ongoing awareness programme on water use, conservation and management	Activity 3.1 Develop information manuals for extension officers, farmers and public for awareness programme on water management and use in agriculture	SR and PR	16	Ensure MOA and Hydrology have allocated financial resource from project funds for Activity 3. Farmers should have access to manuals in their language.	10,000.00
	Activity 3.2. Hold series of workshops and field demonstrations on efficient water use and water harvesting for drip irrigation	CR, SR and PR	16	Ensure manuals are properly reviewed, translated and Extension Service personnel familiar with content	5,000.00
	Activity 3.3 Participate in radio talk shows, expos and visits to farmers groups	SR and PR	12	Programme prepared and reviewed, and facilitators are available at all times to conduct workshops. (Six workshops, one per district)	15,000.00
Action 4. MOA and Partners review, update and implement relevant provisions of the National Water Use and Irrigation Strategy (NWIS)	Activity 4.1 Organize and promote networking with University, private entities and others on implementation of NWIS	SR and PR	9	---	---
	Activity 4.2 Develop programmes for farmers on activating certain provisions of the NWIS	SR and PR	9	---	---

Action 5. Strengthen research, development & demonstration of new technology	Activity 5.1 Assess the current use of drip irrigation and identify needs and gaps (e.g. equipment, agronomic practices, water use)	SR and PR	12	---	---
	Activity 5.2 Promote network of equipment suppliers, importers, & retailors	SR and PR	8	---	---
	Activity 5.3 Strengthen R&D in drip irrigation & best practice at ARDU, University & private entities	S and PR	12	---	---

Next Steps

Ministry of Agriculture CRDU plan a series of meetings with the five farmers' cooperatives to discuss the project concept. An Agriculture Consultant is hired to draft a comprehensive project proposal for submission to FAO and other prospective financial agencies to seek funding for this intervention. Extension officers meet with other farmers not in the participating cooperatives and update them on the project concept and get feedback on the feasibility of these other farmers participating in the training and eventually acquiring their personal improved drip irrigation/fertigation systems.

1.1.3.7 TAP Overview Table

Table 10 is the TAP summary overview for the proposed diffusion of improved drip irrigation/fertigation systems. The TAP overview highlights the actions, activities, ambition, benefits, possible sources of funding, a timeline for implementing the activities, risks, success criteria, indicators for monitoring the implementation and the estimated cost for the successful diffusion of the technology. It summarizes the ambition or scope of the technology diffusion and benefits to realize its successful implementation.

Also presented is a brief overview of the success criteria for each action and indicators for monitoring implementation of these actions.

Table 10: TAP summary overview for improved drip irrigation/fertigation systems diffusion

Sector	Agriculture							
Sub-sector	Water and Agriculture							
Technology	Improved drip irrigation/fertigation systems							
Ambition	Increased use of drip irrigation for crop production is a national priority and is a recommended climate change adaptation technology to reduce stress on water resources, soil and forest resources. Improved drip irrigation systems will be installed at five farming cooperative sites, and one at the Ministry of Agriculture field training station at the Agriculture Showgrounds near Belmopan. The aim is to provide hands-on installation and training in cultivation using improved drip irrigation and fertigation to farmers' cooperatives and individual farmers on a pilot scale initially, then encourage farmers' groups and individual farmers to purchase and install their own irrigation system, especially for farmers in the drought prone regions.							
Benefits	Economic benefits for farmers' groups and individual farmers and family, realized through decreased inputs and increased yields. Environmental benefits will be in the form of reduced deforestation, reduced emissions and water and soil conservation. Farmers knowledge and skills will also be enhanced.							
Actions	Activities to be implemented	Sources of funding	Responsible body and focal point	Time frame (weeks)	Risks	Success criteria	Indicators for monitoring of implementation	Budget per activity (US$)
Action 1. Procure finance to introduce improved drip irrigation / fertigation technology	Activity 1.1 Conduct a feasibility study and C/B analysis for expansion of drip irrigation countrywide	CCCCC/UNDP-GEF/ WB/IDB/ GOB	CRDU-MOA	2	CR & PR 12	High	Completed Feasibility and C/B Report	In kind, GOB
	Activity 1.2 Draft project proposal for funding to establish seven improved drip irrigation/fertigation systems with water catchment for training and demonstration	FAO/GCF	CRDU-MOA	4	SR & PR 20	High	Project proposal drafted, reviewed and submitted	15,000.00
Action 2.	Activity 2.1 Allocate training budget for Training of Trainers programme	FAO/GCF	CRDU/Extension Service-MOA	1	CR 12	High	Funds procured for training	12,000.00

Procure finance to organize and run training programme for groups of farmers	Activity 2.2 Draft and implement training programme for famers in improved drip irrigation /fertigation and water harvesting in all districts	FAO/GCF	CRDU/Extension Service	2	SR & PR 12	High	Training and demonstration programme for farmers realized	18,000.00
	Activity 2.3 Write, print and disseminate improved drip irrigation guidelines in English and Spanish	MOA-GOB	CRDU/Extension Service/	3	SR & PR 9	High	Improved drip irrigation Guidelines in English and Spanish printed and disseminated	12,000.00
Action 3. **In coordination with Hydrology Unit, MOA to conduct an ongoing awareness programme on water use, conservation and management**	Activity 3.1 Develop information manuals for extension officers, farmers and public for awareness programme on water management and use in agriculture	FAO/GCF / UNDP-GEF	Extension Service/Fruit & Grain Seed Production Unit-MOA	4	SR & PR 16	High	Manuals on water use and conservation printed and available	15,000.00
	Activity 3.2 Hold series of workshops and field demonstrations on efficient water use and water harvesting for drip irrigation	FAO	CRDU-MOA & Hydrology Unit/University of Belize School of Agriculture (UB)		CR, SR & PR 16	Mod	Three workshops programmed and conducted	15,000.00
	Activity 3.3 Participate in radio talk shows, expos and visits to farmers groups	GOB	CRDU & Extension Service/Water 7 Climate Change Unit	4	SR & PR 12	Mod	Five activities in public awareness conducted successfully	20,000.00

Action 4. MOA and Partners review, update and implement relevant provisions of the National Irrigation and Water Use Strategy	Activity 4.1 Organize and promote networking with University, private entities and others on implementation of NIWS	FAO/GOB	Extension Service, Policy Unit and UB	3	SR & PR 9	High	Network protocol establish and functional	4,000.00
	Activity 4.2 Develop programmes for farmers on activating certain provisions of the NIWS	FAO/GOB	CRDU-Extension Service	3	SR & PR 9	Mod	Programme developed and coordination with farmers completed	6,000.00
Action 5. Strengthen research, development & demonstration of new technology	Activity 5.1 Assess the current use of drip irrigation and identify need and gaps (e.g. equipment, agronomic practices, water use)	FAO/GCF	ARDU-PSC-Extension Service-MOA	8	SR & PR 12	High	Rapid Assessment completed and submitted by Consultant	12,500.00
	Activity 5.2 Promote network of equipment supplier, importers, & retailors equipment	GOB	PSC/Policy Unit	4	SR & PR 8	Mod	Networking protocol established after series of meeting and consultation	6,800.00
	Activity 5.3 Strengthen R&D in drip irrigation & best practice at ARDU, University & private entities	FAO/GCF	ARDU/UB	4	S & PR 12	Mod	Programme for R&D agreed upon by partners. R&D Task Group formed with two farm reps.	5,000.00 per year
TOTAL								$ 141,300.00

(Note: logistics cost incorporated in overall cost of activities. (These include travel and per diem for public officers)).

1.1.4 Action Plan for crop protective covered structure cooling systems

1.1.4.1 Introduction

A tropical greenhouse aims to create an ideal condition in which plants can be protected against heavy rainfalls, direct solar radiation, disease, insects and birds. High relative humidity and ambient temperature microclimate in a tropical greenhouse create a complicated dynamic system that is strongly influenced by changes of external conditions, making it a challenging environmental control task (Shamshin & Wan Ismael, 2013). The central problem with tropical greenhouses or Protective Cropping or Covered Structures (PCSs) is the high, uncomfortable internal temperatures that develop during hot, sunny days in the tropics, limiting the number of working hours inside these structures.

Protective Covered Structures were introduced in Belize under the 9th European Development Fund (EDF) financed Agriculture Enterprise Development project (AED), and was well received by vegetable farmers. Some structures have been properly managed, and several farmers have experimented with lower cost design structures (Salazar, 2013; Frutos, 2014).

As indicated, one purpose of Protective Covered Structures (PCSs) is to create a controlled environment for optimum growing conditions compared to growing outside in a non-controlled environment (FAO, 2011). A farmer or grower has many options in the design of the greenhouse structure, and on how much control he/she may want or need for the crops that are being grown. Specifically, Protective Covered Structures (PCS) or Tropical Greenhouses contribute to increased productivity, improved produce quality, reduced cost of production, water conservation, and reduced dependence on pesticides (Ramirez, 2010).

Protective Covered Structures in Belize are of four types, namely: Tropical Greenhouse, Bubble House, Bel Tunnel and Plastic Covered Structure (Ramirez, 2010; Reyes, 2010).

Improved PCS designs may incorporate the following cooling technologies:

- Natural Passive Ventilation (Air exchange) and shading systems (cheaper common design);
- Mechanical Active Ventilation powered with a small diesel generator;
- Mechanical Active Ventilation powered with solar energy;
- Evaporative Cooling: i) Evaporative cooling fan-pads, and ii) High pressure fogging.
- Earth-to-air heat exchange system.

1.1.4.2 Ambition for the TAP

Rehabilitation of Protective Covered Structure cooling systems: The Government of Belize, through project funding, bought a total of 30 greenhouses at the rate of BZ$30,000.00 in 2010. Some of these greenhouses are still in use but the majority have fallen into disrepair and have been abandoned. Over the years the CRDU has also been refining the construction of Bel Tunnel cover structures, similar in design to the Tropical Greenhouse, but smaller in size. The technology transfer aims at installing improved cooling systems in at least eight (8) crop PCSs (tropical greenhouses) in operational use around the country, with the capacity to address the inefficient cooling systems for other crop cover

structures as demand for this service increases. The beneficiaries will be both small and medium-scale farmers who routinely utilize crop cover structures. Table 11 summarises the targets and attainment of technology uptake for PCS improved cooling systems.

Table 11: Targets and attainment of technology transfer of improved cooling systems for tropical greenhouses

Sector: Technology - Agriculture	Targets	Too Ambitious	Conservative
Improved cooling system for Crop cover structures (Tropical Greenhouses /Bel Houses)	Refurbishing cooling systems for at least 8 crop cover structures. Intention is to develop a business for rehabilitation of existing cover structure cooling systems as demand for installation increases and maintenance rises	Initial cost for cooling system components could be high for individual small, subsistence farmers.	Yes. **Capital Costs:** US$147,000.00 for cooling system refurbishment of (8) Tropical Greenhouses and Bell Tunnel Covered structures, with ambition to expand into a small service provider industry **Operational costs:** US$28,000.00 for three years (spares & maintenance).

The Ministry of Agriculture's Crop Research and Development Unit (CRDU) will coordinate this intervention. The objective is to build technical capacity in the CRDU to initially improve the cooling system of the eight (8) target PCSs, then provide similar installation and maintenance service to farmers and agro-industry enterprises, interested in upgrading their PCS cooling systems at an affordable cost.

1.1.4.3 Actions and Activities selected for inclusion in the TAP

Summary of barriers and measures to overcome barriers

Table 12 shows a summary of the barriers and measures identified in relation to the transfer of improved cooling system technology for tropical greenhouses and BEL houses. These are the list of barriers and measures originally presented in the adaptation technologies Barrier Analysis and Enabling Framework report. Stakeholders settled for five of the most important measures or actions that could help facilitate the diffusion of the PCS cooling system technology. These measures or actions and corresponding technology transfer activities are presented in Table 13.

Table 12: Barriers and measures for improved designs and diffusion of protective covered structures cooling system technology

Categories	Identified Barriers	Measures to overcome barriers	Intervention		Funding Sources	
			Legal	Other	National	External
Economic and financial	−High upfront costs	─ Expand access to finance – Procure finance for refurbishment of PCS cooling systems powered with RE technology ─ Procure finance to organize and run training programme for rehabilitation of PCS cooling systems		√	√	√
	− Limited subsidies and high import duties/taxes for technology components	− Lobby for reduced import tax on equipment and seeds	√		√	
	− High cost of installation of integrated cooling systems for PCS	− Provide technology companies & suppliers with concession to service specific areas or groups of clients at reduced service costs		√	─ Public-private partnership	
Market conditions	− Gaps in technology value chain	− Conduct feasibility study for setting-up local assembling industry for PCSs in country		√	√	√
	− Local hardware stores often low in stocks of spares & components	− Expand access to products and services. ─ Grow the market for new technologies related to PCS		√	√	√
	− Small market for PCS; special interest groups control	− Review and implement policies & regulations for favourable market climate	√		√	
Legal and regulatory	− Inadequate policy and regulatory framework	− Improve policy and enabling environment (e.g. seed policy, market liberalisation, protectionism, monopoly incumbent technology).	√		√	

	− No office for testing and certification	− Establish regulatory agency for standards, testing and certification (equipment, seeds, etc.)	√		√	√
	− Import of cheaper, inferior-quality equipment/products	− Strengthen regulatory framework (i.e. enforcement & penalty)	√		√	
Network structures	− Networking among professionals and agencies weak and ineffective	− Enhance networking for PCS technology/ improved drip irrigation − Strengthen research, development and demonstration for improved PCS technology		√	√	√
	− Farmers' groups and cooperatives generally work in insolation (crop specific)	− Strengthen Cooperative Dep. and farmers' cooperatives. Use modern ICT for networking	√	√	√	
	− Limited farmer to farmer visits	− Increase local and regional farmer's networking in O&M of PCSs and related agronomic skills		√	√	√
Others	− Limited awareness and knowledge of improved PCS technology cooling system	− Establish management programme and education/awareness campaign among key stakeholders for new technology		√		√
	− Low technical capacity	− Establish training component in technology diffusion programme		√		√
	− Farming communities and farmers suspicious and afraid of change	− Through technology diffusion programme address social, cultural and behavioural issues; improve KAP* among users		√		√
		− CRDU redesigns PCS for tropical conditions using Renewable Energy (solar PV) for cooling systems			√	

1.1.4.4 Actions selected for inclusion in the TAP

Table 13 is a list of the key actions and related activities for implementation of selected actions for the diffusion of PCSs advanced cooling technology for eight (8) PCS or greenhouses, then facilitating similar installation and maintenance service to farmers and agro-industry enterprises, interested in upgrading their PCS cooling systems at an affordable cost.

Table 13: Activities for implementation of selected actions for the diffusion of PCSs advanced cooling technology

Action 1. Procure finance for refurbishment of PCS cooling systems powered with RE technology	**Action 2.** Help facilitate & secure local funds for producers to acquire technology	**Action 3.** Increase service offerings of certified technicians – Public/Private partnership	**Action 4.** Create awareness of technology and identify financial support mechanisms	**Action 5.** Strengthen research and development of new Protective Cover Structure (PCS) technology
1.1 Conduct feasibility study and C/B on PCS use, supply, demands and refurbishment	2.1 Lobby for incentives to get famers interested in improved PCS technology.	3.1 Open a small market for locally designed and manufactured PCSs	4.1 Implement a training and demonstration programmed for erection and operation of improved PCS	5.1 Assess the current use of PCS countrywide, and identify need and gaps (e.g. design, status & equipment, agronomic practices e.g. integrated pest control, and water use).
1.2 Draft and submit bankable pilot project proposal for refurbishment of PCS cooling systems with RE technology	2.2 Support and organize local importers and retailors of PCS systems, pumps, water harvesting equipment, others.	3.2 Advance local designs of BEL Covered Structure with adequate cooling systems	4.2 Organize farmer-to-farmer working visits to improve exposure on the use of PCS, IPC and other agronomic practices in a controlled environment	5.2 Promote network of equipment supplier, importers, & retailors equipment.
	2.3 Organize farmers' cooperatives to seek low interest loans for purchase and operation of improved PCS technology			5.3 Strengthen R&D in PCS & drip irrigation best practice at ARDU, University & private entities.

Actions to be implemented as Project Ideas

1. Strengthen research and development of new Protective Cover Structure (PCS) technology.

The action proposed in (1) above will be coordinated by the MOA Crop Research and Development/Innovation Unit, with support from partners in agriculture such as IICA, Farmers Cooperatives, University of Belize, GOB and FAO. A project proposal seeking finance for initial R&D seed-funding will need to be drafted, vetted and submitted to the regional FAO office in the Caribbean. The aim is to begin the R&D activities to improve PCS technology as a two-year pilot project. Thereafter, the GOB and other partners will support further R&D for agriculture technology diffusion and application, other than new designs and construction of PCSs. The estimated capital investment for the initial pilot project will be US$140,000. This will cover fees for the researchers and engineers, procurement of equipment and PCS components, training manuals, and demonstration seminars/workshops.

1.1.4.5 Stakeholders and Timeline for implementation of TAP

Overview of Stakeholders for the implementation of the TAP

The technology transfer aims at installing improved cooling systems in at least eight (8) crop PCSs (tropical greenhouses) in operational use around the country, with the capacity to address the inefficient cooling systems for other crop cover structures as demand increases. The main stakeholders are the personnel of the CRDU and Extension Service of the MOA, famers and horticulturist operating under over-heated protective cover structures. The beneficiaries will be both small and medium-scale farmers who routinely utilize crop cover structures and horticulturists.

Scheduling and sequencing of specific activities

Table 14 is a listing and timeline of the main actions and activities identified for the diffusion of improved designs of protective cover structure cooling system technology, targeting eight (8) PCSs that are in disrepair. This pilot intervention aims at expanding the knowledge and skills for installing/operating improved PCS cooling system and develop a local market for this specialized service in-country.

Table 14: Schedule and sequence of activities for improved designs and diffusion of protective covered structures cooling system technology

Actions	Activities	Timeline (months)																			
		1	2	3	4	5	6	7	8	9	10	11	12	14	16	18	20	24	26	28	30
Action 1: Procure finance for refurbishment of PCS cooling systems powered with RE technology	Activity 1.1 Conduct feasibility study and C/B on PCS supply, demands and refurbishment																				
	Activity 1.2 Draft and submit bankable project proposal																				

Actions	Activities	Timeline (months)																			
		1	2	3	4	5	6	7	8	9	10	11	12	14	16	18	20	24	26	28	30
Action 2: Help facilitate & secure local funds for producers to acquire technology	Activity 2.1 Lobby for incentives to get farmers interested in improved PCS technology																				
	Activity 2.2 Support and organize local importers and retailors of PCS systems, pumps, water harvesting equipment, others																				
	Activity 2.3 Organize farmer's cooperatives to seek low interest loans for purchase and operation of improved PCS technology																				
Action 3: Increase service offerings of certified technicians – Public/Private partnership	Activity 3.1 Open a small market for locally designed and manufactured PCSs																				
	Activity 3.2 Advance local designs of BEL Covered Structure with adequate cooling systems																				
Action 4. Create awareness of technology and identify financial support mechanisms	Activity 4.1 Implement a training and demonstration programme for erection and operation of improved PCS																				
	Activity 4.2 Organize farmer-to-farmer working visits to improve exposure on the use of PCS, IPC and other agronomic practices in control environment																				
Action 5. Strengthen research and development of new PCS technology	Activity 5.1 Assess the current use of PCS countrywide, and identify needs and gaps (e.g. design, status & equipment, agronomic practices e.g. integrated pest control IPC, and water use)																				

Actions	Activities	Timeline (months)																			
		1	2	3	4	5	6	7	8	9	10	11	12	14	16	18	20	24	26	28	30
	Activity 5.2 Promote network of equipment suppliers, importers, & retailors																				
	Activity 5.3 Strengthen R&D in PCS & drip irrigation best practice at ARDU, University & private entities																				

Estimation of Resources Needed for Action and Activities

Estimation of capacity building needs

The beneficiaries of this action to install improved cooling systems in at least eight PCSs will be both small and medium-scale farmers who routinely utilize crop cover structures. Capacity strengthening will be required for at least two additional technicians working with the CRDU, and four Extension Officers in the Ministry of Agriculture.

Estimations of costs of actions and activities

Estimated capital costs**:** US$147,500.00 for cooling system refurbishment of (8) Tropical Greenhouses and Bell Tunnel Covered structures. Operational costs**:** US$28,000.00 for three years (spares & maintenance).

1.1.4.6 Management Planning

Risks and Contingency Planning

Table 15 shows a listing of the actions, activities, risks, contingencies and estimated costs. The five risks and related actions considered earlier in Table 23 are reviewed for risks. Risk indices scoring 15 and greater were further evaluated for contingency and cost. See Table I-3 in Annex I for a detailed assessment.

Table 15: Risk and contingency planning for improved designs and diffusion of protective covered structures cooling system technology

Action	Activities to be implemented	Risks	Risk Index	Contingency	Cost USD
Action 1:	Activity 1.1 Conduct feasibility study and C/B on PCS supply, demands and refurbishment	CR and PR	12	---	---

Procure finance to refurbish protective covered structure (PCS) cooling systems powered with RE technology	Activity 1.2 Draft and submit bankable project proposal	SR and PR	20	Project steering committee to review proposal and submit to several donors and/or financial institutions	8,000.00
Action 2: Help facilitate & secure local funds for producers to acquire technology	Activity 2.1 Lobby for incentives to get famers interested in improved PCS technology	SR and PR	16	If first try is a failure reorganize the lobby, get policymakers involved and resubmit incentive petition via cabinet paper	5,000.00
	Activity 2.2 Support and organize local importers and retailors of PCS systems, pumps, water harvesting equipment, others	SR and PR	12	---	---
	Activity 2.3 Organize farmers' cooperatives to seek low interest loans for purchase and operation of improved PCS technology	SR	16	Provide logistical support to farmers' cooperative and individual farmers applying for soft loans	5,000.00
Action 3: Increase services offerings of certified technicians – Public/Private partnership	Activity 3.1 Open a small market for locally designed and manufactured PCSs	CR	14	Review the CB analysis and market for PCS, and organized field days for farmers to demonstrate the many benefits of using PCSs (One per district)	24,000.00
	Activity 3.2 Advance local designs of BEL Covered Structure with adequate cooling systems	CR and PR	9	---	Already being done by ARDU. Risk low
	Activity 4.1 Implement a training and demonstration programme for erection and operation of improved PCS	CR and PR	9	---	---

Action 4. Create awareness of technology and identify financial support mechanisms	Activity 4.2 Organize farmer-to-farmer working visits to improve exposure on the use of PCS, IPC and other agronomic practices in a controlled environment	CR and PR	12	---	---
Action 5. Strengthen research and development of new PCS technology	Activity 5.1 Assess the current use of PCS countrywide, and identify needs and gaps (e.g. design, status & equipment, agronomic practices, e.g. integrated pest control, and water use)	CR and PR	12	Ensure an effective survey instrument and personnel to analyse the results	---
	Activity 5.2 Promote network of equipment suppliers, importers, & retailors	SR and PR	12	Organize equipment suppliers and plan regular meetings on incentives, conducting business and expanding the market	---
	Activity 5.3 Strengthen R&D in PCS & drip irrigation best practice at ARDU, University & private entities	CR	14	Schedule meetings in various locations, organize entities and have participants develop TOR and elect leader	8,000.00 per annum initial budget

Next Steps

The MOA CRDU and members of the Extension Service will hold a series of meetings to revaluate the targeted PCS for improved cooling system upgrade. A cost-benefit analysis is conducted to evaluate the feasibility of PCS refurbishment and construction. The CRDU takes the lead in contracting a consultant to draft a bankable project proposal for submission to donor agencies such as FAO, Taiwan Mission in Belize, UNDP GEF-Small Grants, GCF, CCCCC, and others.

1.1.4.7 TAP Overview Table

Table 16 is the TAP summary overview for improved designs and diffusion of protective covered structure cooling systems technology. It highlights the ambition or scope of the technology diffusion, benefits, key actions and related activities to realize its successful implementation. Also presented is a brief overview of the success criteria for each action, indicators for monitoring implementation of these actions, and an estimate in US dollars of the costs to carry out each action.

Table 16: TAP Summary overview for improved designs and diffusion of protective covered structures cooling system technology

Sector	Agriculture							
Sub-sector	Agriculture Systems							
Technology	Improved designs and diffusion of protective covered structures cooling system technology							
Ambition	Refurbishing cooling systems for at least 8 crop cover structures as a pilot intervention. Intention is to develop a business for rehabilitation of existing cover structure cooling systems as demand for installation and maintenance rises. Capital Costs: US$109,500.00 for cooling system refurbishment of (8) Tropical Greenhouses and Bell Tunnel Covered structures. Training programme for installation and operational use of greenhouses (PCS) will be conducted by the MOA Crop Research and Development Unit (CRDU). Operational costs: US$28,000.00 for three years (spares & maintenance).							
Benefits	Beneficiaries will be small and medium scale farmers cultivating under PCS enhancing yields and income. Environmental benefits will be reduced deforestation for more cultivation, reduced land degradation, soil conservation and improved agronomic practices.							
Actions	**Activities to be implemented**	**Sources of funding**	**Responsible body and focal point**	**Time frame Months**	**Risks**	**Success criteria**	**Indicators for monitoring of implementation**	**Budget per activity**
Action 1: Procure finance for refurbishment of PCS cooling systems powered with RE technology	Activity 1.1 Conduct feasibility study and C/B for PCS supply, demand and refurbishment	FAO/GOB/ UNDP-GEF	CRDU-MOA	0.75	CR & PR 12	High	Feasibility and C/B Report	8,000.00, in kind GOB
	Activity 1.2 Draft and submit bankable project proposal	FAO/GOB/ UNDP-GEF	Project Steering Committee/ CRDU-MOA	1	SR & PR 20	High	Bankable project proposal revised and submitted	8,000.00
Action 2:	Activity 2.1 Lobby for incentives to get famers interested in improved PCS technology	FAO/GOB	CRDU/Policy Unit-MOA	1	SR & PR 16	Mod	Maintain advocacy among key stakeholders and policymakers	5,000.00

Help facilitate & secure local funds for producers to acquire technology	Activity 2.2 Support and organize local importers and retailors of PCS systems, pumps, water harvesting equipment, others	GOB	CRDU/Policy Unit	0.75	SR & PR 12	Mod	May also require some form of incentives to get attention and interest of business actors	6,000.00
	Activity 2.3 Organize farmers' cooperatives to seek low interest loans for purchase and operation of improved PCS technology	FAO/DFC Credit Union	CRDU/Extension Service	1.5	SR 16	High	Some farmers are organized. Need to motivate them and strengthen existing cooperatives	5,000.00
Action 3: Increase services offerings of certified technicians – Public/Private partnership	Activity 3.1 Open a small market for locally designed and manufactured PCSs	UNDO-GEF	CRDU to coordinate with Private Sector entity who spearheads this action	2	CR & PR 14	Mod	Feasibility and market may be key factors for success. Private Sector entity should take lead	24,000.00
	Activity 3.2 Advance local designs of BEL Covered Structure with adequate cooling systems	FAO/ UNDP-GEF	CRDU technical strengthening to lead and coordinate this action	2	CR & PR 9	High	New climate and eco sensitive designs with RE power supply developed for diverse cropping	Already being done by CRDU. Risk low
Action 4.	Activity 4.1 Implement a training and demonstration programmed for erection and operation of improved PCS	FAO/UNDP-GEF	Led and Coordinated by CRDU-MOA	3	CR & PR 9	High	Number of trained farmers and producers per annum	20,000.00

Create awareness of technology and identify financial support mechanisms	Activity 4.2 Organize farmer-to-farmer working visits to improve exposure on the use of PCS, integrated pest management (IPC), and other agronomic practices in a controlled environment	FAO/GOB	Extension Service and partners (CARDI, CREI, etc)	3	CR & PR 12	High	Number of exchange visits per annum	15,000.00
Action 5. Strengthen research and development of new PCS technology	Activity 5.1 Assess the current use of PCS countrywide, and identify needs and gaps (e.g. design, status & equipment, agronomic practices, e.g. integrated pest control, and water use)	FAO/UNDP-GEF	Consultant working with CRDU personnel	2.5	CR & PR 12	High	Assessment Report	20,000.00
	Activity 5.2 Promote network of equipment suppliers, importers, & retailors	FAO/GOB	Extension Service, CRDU and Policy Unit	1.5	SR & PR 12	Mod	Network of equipment suppliers established and functional. Interest maintained	4,000.00 per annum
	Activity 5.3 Strengthen R&D for PCS & drip irrigation best practice at CRDU, University & private entities	FAO/UNDP-GEF/ GCF	CRDU and Extension Service	4	CR 12	Mod	Number of research reports and seminars to present R&D findings	8,000.00 per annum initial budget
Total							**US$**	**147,000.00**

1.1.5 Action Plan for in-country Irish potato clean-stock production unit to produce quality seed-tuber planting material varieties

1.1.5.1 Introduction

Since potato was first planted in Belize it has been observed that after one season in the field the crop becomes infected with insect-transmitted viruses. As a result, tubers collected from one season become diseased and cannot be used as seed-tubers for planting the following season. To address this issue, fresh, quality potato seed tubers are imported from the United States each year. Unfortunately, these varieties have been developed for the temperate climates.

The effects of global warming are already evident in Belize, with increase of surface air temperature and high variability in seasonal rainfall (GOB-NCCO, 2016), and unless more suitable varieties of Irish potato seedlings are made available to farmers, it may become almost impossible to produce potatoes at a cost-effective scale in Belize. If this were to occur, the country's food security could be jeopardized. Officials in Belize have not, so far, investigated alternative potato varieties, but the urgency to do so increases with the advancing threat of climate change.

On way to address the need to import temperate varieties of Irish potato planting material annually is to introduce technology for an in-country potato seed-tuber production system through micro-propagation of imported breeder seed-tubers, with the approval of the plant breeder organization. The system will ensure quality, disease-free and diversified potato varieties that have been tested locally and have demonstrated high productivity under Belize's tropical conditions and that are made available to farmers.

Additionally, this technology will permit an increase in national potato production by extending the potato cropping season, and by expanding potato cultivation into other areas which are too warm for potato farming using varieties currently available. This will not only reduce the need to import potatoes to supply the national consumer markets, but it will also save on foreign exchange by eliminating the annual requirement to import expensive, foreign-sourced seed-tubers. An improved and expanded potato production system resilient to warmer climatic conditions would enhance national food security and bring economic benefits for many farming communities in Belize.

1.1.5.2 Ambition for the TAP

Summary of key barriers for micro-propagation and successful diffusion of clean, certified Irish potato seed-tubers

Clean, certified Irish potato seed-tubers replicated locally through micro-propagation of imported climate resilient, 'source basic seed' would likely be twice the cost of a unit of incumbent seeds, but GOB subsidy in the initial phase would make it affordable to farmers. Certified seeds-tubers will be climate resilient and yields per acre or hectare can be higher with the appropriate input. Initial cost for drip irrigation (if used) is not included, but the benefits to potato growers would be profitable in the

short and medium term. If storage is available, farmers will very likely be able to fetch higher prices per unit weight of their potato as market demands increase.

The highly detrimental barriers for this technology transfer identified and analysed in the Barrier Analysis are: the high up-front costs, and time constraint for upgrading the UB Micro-Propagation Laboratory facilities and upgrading the necessary technical capacity. Also, another barrier is the extended, start-up time for the micro-propagation process from imported 'Source Basic Seeds (i.e. clean parent material) to micro-tuberization stage, reproduction of mini-tubers in screen houses (PCS), and then mini-tuber germination to produce certified seed-tubers for farmers. However, the propagation of new batches of clean, planting material will be staggered and ongoing, once the process commences; so, there will always be mini-tubers in storage and at the stage of germination, to produce additional quantities of certified seed-tubers for growers.

Trials on different varieties of Irish potato could be encouraged at random, specifically for varieties that meet certain market demand, both locally and regionally, and in this way, Belize may be able to develop a profitable, potato production industry. The scope as per market mapping for micro-propagation of clean, climate resilient, certified Irish potato seed-tubers (Ref. Annex II H2 Barrier Analysis & Enabling Framework report, Adaptation, 2018) is:

- Source Basic Seeds (Clean parent material): Procured from potato breeding centres in the United States and/or the International Potato Centre in Peru (CIP), private sector importers, GOB through MOA/UB, CARDI, others.
- Import duties/taxes and subsidies: Taxes may apply, but subsidies may be granted to importers which can be passed down to the farmers at the other end of the market chain.
- UB micro-propagation laboratory: Equipment and material will have to be procured in the capital cost for up-grading laboratory facilities, and funds must be made available for the first 2.5 years of operation and maintenance. Funds for an expert consultant for developing production strategic workplan and protocol for micro-propagation of 'Source Basic Seeds" to certified potato seed tubers for farmers must be part of the capital costs, initially. Training of micro-propagation laboratory technicians and field workers, and farmer's outreach programme and technology awareness/education campaign should also be funded from capital cost.
- Importers and Retailers: Equipment and spares for irrigation, fertigation, cover structures, nursery, and water pumping/harvesting and storage, shall be imported, and stocks made available. Import taxes are mostly zero rated for irrigation and solar PV systems, but taxes are applied for certain components such as inverters, batteries, and miscellaneous spares.
- Input and Service Providers: Generally available. Gaps exist in provision of information on technology and the changing market, and also networking among producers and service providers and importers.
- Enabling Business Environment: MOA and partners (UB, CARDI, BELTRAIDE, IICA, DFC and foreign breeders) are available to provide guidance and advise to farmers on issues related to affordable loans, other finance opportunities, the market, and policy changes. The gap here seems to be limited networking among main actors, the leadership role here is the UB/MOA, whose extension service and policy office is closest to farmers. The Extension Service plays a

crucial role and must be empowered (through training, increased capacity and public relations) to continue the good work of improving production among the small and medium scale farmers. An MOU between MOA and UB will have to be drafted and ratified.

The micro-propagation of climate resilient, Source Basic Seeds of Irish Potato is envisioned to become sustainable and profitable in the medium term as potato production increases, and market opportunities are secured.

Technology Application:

The establishment of an in-country Irish potato clean-stock production unit (UB-MOA) to produce certified seed-tuber planting material varieties better suited to Belize's current and future climate will require: i) 4 Solar-powered air conditioning units to replace inefficient units at the laboratory on the UB compound at Central Farm; ii) 3 Solar cooling and irrigation systems with solar pumps and solar fans for Screen houses; and iii) 9 Solar-powered air conditioning units for 3 storage structures.

Table 17 shows a preliminary estimated capital and operating costs for quality Irish potato seed-tubers micro-propagation.

Table 17: Estimated capital and operating costs for micro-propagation of Irish potato seed-tubers

Capital Investment Cost	Total Capital Cost:	US$ 455,000
Operating Cost	Maintenance and operations (5-years)	US$375,000.00
	Establishment of standards & certification	US$50,000.00
	Total operating costs:	**US$425,000.00**
Total Project Costs		**US$880,000.00**

1.1.5.3 Actions and Activities selected for inclusion in the TAP

Summary of barriers and measures to overcome barriers

Table 18 is a summary of the main barriers and measures identified earlier for the diffusion of in-country micro-propagation of Irish potato seed-tubers technology.

Table 18: Barriers and measures related to the transfer and diffusion of in-country micro-propagation of Irish potato seed-tubers technology

Categories	**Identified Barriers**	**Measures to overcome barriers**	**Intervention**		**Funding Sources**	
			Legal	Other	National	External

Economic and financial	− High capital investment	− Expand access to low interest finance & non-reimbursable funds		√	√	√
	− Limited tax exemption & subsidies for components import	− Lobby for reduced import tax on equipment and seeds	√		√	
	− High cost of installation	− Provide technology companies & suppliers with concession to provide service at reduced service costs		√	(Public-private partnership) √	√
Market conditions	− Gaps in technology value chain	− Streamline certified seed-tuber production from micro-propagation phase to sales of Irish potato seedlings to farmers		√	√	
	− Local hardware stores and retailors often low in stocks of spares & components	− Improve access to products and services. Grow market for new & related technology		√	√	√
	− Unstable market, monopoly, special interest groups	− Implement policies & regulations for favourable market climate	√		√	
Legal and regulatory	− Inadequate policy and regulatory framework	− Recommend policy change and enabling environment	√		√	
	− No office for testing and certification	− Establish regulatory agency for standards, testing and certification (equipment, seeds, etc.)	√		√	√
	− Import of cheaper, inferior-quality equipment/products	− Strengthen regulatory framework (e.g. implementation & penalty)	√		√	
Network structures	− Networking among professionals and agencies weak and ineffective	− Enhance networking for certified seed production/ improved drip irrigation / potato cultivation chain actors. −Strengthen research, development and demonstration of new technology		√	√	√
	− Farmers' cooperatives generally work in insolation (crop specific)	− Strengthen Cooperative Dep. and support the Association of farmers' cooperatives	√		√	

	− Limited awareness and knowledge of new technology among farmers	− Conduct management programme & awareness campaign for new technology among users		√		√
Others	− Low technical capacity	− Establish training component in technology diffusion programme and institutional and technical capacity strengthened		√		√

1.1.5.4 Actions selected for inclusion in the TAP

A list of the key actions and activities for inclusion in the TAP is contained in Table 19. The key actions for this intervention are: Expand access to low interest finance & non-reimbursable funds; and streamline certified seed-tuber production from micro-propagation phase to sales of climate resilient Irish potato seedlings to farmers.

Table 19: Activities for implementation of actions for micro-propagation of quality climate resilient Irish potato seed-tubers

Action 1. Expand access to low interest finance & non-reimbursable funds	**Action 2.** Establish an on-going training programme for laboratory technicians and nursery field workers	**Action 3.** Streamline certified seed-tuber production from micro-propagation phase to sales of climate resilient Irish potato seedlings to farmers	**Action 4.** Strengthen research and development of micro propagation of horticulture and other tuber crop varieties
1.1 Draft a bankable project concept paper and project document for in-country micro propagation	2.1 Bio-technology expert develops training programme	3.1 Expert develops micro propagation laboratory tuberization protocol & field guidelines	4.1 Assess the market for planting material of potato and other tubers (pulses) countrywide
1.2 Streamline certified seed-tuber production from micro-propagation phase to sales of climate	2.2 Three Laboratory technicians and four field workers selected and hired	3.2 Initiate micro-propagation process of imported Irish potato seed-tubers	4.2 Promote network of equipment suppliers, importers, & retailors of nursery /irrigation
1.3 Allocate funds for upgrading UB plant micro propagation laboratory & nurseries	2.3 Training and field demonstration organized and conducted	3.3 Cool storage facility at UB Central Farm constructed and equipped	4.3 Strengthen R&D in PCS & drip irrigation best practice for nurseries at CRDU & University of Belize, and soil conservation/pest management
1.4 Allocate funds for cool temperature storage facility		3.4 Training and public awareness programme for new technology conducted	

1.5 Procure funds for contracting a bio-technology expert to develop and establish Irish potato seed tubers technology			

Actions to be implemented as Project Ideas

1. Integrated soil management and pest control for Irish potato cultivation.
2. Streamline certified seed-tuber production from micro-propagation phase to sales of climate resilient Irish potato seedlings to farmers

The action listed in (1) above is being considered as an activity (4.3) in the prioritized micro-propagation technology of quality, climate resilient varieties of Irish potato at the UB micro-propagation laboratory. A project Idea was developed on the subject of soil and water management and conservation in Section 1.2.2.3 below. The second action to be implemented as a project idea is "Streamline micro-propagation of climate resilient varieties of Irish potato seed-tuber from micro-propagation phase to sales of 'quality' seedlings to farmers". This latter is also one of the project ideas further developed and considered for climate change adaptation in the Agriculture sector (See Section 1.2.2.2).

1.1.5.5 Stakeholders and Timeline for implementation of TAP

Overview of Stakeholders for the implementation of the TAP

The main stakeholders will be personnel of the UB plant micro-propagation laboratory, MOA Extension Services, and Irish potato farmers. MOA and partners (UB, CARDI, BELTRAIDE, IICA, DFC and foreign breeders) are available to provide guidance and advise to farmers on issues related to affordable loans, other finance opportunities, the market, and policy changes.

Scheduling and sequencing of specific activities

Table 20 is a timeline for the actions and activities considered for the implementation of in-country micro-propagation of certified, climate resilient Irish potato seed-tubers. The project cycle is projected to run for five (5) years. Only the first 2.5 years or 30 months is covered in the chronogram of activities.

Table 20: Schedule and sequence of activities for in-country micro-propagation of climate resilient Irish potato certified seed-tubers

Actions	Activities	Timeline (months)																		
		1	2	3	4	5	6	7	8	9	10	11	12	14	16	18	20	24	26	28	30
Action 1. Expand access to low interest finance & non-reimbursable funds	Activity 1.1 Draft a bankable project concept paper and project document for in-country micro-propagation of climate resilient varieties of Irish Potato seed-tubers.																				
	Activity 1.2 Streamline certified seed-tuber production from micro-propagation phase to sales of climate resilient Irish potato seedlings to farmers																				
	Activity 1.3 Allocate funds for upgrading UB plant micro propagation laboratory & nurseries for production of certified potato seed-tubers																				
	Activity 1.4 Allocate funds for cool temperature storage facility																				
	Activity 1.5 Procure funds for contracting a bio-technology expert to develop and establish an Irish potato micro-propagation protocol to produce certified seed-tubers																				
Action 2. Establish an on-going training programme for laboratory technicians and nursery field workers	Activity 2.1 Bio-technology expert develops training programme																				
	Activity 2.2 Three Laboratory technicians and four field workers selected and hired																				
	Activity 2.3 Training and field demonstration conducted																				

Actions	Activities	Timeline (months)																			
		1	2	3	4	5	6	7	8	9	10	11	12	14	16	18	20	24	26	28	30
Action 3. Streamline certified seed-tuber production from micro-propagation phase to sales of climate resilient Irish potato seedlings to farmers	Activity 3.1 Expert develops micro propagation laboratory tuberization protocol																				
	Activity 3.2 Initiate micro-propagation process of imported Irish potato seed-tubers																				
	Activity 3.3 Cool storage facility at UB Central Farm constructed and equipped																				
	Activity 3.4 Training and public awareness programme for new technology conducted																				
Action 4. Strengthen research and development of micro propagation of horticulture and other tuber (pulses) crop varieties	Activity 4.1 Assess the market for planting material of potato and other tuber (pulses) countrywide, and identify need and gaps (design, status & equipment, agronomic practices e.g. integrated pest control [IPC] in nurseries & PCS, and water use)																				
	Activity 4.2 Promote network of equipment suppliers, importers, & retailors of nursery /irrigation equipment																				
	Activity 4.3 Strengthen R&D in PCS & drip irrigation best practice for nurseries at CRDU, University of Belize & private entities																				

Estimation of Resources Needed for Action and Activities

Estimation of capacity building needs

Hiring and training of two additional technical personnel and three field technicians will be required for conducting the micro-propagation protocol for bio-technology reproduction of quality Irish potato seed tubers for the local market. It must be stated that the UB plant micro-propagation laboratory also intends

to diversify its bio-technology application for several other crops aside from sugarcane, bananas, and Irish Potato.

Estimations of costs of actions and activities

Initial investment cost to implement this technology uptake, including minor refurbishment of the UB plant micro-propagation laboratory, setting up new nurseries, procuring certified breed seed-tubers, one large cool storage facility, hiring two additional technical personnel and three field technicians is US$455,000.00. The operational cost for five years is estimated at US $425,000.00.

Capital Investment Cost	Potato seed-tuber expert 4-week working visit to Belize to develop full project document Cost: US$30,000.00 The initial cost of new varieties of seed tubers imported into Belize plus UB micro-propagation lab services and nursery infrastructure development and certification will be in the order of US$300,000. Construction of cool temperature-controlled potato storage facilities in three locations – US$100,000 BAHA cost for phyto-sanitary services will run in the order of US$5,000 for initial importation of seed tubers and travel of BAHA staff to conduct evaluation in source country. Through BELTRADE fiscal incentives for agro-business and processing, the climate resilient Irish potato seed tuber shipment will be imported with custom duty exceptions US$ 20,000	
	Total Capital Cost:	US$ 455,000
Operating Cost	Establishment of farmer field trials to evaluate varieties: US$25,000	
	Approximate cost of seed-tuber production in screen-house or tropical green house by Ministry of Agriculture and farmer groups - US$50,000 per year, for 3 years of the proposed 5-year project cycle – Total US$150,000.	
	Initial costs for certified seed-tuber acquisition for selected farmers (20), cultivation, harvesting and storage of crops for two seasons – US$100,000.	
	Training programme and public awareness – US$50,000.00 GOB in kind (First 3 year) – US$50,000.00 Establishment of standards & certification – US$50,000.00	
	Total operating costs:	US$425,000.00
Total Project Costs		**US$880,000.00**

1.1.5.6 Management Planning

Risks and Contingency Planning

Table 21 below is a summary of actions, activities, risks, contingency and costs for implementing an in-country, micro-propagation of 'quality' Irish potato seed-tubers. Risks of activities based on significance and consequence are evaluated in Annex I of this Report. Risk indices scoring 15 and greater are further evaluated for contingency and cost. See Table I-4 in Annex I for detailed sample assessment.

Table 21: Risk and contingency planning for in-country Irish potato clean-stock production

Action	Activities to be implemented	Risks	Risk Index	Contingency	Cost (USD)
Action 1. Expand access to low interest finance & non-reimbursable funds	Activity 1.1 Draft a bankable project concept paper and project document for in-country micro-propagation of climate resilient varieties of Irish Potato seed-tuber.	CR and PR	12	--	15,000.00
	Activity 1.2 Streamline certified seed-tuber production from micro-propagation phase to sales of climate resilient Irish potato seedlings to farmers	SR & PR	20	Project steering committee to review proposal and submit to several donors and/or financial institutions	300,000.00 Portion of capital Investment
	Activity 1.3 Allocate funds for upgrading UB plant micro propagation laboratory & nurseries for production of certified potato seed-tubers	CR & PR	16	Lobby for incentives with policymakers and Minister. Get ministerial support	40,000.00
	Activity 1.5 Procure funds for contracting a bio-technology expert to develop and establish an Irish potato micro-propagation protocol to produce certified seed-tubers	CR and SR	25	Organize technical committee review the present status of FAO 'quality' seed policy. Make recommendations for a policy statement. Get support of CEO and prepare cabinet paper on this issue if deemed necessary.	20,000.00

Action 2. Establish an on-going training programme for laboratory technicians and nursery field workers	**Activity** 2.1 Bio-technology expert develops training programme	CR & PR	16	Identify experts and farmers for training workshop. At least 5 sessions of training @ $4,000 per session, expert service $30,000	15,000.00
	Activity 2.2 Three laboratory technicians and four field workers selected and hired	CR	20	If selection and hiring is unsuccessful on first attempt, the process will be repeated with a more extensive advertisement process	10,000.00
	Activity 2.3 Training and field demonstration conducted	CR & PR	12	Procure expert trainers	18,000.00
	Activity 2.4 Allocate funds for cool temperature storage facility (Three locations)	CR & SR	16	Resubmit project concept to GOB/UB/FAO and other donor agencies.	100,000.00
Action 3. Streamline certified seed-tuber production from micro-propagation phase to sales of climate resilient Irish potato seedlings to farmers	Activity 3.1 Expert develops micro propagation laboratory tuberization protocol	SR	6	Resubmit expression of interest via popular media (UNDP, CCCCC, WB, etc.)	40,000.00
	Activity 3.2 Initiate micro-propagation process of imported Irish potato seed-tubers	SR & PR	9	Trials conducted to test the process	12,000.00 Project funds allocated
	Activity 3.3 Additional equipment procured, laboratory and cool storage facility at UB Central Farm	CR & PR	20	If an in-country facility for manufacturing of cool storage system and PCSs is not possible, then extend the concept to include other goods so it is feasible and does not suffer from economy-of- scale. Will require high initial investment	40,000.00
	Activity 3.4 Training and public awareness programme for new technology conducted	CR	16	If GOB cannot allocate the funds, then identify funds from other sources through advocacy and lobbying. Draft and submit project proposal	30,000.00

Action 4. Strengthen research and development of micro propagation of Irish potato, horticulture and other tuber crop varieties	**Activity** 4.1 Assess the market for planting material of potato and other tuber (pulses) countrywide, and identify needs and gaps (e.g. design, status & equipment, agronomic practices, e.g. integrated pest control in nurseries & PCS, and water use)	SR & PR	12	Market Assessment Report submitted to UB & MOA after further consultation and revision by Consultant	15,000.00
	Activity 4.2 Promote network of equipment suppliers, importers, & retailors of nursery /irrigation equipment	CR & SR	12	Equipment and agriculture supply providers are organized into working group to provide improved services to farming communities	8,000.00 annual budgets for activities and expos
	Activity 4.3 Strengthen R&D in PCS & drip irrigation best practice for nurseries at CRDU, University of Belize & private entities	S & PRR	16	Have an option B for a roving Agronomist who will conduct improved agronomic practices (integrated soil and water management, etc.)	36,000.00 per annum
	Activity 4.4 Promote improved agronomic practices specific for 'quality' seed-tuber production (e.g. soil conservation, water conservation, etc.)	CR & PR	9	Procure the services of an additional expert agronomist to work with the Seed Production Unit to help facilitate demonstration workshops	35,000.00 per annum
Action 5. Support Agriculture infrastructure and management	5.1 Assessing the current micro propagation seed-tuber production status and methodology to identify needs and gaps (e.g. agronomic practices)	RC	20	Revisit the CB and feasibility study of establishing an Agriculture Regulating Agency with BAHA & Ministry of Trade and Economic Development. May have to prepare updated policy recommendations and cabinet paper.	20,000.00

	5.2 Establish a regulating agency for quality seeds and seed-tuber micro-propagation and agriculture equipment	CR & PR	20	Revisit the FAO recommendation on "quality' in-country seed certification rather than the costly, external "certification" for BAHA for example	12,000.00
	5.3 Strengthen stock seed source at Central Farm	CR & PR	20	Stock seed source at Central Farm requires adequate cool storage facility and accessories. Ensure these are available, otherwise procure funds for completion of facilities.	15,000.00

Next Steps

Initially, UB micro-propagation laboratory Director and technical experts should hold a series of meetings with the MOA Grain Seed Production Unit and CRDU to assess the market opportunities for in-country micro-propagation of climate resilient Irish potato seed-tuber varieties. Next a survey should be conducted among potato-growing farmers and potential farmers on the concept of supply 'quality' water and temperature tolerant varieties of potato for the local market. UB should then secure the service of a Consultant to develop a bankable project proposal for expanding the services of the University of Belize (UB) micro-propagation laboratory to include the bio-technological production of quality Irish potato seed-tubers as planting material. A public awareness and education programme should be developed and conducted to sensitize the farming community about the proposed intervention.

An investigation should commence for suitable and clean Irish potato seed-tuber stocks regionally and internationally and discussions should be encouraged on getting the license to micro-propagate and field test several varieties of heat-tolerant Irish potato seedlings. The Belize Agriculture Health Authority (BAHA) should be invited to these preliminary sessions, as they will be responsible for the phytosanitary aspect of seed importation.

1.1.5.7 TAP overview table

Table 22 shows the TAP overview table for in-country Irish potato clean-stock production of certified seed-tuber planting material varieties. It highlights the technology diffusion ambition, benefits, actions and related activities to facilitate the transfer and diffusion of the technology. Activity risks, success criteria, indicators for monitoring the implementation and estimated costs are all illustrated in the summary table.

Table 22: Summary overview for in-country Irish potato clean-stock production of certified seed-tuber planting material varieties

Sector	Agriculture							
Sub-sector	Crops and Grains							
Technology	Micro-propagation of climate resilient Irish Potato seed-tubers (laboratory and nursery facility available)							
Ambition	On way to address the need to have to import temperate varieties of Irish potato planting material annually is to introduce technology for an in-country potato seed-tuber production system through micro-propagation of imported breeder seed-tubers, with the approval of the plant breeder organization. UB already has a functional plant micro-propagation facility and only needs to invest in special requirements and some equipment and trained bio-technologist to micro-propagate Irish potato seed-tubers. The system will ensure quality, disease-free and diversified potato varieties that have been tested locally and demonstrated for high productivity under Belize's tropical conditions and made available to farmers.							
Benefits	This initiative could open the door for increased Irish potato production in country and expand the production market to many more farming communities, and at the same time enhance the country's food security under more extreme climatic conditions associated with climate change.							
Action	Activities to be implemented	Sources of funding	Responsible body & focal point	Time frame WKs	Risks	Success criteria	Indicators for monitoring of implementation	Budget per activity (USD)
Action 1. Expand access to low interest finance & non-reimbursable funds	Activity 1.1 Draft a bankable project concept paper and project document for in-country micro-propagation of climate resilient varieties of Irish Potato seed-tubers.	CGF, GEF, WB, IDB,	UB and MOA & NCCO	12	CR & PR 12	High	Bankable project proposal drafted, revised and submitted	15,000.00
	Activity 1.2 Streamline certified seed-tuber production from micro-propagation phase to sales of climate resilient Irish potato seedlings to farmers	FAO, GCF, UNDP-GEF	UB & Grain Production Unit and Extension Service	20	SR & PR 20	High; portion of costs will come from capital investment	Irish potato 'certified' or 'quality' seed-tuber planting material production and sales to farmers' groups and individual farmers	300,000.00

	Activity 1.3 Allocate funds for upgrading UB plant micro propagation laboratory & nurseries for production of certified potato seed-tubers	GCF, FAO, WB	UB	16	Cr & PR 16	High	UB plant micro-propagation laboratory facilities upgraded, including nurseries	40,000.00
	Activity 1.4 Procure funds for contracting a bio-technology expert to develop and establish an Irish potato micro-propagation protocol to produce certified seed-tubers	GCF, FAO, WB	UB	25	CR & SR 25	High	Bio-technology expert hired and develops Irish potato micro-propagation protocol and best practice	25,000.00
Action 2. Establish an on-going training programme for laboratory technicians and nursery field workers	Activity 2.1 Bio-technology expert develops training programme	GCF, FAO, WB, UBDP-GEF	UB	16	CR & PR 16	High	Training programme developed and implemented	15,000.00
	Activity 2.2 Three laboratory technicians and four field workers selected and hired	GCF, UB-GOB	UB	20	CR 20	High; cost to fund process of selection and hiring	Three trained laboratory technicians hired along with four nursery workers	6,000.00
	Activity 2.3 Training and field demonstration conducted	GCF, UB-GOB	UB	12	CR & PR 12	High	Training sessions successfully completed	18,000.00
	Activity 2.4 Allocate funds for cool temperature storage facility	GCF, UNDP-GEF	UB, MOA		CR & SR 16	Mod (Funds may not be procured on first try)	Funds procured. facility and equipment in place	100,000.00

Action 3. Streamline certified seed-tuber production from micro-propagation phase to sales of climate resilient Irish potato seedlings to farmers	Activity 3.1 Expert develops micro propagation laboratory tuberization protocol	GCF, UNDP-GEF	UB	16	SR 6	High	Protocol drafted, tested and adopted	40,000.00
	Activity 3.2 Initiate micro-propagation process of imported Irish potato seed-tubers	GCF, FAO, UNDP-GEF	UB	6	SR & PR 9	High; Project funds allocated	Process initiated and shows potential for success	12,000.00
	Activity 3.3 Cool storage facility at UB Central Farm constructed and equipped	GCF, FAO	UB	9	CR & PR 20	High	Cool storage at Central Farm renovated and equipped	40,000.00
	Activity 3.4 Training and public awareness programme for new technology conducted	FAO, GCF, UNDP-GEF	UB/MOA	20	CR 16	High	Public awareness programme drafted and presented	30,000.00
Action 4. Strengthen research and development of micro propagation of Irish potato, horticulture and other tuber crop varieties	Activity 4.1 Assess the market for planting material of potato and other tubers (pulses) countrywide, and identify needs and gaps (e.g. design, status & equipment, agronomic practices, e.g. integrated pest control in nurseries & PCS, and water use)	FAO, MOA/GOB	UB/MOA	16	SR and PR 12	High	Market assessment of all planting material, practices and facilities completed and reviewed	15,000.00

	Activity 4.2 Promote a network of equipment suppliers, importers, & retailors of nursery /irrigation equipment	MOA/GOB	MOA Extension Service	12	CR and SR 12	Mod (Lack of interest may be problematic) Annual budgets for activities and expos	Provide incentives to suppliers and scheduled regular meetings	8,000.00
	Activity 4.3 Strengthen R&D in PCS & drip irrigation best practice for nurseries at CRDU, University of Belize & private entities	FAO, GOB	MOA/UB	12	S and PR 16	Moderate; finance budgeted per annum	Will require advocacy at the highest level to stimulate interest of policymakers and scientists	36,000.00
	Activity 4.4 Promote improved agronomic practices specific for seed production (e.g. soil conservation)	FAO	MOA & UB		CR and PR 9	Moderate; finance budgeted per annum	Ensure an agronomic expert (e.g. Soil Scientist) is identified & hired	35,000.00
Action 5. Support Agriculture infrastructure and management	5.1 Assessing the current micro propagation seed-tuber production status and methodology to identify needs and gaps (e.g. agronomic practices)	FAO/GOB	MOA & UB		CR 20	High	Assessment report completed internally or by a consultant	20,000.00
	5.2 Establish a regulating agency for quality seeds and seed-tuber micro-propagation and agriculture equipment	FAO, GCF, UNDP-GEF	BAHA-MOA & UB		CR and PR 20	Mod	For example, revisit the FAO recommendation on “quality’ in-country seed certification rather than the costly, external “certification” for BAHA	12,000.00

	5.3 Strengthen stock seed source at Central Farm	FAO/UNDP-GEF	MOA		CR and PR 20		Stock seed source at Central Farm requires adequate cool storage facility and accessories. Ensure these are available, otherwise procure funds for completion of facilities.	15,000.00
TOTAL							**US$**	**782,000.00**

1.2 Project Ideas for Agriculture Sector

1.2.1 Brief summary of the Project Ideas for Agriculture Sector

Several climate change adaptation project ideas were identified and suggested for consideration in this TAP. Three of these project ideas are further developed for the Agriculture sector, namely:

1) Enhance the cultivation of climate resilient varieties of open pollinated corn and black beans among small and medium-scale farmers;
2) In-country micro-propagation, field testing and marketing of 'quality', climate resilient varieties of Irish potato tuber-seeds;
3) Sustainable soil and land management in Agriculture and Agroforestry.

The details for these three project ideas are presented in the following sections.

1.2.2 Specific Project Ideas

1.2.2.1 Enhance the cultivation of climate resilient varieties of open pollinated corn and beans among small and medium-scale farmers

Introduction/Background

The technology for improved grain production in Belize is at the top of the MOA's list of crops being promoted in its strategy to ensure food safety and livelihood security among small farmers and farming communities in Belize (R. Thompson, Agriculture Officer responsible for Projects, personal communication, September 2017). Thus, the technology will encompass not only the new varieties of open pollinated corn and bean seeds, but also the complete process from land preparation, planting, harvesting, storage of grains, marketing and replanting. Seed production groups will ensure the viability of the seed stock. Seeds for planting (quality seeds) and marketing (commercial grain) will be available for famers at a reasonable price.

The proposed technology diffusion to produce heat and drought resistant varieties of open-pollinated corn and bean seeds for production and marketing among small farmers in Belize through the Technology Needs Assessment project (UNEP/DTU, 2013) is an initiative being promoted by the Ministry of Agriculture to increase the capacity of four farming cooperatives and its Grain Production Unit at Central Farm. The objective is to expand the production of climate resilient, quality corn and beans seeds by the four farming cooperatives as planting material for the local market. The intervention will run for three years to accommodate six growing seasons (three primary or main seasons and three minor or secondary seasons or 'mata hambre').

Objective

To support corn and beans production among rural producers for food security and income generation.

Outputs

The expected outputs are:

- Increased yields of climate resilient, open pollinated 'quality' corn and beans per season/year;
- Higher sales and profits to the four grain-producing farmers' groups or cooperatives;

- Incremental yields and profit margins for small farmers participating in the 'quality' grain production programme

Relationship to the country's sustainable development priorities

The country of Belize's sustainable development plan is based on a low carbon development strategy which will create a platform for low carbon growth in new areas, and at the same time attaining the national development goals as envisaged in the country's several policy frameworks over the last decades (NCCO/GOB, 2017). These include: 1) Horizon 2010-2013; 2) National Energy Policy Framework; 3) Sustainable Energy Action Plan 2014-2033; 4) National Climate Resilient Action Plan; 5) Growth and Sustainable Development Strategy 2016-2019, and 6) the National Climate Change Policy, Strategy, and Action Plan 2015-2020. Two of the underpinning goals are: a strategic approach to building economic and social resilience (which includes livelihood and food security), and pursuance of a low-carbon development path for the medium and long term.

The last agriculture census in Belize indicted that there were approximately 12,000 farmers; 24% of farmers had less than 5 acres, 33% between 5 and 20 acres, and 74% of farms are less than 50 acres in size (FAO, 2011). Much of the land used for agriculture (37%) was classified as shifting agriculture and unimproved pastures, followed by mechanized agriculture for grains, practiced primarily by the bigger, Mennonite farmers who cultivate most hybrid varieties. The targets for the technologies are aimed at the majority of small farmers who are more vulnerable to the vagaries of the climate, the instability of the markets and externalities.

Project Deliverables

Table 23: MOA short-term strategy for corn and beans production

Components for quality corn seed production	**Deliverables (2018-20) Corn** *(Zea mays)*
1. Maintain a reliable supply of Open Pollinated (OP) stock seed for rural producers. 2. Strengthen the selection of climate resilient germplasm (local or introduced) that is tolerant to pests and diseases. 3. Promote biofortified varieties of corn to enhance nutrition. 4. Develop and implement an integrated pest and disease management for corn production. 5. Strengthen production systems for seed and grain to be cost effective, sustainable and climate resilient.	1. A report on the demand for yellow and white OP quality seed on a seasonal and yearly basis. 2. Trained selected producers in quality corn seed production. 3. Four acres of yellow OP corn established for seed production in four districts with producer groups. 4. 20,000 lbs of yellow OP corn seed with 95% germination rate produced at Central Farm. 5. A protocol for the production and quality assessment of OP corn seeds. 6. A report on bio-fortified and heat/drought tolerant varieties available regionally.
Components for quality bean seed production	**Deliverables (2018-20) Beans** (*Phaseolus vulgaris*)
1. Maintain a reliable supply of quality seeds of small red and black beans.	1. 5000 lbs of small red bean seed with 95% germination rate produced.

2. Strengthen the selection of climate resilient germplasm (local or introduced) that is tolerant to pests and diseases. 3. Promote bio-fortified varieties of pulses to enhance nutrition. 4. Develop and implement an integrated pest and disease management for coconuts. 5. Strengthen production systems to be cost effective, sustainable and climate resilient. 6. Promote good post-harvesting practices among producers.	2. 5000 lbs of black bean seed with 95% germination rate produced. 3. Four acres of small red beans established for seed production in four districts with producer groups. 4. Four acres of small black beans established for seed production in four districts with producer groups. 5. A report on the demand for yellow and white OP quality seed indicating seasonal and yearly demand. 6. A protocol for the production and quality assessment of bean seeds. 7. A report on bio-fortified and heat/drought tolerant varieties available regionally.

Project Scope and Possible Implementation

Project activities are based on the list of components indicated above. The possibility of implementation is high, since some field work in climate resilient, 'quality' grain production was already introduced by FAO back in 2014.

Timelines

The planting and production of 'quality' corn and beans are projected for a 3-year (six-seasons) period among 'quality' seed producers, after initial purchase of 'breeder' seeds from research centres. This will enable field testing of varieties, monitoring seed vitality and choosing the optimum variety for local climate. The cultivation system will be rain-fed.

Budget/Resource requirements

Projected cost per acre of corn and bean seed production is estimated at BZ$843.00/ac for corn and BZ$707.25/ac for beans. See Table 24 for a summary of net cost and profits for 16 acres of corn and beans production.

Table 24: Estimated cost per acre for corn and beans

Corn	**Cost of Production**	**Beans**	**Cost of Production**	**Total**
16 acres @ $843.00/ac [Cost]	$ 13,488	16 acres @ 707.25/ac	$ 11,316	$ 24,804.00
Yield/sales 2000 lb/ac @ $1.50 /lb	$ 48,000.00	Yield/sales 1000 lb /ac @ $2.00/lb	$ 32,000.00	$ 80,000.00
Profits/benefits	$ 34,512.00		$ 20,684.00	$55,196.00

Funds required to implement this project among four (4) 'quality' grain producing farmers' cooperatives cultivating 4-acres each of corn and beans (32 acres total) is: BZ$24,804.00 + BZ$200,000.00 for technology transfer programme: building of grain storage infrastructures (at least two), equipment rentals, value added, training, and fuel. The total is BZ$224,804.00.

Source of finance: FAO, UNDP-GEF, GCF; locally from DFC at an interest rate of 6% or Credit Union at 1 % on the remaining principal.

Measurement/Evaluation

Accomplishment and success will be measured through:

- Yields per acre
- Returns on investments for 'quality' grain seeds
- Number of small farmers participating in the 'quality' grain seed production programme
- Percent of responses from farmers having a medium level knowledge of adaptation measures to climate change in Agriculture.

Possible Complications/Challenges

Complications could arise from unforeseen events such as impacts from tropical cyclones and floods; lack of adequate grain storage facilities, and volatile market (including inflation and increased cost of fuel and inputs).

Responsibilities and Coordination (Who does what, when and how?)

Partners: Grain Production Unit (MOA), CARDI, Producers (Grain-producing cooperatives), Extension Service (MOA), CIMMYT, INIAS.

1.2.2.2 In-country micro-propagation, field testing and marketing of 'quality', climate resilient varieties of Irish potato tuber-seeds

Introduction/Background

Since potato was first introduced into Belize, it has been observed that after one season in the field the crop becomes infected with insect-transmitted viruses. As a result, tubers collected from one season become diseased and cannot be used as seed-tubers for planting the following season. To address this issue fresh, quality potato seed tubers are imported from the United States each year. Unfortunately, these varieties have been developed for the temperate climates and are not totally adapted to tropical conditions.

On way to address the need to import temperate varieties of Irish potato planting material annually, is to introduce technology for an in-country potato seed-tuber production system through micro-propagation of imported breeder seed-tubers, with the approval of the plant breeder organization or research centre. The system will ensure quality, disease-free and diversified potato varieties that have been tested locally and demonstrated for high productivity under Belize's tropical conditions and made available to farmers.

The effects of global warming are already evident in Belize, with increase of surface air temperature and high variability in seasonal rainfall (GOB-NCCO, 2016), and unless more suitable varieties of Irish potato seedlings are made available to farmers, it may become almost impossible to produce potatoes at a cost-effective scale in Belize. If this were allowed to occur, the country's food security could be jeopardized. Officials in Belize have not, so far, investigated alternative potato varieties but the urgency to do so increases with the advancing threat of climate change.

Bio-technology advances in plant micro-propagation is considered for replication of climate resilient varieties of Irish Potato breeder seed tubers, which will permit an increase in national potato production by extending the potato cropping season and by expanding Irish potato cultivation into other areas which are too warm for the varieties currently available. This will not only reduce the need to import potatoes to supply the national consumer markets, but it will also save on foreign exchange by eliminating the annual requirement to import expensive, foreign-sourced seed-tubers. An improved and expanded potato production system resilient to warmer climatic conditions would enhance national food security and bring economic benefits for many farming communities in Belize, and to the University of Belize itself.

Objectives

The specific objective of the intervention is to supply in-country, 'quality', climate resilient varieties of Irish potato seed-tubers to the local market through improved micro-propagation bio-technology at the University of Belize Facility at Central Farm.

Outputs

- Total number of 'quality' climate resilient Irish potato seed-tubers produced per season/year;
- Sales and profits to the Laboratory Facility;
- Yields and profit margins for small farmers participating in the 'quality' climate resilient Irish potato seed-tubers produced per season/year;
- Increased number of Irish potato growing farmers and acreage cultivated.

Relationship to the country's sustainable development priorities

The Ministry of Agriculture is guided by the National Agriculture and Food Policy (NAFP) 2015-2030, with the strategic objective of increasing agricultural production, productivity, competitiveness, and market opportunities. Emphasis is being placed on innovation, research and development, and partnerships to capitalize on available opportunities that have a comparative advantage.

The over-arching goal of the NAFP is "to engender a conducive environment for the development of an Agriculture and Food Sector that is competitive, diversified, and sustainable; that enhances food security and nutrition; and that contributes to the achievement of the socio-economic development goals of Belize" (GOB, 2015) as stipulated in the Growth and Sustainable Development Strategy 2016-2019.

Project Deliverables

- Upgraded UB plant micro-propagation laboratory facility;
- Increased production of 'quality' climate resilient Irish potato seed-tubers produced per season/year at the plant laboratory and nurseries;
- Sales and profit of 'quality' Irish potato seed-tubers to farmers;
- Yields and profit margins to participating potato farmers per season/year.

Project Scope and Possible Implementation

On way to address the need to have to import temperate varieties of Irish potato planting material annually is to introduce technology for an in-country potato seed-tuber production system through micro-propagation of imported breeder seed-tubers, with the approval of the plant breeder organization. UB already has a functional plant micro-propagation facility, and only need to invest in special requirements, some equipment and a trained bio-technologist to micro-propagate Irish potato seed-tubers. The system will ensure 'quality' or locally certified (FAO 2014 guidelines), disease-free and diversified potato varieties that have been tested locally and demonstrated for high productivity under Belize's tropical conditions and made available to farmers.

Project activities: Table 25 is a summary of the proposed actions and activities related with the in-country micro-propagation of climate resilient Irish potato seed-tubers. The critical action is to procure finance for this intervention. The Manager of the UB plant propagation laboratory is optimistic of this business intervention and is a willing partner along with the MOA to see this project implemented.

Table 25: Micro-propagation of 'quality' climate resilient varieties of Irish potato seed-tubers

Actions	**Activities**	**Timeline (months)**																			
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**14**	**16**	**18**	**20**	**24**	**26**	**28**	**30**
Action 1. Expand access to low interest finance & non-reimbursable funds	Activity 1.1 Draft a bankable project concept paper and project document for in-country micro-propagation of climate resilient varieties of Irish Potato seed-tuber.																				
	Activity 1.2 Streamline certified seed-tuber production from micro-propagation phase to sales of climate resilient Irish potato seedlings to farmers.																				

Actions	Activities	Timeline (months)																			
		1	2	3	4	5	6	7	8	9	10	11	12	14	16	18	20	24	26	28	30
	Activity 1.3 Allocate funds for upgrading UB plant micro propagation laboratory & nurseries for production of certified potato seed-tubers																				
	Activity 1.4 Allocate funds for cool temperature storage facility																				
	Activity 1.5 Procure funds for contracting a bio-technology expert to develop and establish an Irish potato micro-propagation protocol to produce certified seed-tubers																				
Action 2. Establish an on-going training programme for laboratory technicians and nursery field workers	Activity 2.1 Bio-technology expert develops training programme																				
	Activity 2.2 Three Laboratory technicians and four field workers selected and hired																				
	Activity 2.3 Training and field demonstration conducted																				
Action 3. Streamline certified seed-tuber production from micro-propagation phase to sales of climate resilient Irish potato seedlings to farmers	Activity 3.1 Expert develops micro propagation laboratory tuberization protocol																				
	Activity 3.2 Initiate micro-propagation process of imported Irish potato seed-tubers																				
	Activity 3.3 Cool storage facility at UB Central Farm constructed and equipped																				
	Activity 3.4 Training and public awareness programme for new technology conducted																				

Actions	Activities	Timeline (months)																		
		1	2	3	4	5	6	7	8	9	10	11	12	14	16	18	20	24	26	28	30
Action 4. Strengthen research and development of micro propagation of horticulture and other tuber (pulses) crop varieties	Activity 4.1 Assess the market for planting material of potato and other tuber (pulses) countrywide, and identify needs and gaps (e.g. design, status & equipment, agronomic practices e.g. integrated pest control in nurseries & PCS, and water use)																			
	Activity 4.2 Promote network of equipment suppliers, importers, & retailors of nursery /irrigation equipment																			
	Activity 4.3 Strengthen R&D in PCS & drip irrigation best practice for nurseries at ARDU, University of Belize & private entities																			

Timelines

The proposed timeframe for the in-country micro-propagation of 'quality', climate resilient Irish potato seed-tubers is 5 years, in order to accommodate cultivation cycles for a two-year period.

Budget/Resource requirements

Preliminary estimated capital investment in USD for micro-propagation of 'quality', climate resilient varieties of Irish Potato seed-tubers is **US$455,000.** The operational costs for the intervention over the five-year period is estimated at US$425,000.

Measurement/Evaluation

Measurement and evaluation will consist of annual, total tuber-seeds propagated successfully and sold. Evaluation will also consider sales per season or year, number of potato farmers participating and statistics of seasonal/annual production/yields.

Possible Complications/Challenges

The detrimental barriers or major constraints for this technology transfer identified and analysed in the Barrier Analysis are: i) high up-front costs, ii) time constraint for upgrading the UB Micro-Propagation laboratory facilities, and iii) upgrading the necessary technical capacity. Also, another barrier identified during consultation with a bio-technology expert is the extended, start-up time for the micro-propagation process from imported 'Source Basic Seeds (i.e. clean parent material) to micro-

tuberization stage, reproduction of mini-tubers in screen houses (PCS), and finally mini-tuber germination to produce 'quality' or locally certified, seed-tubers for farmers.

Responsibilities and Coordination

The University of Belize School of Agriculture Plant Micro-Propagation Laboratory Unit, in close coordination with the Ministry of Agriculture (MOA) CRDU/Grain Production Unit, will spearhead this initiative. Potato farmers and other key stakeholders will be convened at the start of the project to sensitize them on the initiative and its medium and long-term benefits.

1.2.2.3 Sustainable soil and land management in Agriculture and Agroforestry in the Greater Belize River Watershed

Introduction/Background

Figure 1: Interacting components of soil environment

Source: **http://soilquality.org.** NRCS East National Technology Support Centre, University of Illinois at Urbana-Champaign, USA

Soil conservation and soil fertility are critical for sustainable and eco-friendly agriculture and other land use activities.

As illustrated above, the agroecosystem is made up of many interacting components. Soil quality is one important part of sustainable agroecosystem management, analogous to water and air quality. Assessing soil quality may help managers identify practices that could be adapted to become more sustainable. Soil management is cross-cutting across all subsectors of agriculture, agro-forestry and land use.

Increasing stress from unstainable land use is impacting the water quality and soil fertility of the Greater Belize River Watershed (GBRW). The GBRW straddles the central region of Belize, it is the largest watershed in Belize, is home to more than 40% of Belize's population, and is an area that has seen up-scaled agricultural expansion over the past decade. This had led to increasing soil erosion, bank failure, land degradation, loss in biodiversity, which have contributed to decreasing water quality and increasing soil infertility. As shown in Table 27, the estimated annual average soil loss for the Belize River watershed is 12.5 tons/ha/year, with the Chiquibul, Roaring Creek and Lower Mopan sub-watersheds contributing more than 20 tons/ha/yr. to the annual soil loss. The effects of climate change will exacerbate the situation in the short and medium term.

Table 26: Annual average soil loss and category per sub-watershed of the GBRW

Sub-watershed	Annual average soil loss (ton/ha/year)	Category
Barton Creek	17	High
Laboring Creek	2.5	Low
Roaring Creek	20.7	High
Lower Belize River	0.8	Very Low
Middle Belize River	5	Moderate
Chiquibul River	25.4	High
Macal River	15	High
Upper Mopan River	10.1	High
Lower Mopan River	20	High
Sal Si Puedes River	8.2	Moderate
Belize River Watershed	Avg. =12.5	High

(Source: Laboratorio SIG Larna, Universidad Rafael Landivar; WWF, 2014)

It is estimated that some 325,114 acres of land are under agriculture out of a total of 1,499,146 acres comprising this watershed. Agriculture expansion is happening at a high rate. In 2016 alone, 4,044 hectares or 9,993 acres were converted for agricultural use. In the absence of a soil conservation strategy and action plan, the result of such land use change are increased release of agrochemicals and other pollutants into surface and groundwater resources, loss of the riparian forest buffer, increased sedimentation and land degradation, and decreased soil fertility. Three areas of major concern related to overexploited land use and unsustainable practices in agriculture are soil erosion, loss of fertility and runoff of agrochemicals into groundwater and surface water bodies, which eventually end up in the marine environment. Soil conservation and soil fertility are critical for sustainable and eco-friendly agriculture and other land use activities. Integrated Land Management and comprehensive soil quality monitoring and testing is not carried out in an organized and systematic form in Belize.

The project will consist of three main components or actions: i) Development of a strategy and practical field guidelines and work-plan to conduct integrated soil management; ii) Soil testing, soil conservation practices, and soil and water quality monitoring conducted on a regular basis in critical farming areas in the watershed; and iii) Public awareness and capacity building for farmers in soil conservation for tillage and minimum tillage cropping systems. Soil monitoring will require the acquisition and use of special soil and water monitoring equipment.

Objective

To introduce a practical soil management strategy for cost-effective good practices in soil conservation to improve soil stability and fertility among medium and large farmers in the GBRW.

Relationship to the country's sustainable development priorities

The Growth and Sustainable Development Strategy (GSDS) states that the overarching goal of the Government of Belize is "to improve the quality of life for all Belizeans, living now and in the future". The MOA identifies Critical Success Factor 1 (CSF1) "optimal national income and investment" as the specific area where it can contribute significantly to this goal. To this end, the MOA subscribes to Necessary Conditions (NC1) 3.5: Technological adaptation and innovation (including green technology) and Action 14: Build institutional capacity to encourage technological adaptation and innovation.

Agriculture is guided by the National Agriculture and Food Policy (NAFP) 2015-2030, with the strategic objective of increasing agricultural production, productivity, competitiveness, and market opportunities. Emphasis is being placed on innovation, research and development, and partnerships to capitalize on available opportunities that have a comparative advantage.

"The National Adaptation Strategy to Address Climate Change in the Agriculture Sector in Belize", (CCCCC, 2014), recommended the establishment of a Soil and Tissue Laboratory as a Climate Change adaptation measure under Infrastructure and Equipment. The report adds that the major agricultural industries in Belize rely on foreign laboratories for their soil and tissue analysis needs.

Project Deliverables

- Improved soil quality and land use good practice increases the value and crop yields of agricultural lands, and bring economic benefits to farmers, their family and their community. It also provides employment and enhances food security;
- Improved soil quality and good land management practices is a security for the farmer and his immediate family and community.
- Integrated land management and soil quality monitoring help reduce agricultural land degradation, excessive water use, and maintain soil fertility. It also helps to reduce the use of agrochemicals and arrest the deforestation of virgin tropical forests that is later converted to mono-crop agricultural land.
- It enhances eco-friendly and smart agriculture and reduces loss of bio-diversity and fragmentation of the Mesoamerican Biological Corridor.

Project Scope and Possible Implementation

The scope of this intervention will be in the high cropping area of the Belize River Watershed and will extend for a period of three (3) years. A sustainability strategy will be implemented for the MOA to coordinate and streamline its soil conservation programme for the GBRW and other stressed watersheds elsewhere in Belize.

Timelines

The timeline for the project idea "Sustainable soil and land management in Agriculture and Agroforestry in the Greater Belize River Watershed", is three (3) years, initially.

Budget/Resource requirements

Capital Investment:

1)	Equipment & Reagents for Soil Laboratory	US$ 125,000.00
2)	Soil Quality and Irrigation Unit equipment (six sets)	US$ 180,000.00
3)	Salary for two Soil Technicians @ US$15,000 per person per year for three (3) years	US$ 90,000.00

4) Training (1 MSc, Two technicians & Farmers) US$ 80,000.00
5) One only Isuzu pickup truck US$ 30,000.00

Total **US$ 520,000.00**

Operating costs: US$15,000.00 per year. Total for three (3) years: US$45,000.00

Investment costs may also have to cover the cost of establishing a Public Sector operated Soil-Water Laboratory

Measurement/Evaluation

Criteria for measuring accomplishments will include: i) establishment of an equipped soil laboratory; ii) Database of soil and water quality; iii) Trained technicians and at least one soil scientist at the MSc level directing the soil lab; iv) after initial intervention (by year three), marked improvement in degraded land areas (rehabilitation of 60%) of targeted degraded areas; and v) improved soil fertility;

Possible Complications/Challenges

Complications and challenges may include: i) lack of interest to participate in the soil conservation intervention/programme by famers, especially the large-scale farmers that are mostly responsible for the current degradation; ii) inability to procure the necessary capital investment to finance the 'soil conservation/monitoring project; iii) lack of political will at the policy level to support the establishment of a National Soil Laboratory; and iv) inferior soil and water monitoring equipment that malfunction in the field after short period of exposure, requiring costly replacement.

Responsibilities and Coordination

Responsibility and coordination of this soil monitoring and conservation intervention will lie with the MOA Crop Research and Development/Innovation Unit, with headquarters in Central Farm. Partners for this initiative will be UB School of Agriculture Plant propagation laboratory; BAHA, CARDI, IICA, CREI, SIRDI, Medium and Large Farmers' groups, the Agro-business, FAO and other regional and international agriculture entities.

Chapter 2. Technology Action Plan and Project Ideas for Water Sector

2.1 TAP for Water Sector: Implementation of Water Safety Plans for Strategic Management of Eight Rudimentary Water Systems

2.1.1 Sector Overview

Potable water supply services are provided by the Belize Water Services Limited (BWSL) for all urban centres and nearby communities, while Rudimentary Water Systems (RWS) run by Village Water Boards supply water to most rural communities. BWSL water production per annum has been increasing nationwide with urban expansion and increase in demands. Belize Water Services Limited operates in licensed service areas, serving all the municipalities of the country as well as some 35 villages. As of March 2017, BWS served over 57,200 customers or approximately 250,000 consumers, with a total average water demand of over 208 million US gallons per month (BWS, 2017). Over 60% of the water supplied is produced using conventional water treatment processes with rivers as its sources. Satellite water wells are used for the majority of the other water systems. In San Pedro and Caye Caulker, BWS distributes water which has been treated by Reverse Osmosis, converting sea water to drinking water. Other large water users in the Private sector are mandated to apply for an annual water abstraction licence from the National Integrated Water Resource Management Authority (NIWRA). Table 27 is a summary of BWSL water production, sales and none-revenue water for 2015/16 and 2016/17.

Table 27: Summary of Key Performance Indicators of BWSL for 2015-2017

Operating KPI	2016/17	2015/16	% Change
Sales Volume	2,505.4	2,404.6	4.2%
Production Volume	3,356.2	3,202.4	4.8%
Non-Revenue Water %	25.4%	24.9%	1.8%
Volume figures in Millions of US Gallons (MUSG)			

In rural communities, Village Water Boards manage the Rudimentary Water Systems and piped water to residence. Here, the coverage nationwide is about 95% and the water source is mostly groundwater. There are some 150 Village Water Boards and about a third of them have experienced and continue to experience water quality, infrastructural and management problems in the water supply chain. The Public Health Bureau (PHB) in the Ministry of Health (MOH) is the agency primarily responsible for monitoring water quality and water related health issues in Belize. The PHB will be the agency coordinating the RWS water safety plans (WSP) for the target communities under the *Integrated Management Strategy for Water Safety in Eight Rural Water Supply Systems in Belize*. The targeted Rudimentary Water Systems (RWS) will be distributed as follows: three in the southern Toledo District, three in the Stann Creek District, and two in the Cayo District. Annual data of total RWS production is not available at this time. Most of the RWS service is metered. However, several RWS are not metered systems, and GOB subsides water supply to those most in need of this measure.

Properly developed and executed WSP can be regarded as an effective climate change adaptation measure to manage, utilize and conserve the country's water resources, especially for vulnerable and marginalized rural communities.

Water Safety Plans

The World Health Organization (WHO, 2008) Guidelines for Drinking Water Quality (GDWQ) is the basis for current water quality standards in many countries around the world, including Belize. In the WHO water quality guidelines, Water Safety Plans (WSPs) are described collectively as a systematic and integrated approach to water supply management based on assessment and control of various factors that pose a threat to the safety of drinking water. WSPs enable identification of threats to water safety during all phases in the supply chain, from the catchment sites to the transport, treatment and distribution of potable water. This approach is fundamentally different from those traditionally adopted by water suppliers, which rely on treatment and end-product testing to ensure water safety. When implemented successfully, the WSP approach can ensure that water quality is maintained in almost any water service and delivery systems. Figure 1 shows a schematic of the framework for safe drinking adapted from Davidson et al. (2005). The main programmes of the safe drinking water framework are: System assessment, monitoring, and management and communication.

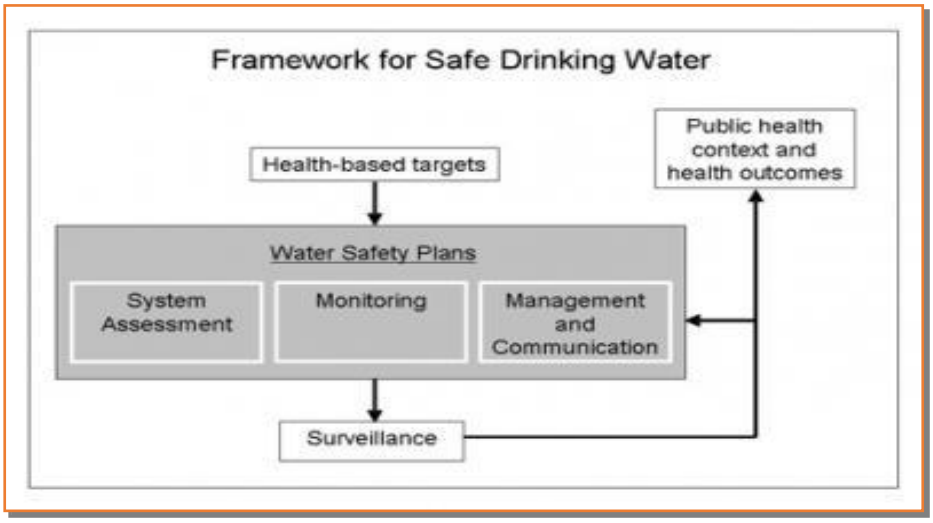


Figure 2: Steps in the development of a Water Safety Plan

(Adapted from Davison et al., 2005)

2.1.2 Action Plan for Integrated Management Strategies for Water Safety for Eight Rural Water Supply Systems in Belize

2.1.2.1 Introduction

An Integrated Management Strategy for Water Safety in Eight Rural Water Supply Systems will target rural communities in Belize where recurrent interruption of water services and health problems have been reported because of poor water quality service. In these communities, Village Water Boards are on record for poor water delivery services and inadequate management of water service systems is prevalent. Once proven to work in these communities, the Water Safety Plan(s) may be extended to other communities facing similar difficulties with their rudimentary water supply systems, and communities where rudimentary water infrastructure and water boards will be established in the near future (Boden, J, Principal Public Health Officer, pers. Comm. Oct. 2016).

The components of the adaptation technology related to the Water Safety Plan will consist of:

1) The improved technology will consist of: i) Installation of eight solar power-driven water pumps; ii) Array of deep-power batteries; iii) water meters; iv) a stock of PC pipes, fittings, seals, and faucets; v) 3-year supply of reagents and additional equipment for water quality analysis; vi) financial management software; vii) eight desktop PCs and printers.

2) There will be an initial assessment, then periodic assessment and monitoring of the target communities RWS during the project cycle period. This will entail assessing and maintenance of the RWS infrastructure in coordination with the Village Water Boards; monthly water quality sampling and analysis; and water borne illness monitoring.

3) Drafting and adoption of a comprehensive Water Safety Plan for Rudimentary Water Supply Systems. An expert in the field of Public Health and Water will be hired for three months to coordinate and develop the WSP. Adoption by Cabinet and operationalization by the MOH and partners will take at least eight months.

4) Following adoption of the WSP, the Public Health Bureau, along with key stakeholders such as Rural Water Unit (Ministry of Labour, Local Government and Human Development), Social Investment Fund (SIF), PAHO, Red Cross, National Association of Village Councils (NAVCO), etc. will operationalize the WSP in the eight target communities for the remaining two years of the technology diffusion project cycle. The Government of Belize through the MOH will then take over the financial responsibility to sustain and replicate the WSP in other target communities.

5) Institutional strengthening will be required for the Public Health Bureau and eight Village Water Boards, selected members of the Village Water Boards will be trained (two per water board per year for 3 years, with a total of 48 persons trained). Strengthening of the Public Health Water Laboratory, and employment of at least four rudimentary water system technicians, two

water quality analysts, and one National WSP Coordinator will be necessary. The WSP Coordinator will be nominated from among Public Health personnel.

6) Cost for hiring one Water Consultant for three months to develop and coordinate the public consultation and development and adoption of the WSP.

2.1.2.2 Ambition for the TAP

The aim of establishing an integrated management strategy for water safety and a reliable, potable water system to rural communities is to ensure an efficient water delivery service that meets all engineering and health safety standards. For those unable to pay the minimal fee for the service, GOB will provide a mechanism to defray the cost, so that the RWS remains viable.

The benefits include: Human health and safety; reduced costs to the national health service; more time for productive activities, improved nutritional intakes and decreased food insecurity. The intervention will engender increased cooperation among key actors in RWS operations and village Water Boards.

2.1.2.3 Actions and Activities selected for inclusion in the TAP

A summary of barriers and proposed measures to overcome barriers for the integrated management of RWS is presented in Table 28. The key measures or actions are: Secure financing for developing and implementing Water Safety plans; update protocol to address water safety issues related to RWS; and improve financial management of threatened RWS.

Table 28: Barriers and measures related to an Integrated Management Strategy and Water Safety Plans for Eight Rudimentary Water Systems

Barrier	Measure
High initial investment	1. Utilize capital financing for development of Water Safety Plans and effective training of Trainers and target Water Board members
High cost of installation and operation of RWS	2. Expand access to finance
Poor financial management of RWS	3. Improve financial and operational management of RWS
Appointment and voluntary service- Inadequate policy and regulatory framework	4. Establish contract service for all Water Boards in the country
Poor/limited institutional capacity of Village Water Boards	5. Lobby for Policy revision regarding Village Water Board contracts/appointment 6. Update protocol to address water safety issues related to RWS.
Water authorities and Public Health reactive to issues related to RWS services, not pro-active.	7. Hire WSP experts and build institutional capacity
Low technical capacity for developing WSP protocol and train trainers	8. Establish training component in technology diffusion programme 9. Through technology diffusion programme address social, cultural and behavioural issues; improve KAP* among users
Stakeholders afraid of change	

2.1.2.4 Actions selected for inclusion in the TAP

Activities identified for implementation of selected actions

Table 29 shows the proposed actions and activities for the implementation of an integrated water management strategy and water safety plans in eight (8) threatened rudimentary water systems at villages in Belize. At the top of the list of action for this intervention is for the coordinators expanding access to funds for the refurbishment of the target RWS before the implementation of an integrated water management strategy and Water Safety plans for the respective Village Water Boards.

Table 29: Activities for selected actions to implement integrated water management strategy and WSP for eight RWS

Action 1. Expand access to funds for refurbishing target Rudimentary Water System (RWS)	**Action 2.** Develop and implement Water Safety Plans.	**Action 3.** Procure funds for operation and maintenance of eight RWS for three years	**Action 4.** Improve financial and operational management of RWS	**Action 5.** Review the Village Council Act for Amendment
1.1 Organize Line Ministries/Departments & Water Boards, and form Task Group to implement Project Idea	2.1 Contract a water expert to draft WSP	3.1 Conduct C/B analysis of RWS including a thorough client survey per community	4.1 Improve revenue stream, service provision, collection and financial management	5.1 Internally review Village Council Act and if needed, make recommendation for change
1.2 Procure non-reimbursable or low interest funds for hiring WSP Expert and six technical personnel	2.2 Implement WSP in eight RWS simultaneously	3.2 Update protocol for water treatment and water delivery service and safety	4.2 Review audit requirement and do audit on regular basis	5.2 Under NAVCO, organize targeted RWS boards to meet regularly and share experiences and best practices
1.3 Institute training programme for technicians and Water Board members.	2.3 Monitor and evaluate WSP implementation for 3-year period	3.3 Establish metered RWS where this is non-existing, and/or upgrade metered systems and collection process		
		3.4 Procure spares for the three-year pilot interventions (e.g. solar water pumps, water meters, pipes and fittings, miscellaneous spares and equipment, etc.).		

Actions to be implemented as Project Ideas

1. Review the Village Council Act and recommend policy change for Village Water Board members. This Action is being considered in the proposed intervention to implement an integrated water management strategy and WSP for eight threatened rudimentary water systems.

2.1.2.5 Stakeholders and Timeline for implementation of TAP

Overview of Stakeholders for the implementation of the TAP

The main stakeholders are the Village Water Boards, Public Health Bureau, Rural Water Department in the Ministry of Labour, Local Government, and Rural Development. The beneficiaries are the villagers from the eight villages selected for the intervention.

Scheduling and sequencing of specific activities

The schedule and sequence of actions and activities for this intervention are summarised in Table 30 below. The project cycle will run for a period of three calendar years, but the chronogram only covers the first 30 months as shown in Table 30.

Table 30: Schedule and sequence of activities for Integrated Management Strategy and Water Safety Plans for Eight RWS

Actions	Activities	Timeline (months)																			
		1	2	3	4	5	6	7	8	9	10	11	12	14	16	18	20	24	26	28	30
Action 1. Expand access to funds for refurbishing RWS	Activity 1.1 Organize Line Ministries/Dept. & Water Boards, and form Task Group to implement Project Idea for RWS																				
	Activity 1.2 Identify and procure non-reimbursable or low interest funds for hiring WSP Expert and six technical personnel																				
	Activity 1.3 Institute training programme for technicians and Water Board members																				
Action 2. Develop and implement Water Safety Plans	Activity 2.1 Contract a water expert to draft WSP																				
	Activity 2.2 Implement WSP in eight RWS simultaneously																				

Actions	Activities	Timeline (months)																			
		1	2	3	4	5	6	7	8	9	10	11	12	14	16	18	20	24	26	28	30
	Activity 2.3 Monitor and evaluate WSP implementation for 3-year period																				
Action 3: Procure funds for operation and maintenance of eight RWS for three years	Activity 3.1 Conduct C/B analysis of RWS including a thorough client survey per community																				
	Activity 3.2 Update protocol for water treatment and water delivery service and safety																				
	Activity 3.3 Establish metered RWS where this is non-existing, and/or upgrade metered systems and collection process																				
	Activity 3.4 Procure spares (e.g. solar water pumps, water meters, pipes and fittings, miscellaneous spares and equipment, etc.).																				
Action 4. Improve financial and operational management of RWS	Activity 4.1 Improve revenue stream, service provision, collection and financial management																				
	Activity 4.2 Review audit requirement and do audit on regular basis																				
Action 5. Review the Village Council Act for Amendment	Activity 5.1 Internally review Village Council Act and if needed, make recommendation for change via proper channels																				
	Activity 5.2 Through NAVCO, organize targeted RWS boards to meet regularly and share experiences and best practice.																				

Estimation of Resources Needed for Action and Activities

Estimation of capacity building needs

Institutional strengthening will be required for the Public Health Bureau and eight Village Water Boards, training of selected members of Village Water Boards (two per Water Board per year for 3 years, 6 per water board and 48 in total). Strengthening of the Public Health Water Laboratory, and employment of at least four Rudimentary Water System Technicians, two Water Quality Analysts, and one National WSP Coordinator is required. The WSP Coordinator will be nominated from among Public Health personnel.

Procurement of funds will have to be done for the hiring of one Water Consultant for three months to develop and coordinate the public consultation and development and adoption of the WSP

Estimations of costs of actions and activities

Estimated Capital Investment: US$427,500.00 will cover costs for hiring one Public Health and Water expert for three months, hiring two water quality analysts and four Rudimentary Water System technicians (3 years), purchasing eight spare water pumps, one vehicle for field work, information and database equipment, and training costs.

Operating cost: US$71,000.00 for a 3-year project cycle.

2.1.2.6 Management Planning

Risks and Contingency Planning

Table 31 is a summary of actions, activities, risks, and contingency planning for facilitating the uptake of an integrated management strategy for water safety for eight threatened rudimentary water systems. Risk indices scoring 15 and greater were further evaluated for contingency and cost. See Annex I for detailed sample assessment.

Table 31: Risk and contingency planning for facilitating the technology transfer for an Integrated Management Strategy for Water Safety for RWS.

Action	Activities to be implemented	Risks	Risk Index	Contingency	Cost
Action1: Expand access to funds for refurbishing RWS and develop training programme	Activity 1.1 Organize Line Ministries/Departments & Water Boards, and form a Task Group to implement project ideas for RWS	SR and PR	12	Organize an effective Technical Working Group	5,000.00 GOB In kind
	Activity 1.2 Identify and procure non-reimbursable or low interest funds for hiring WSP expert and two technical personnel	CR and SR	9	Review potential sources of finance locally and externally	125,000.00 WSP Expert…… 35,000.00

					Technicians … 15,000.00 per annum for 3-year
	Activity 1.3 Institute training programme for technicians and Water Board members	SR and PR	18	Review guidelines and training programme and contract facilitators	6,000.00
Action 2: Develop and implement Water Safety Plans	Activity 2.1 Contract a Water Expert to draft WSP	CR and PR	20	A suitable water expert may not be available locally and a request may have to be done at the regional or international level via UNDP or UNEP or CCCCC procurement digital facility	Already included above in Activity 1.2
	Activity 2.2 Implement SWP in eight RWS simultaneously	SR and PR	25	Project manager or coordinator makes changes as necessary	40,000.00
	Activity 2.3 Monitor and evaluate WSP implementation for 3-year period	SR and PR. Problems with implement-ation especially (Year 1)	9	Institute changes as necessary	9,000.00 @ 3,000 per annum
Action 3: Procure funds for operation and maintenance of eight RWS for three years	Activity 3.1 Conduct C/B analysis of RWS including a thorough client survey per community	CR and PR	16	Survey may not be satisfactory, and may need to be repeated for one or more RWS	32,000.00 @ 4,000.00 per RWS (8 in all)
	Activity 3.2 Update protocol for water treatment and water delivery service and safety	SR and PR	12	Liaise closely with Public Health Bureau Water Laboratory	15,000.00, @ 5,000.00 per annum for 3 years
	Activity 3.3 Establish metered RWS where this is non-existing, and/or upgrade metered systems and collection process	PR	15	Work with NAVCO and Rural Water to ensure metering and upgrade to delivery system is satisfactory. Only unmetered RWS will be targeted for upgrade	16,000.00

	Activity 3.4 Procure spares (e.g. solar water pumps, water meters, pipes and fittings, miscellaneous spares and equipment, etc.).	CR	20	Ensure funds for this activity is available from Capital budget. $5,000 per RWS	40,000.00
Action 4: Improve financial and operational management of RWS	Activity 4.1 Improve revenue stream, service provision, collection and financial management	PR	12	Keep a monthly record of all service charges. Operational costs should cover this activity	16,000.00 @ 2,000.00 per RWS
	Activity 4.2 Review audit requirement and do audit on regular basis	SR and PR	12	Hire professional and experienced Audit Firm, @ $5,000.00 per RWS	40,000.00
	Activity 4.3 Monitor and evaluate WSP on a regular basis (At least once per year)	SR	12	---	16,000.00 @ 2,000.00 per RWS
Action 5: Review the Village Council Act for Amendment	Activity 5.1 Internally review Village Council Act and if needed, make recommendation for change via proper channels	PR	16	Revisit review with technical and policy working. Request the services of the Attorney General Office	8,000.00
	Activity 5.2 Through NAVCO, organize targeted RWS Boards to meet regularly and share experiences and best practices.	SR	12	---	4,500.00 @ 750.00 per meeting, 2 meetings per year for 3 years

Next Steps

The Public Health Bureau in the MOH and the Rural Water in the Ministry of Labour, Local Government and Rural Development will coordinate this intervention. The first step needed to get the project off the ground is to select the most threatened and vulnerable villages whose RWS is non-functional or experiencing major problems. Eight threatened RWS will then be shortlisted as candidates for this intervention. A meeting is then planned with the Village Water Boards of these RWS, where they are all invited as active participants/stakeholders in the project. A work plan is then drafted, and a project proposal for funding is then submitted to local and foreign financial entities.

A rapid assessment is conducted on the status and needs of these RWS, while a technical advisory committee is established to work on a cost benefit analysis of all eight RWS. All financial statements and audits (if any) should be reviewed.

2.1.2.7 TAP overview table

Table 32 is the TAP overview matrix for facilitating an Integrated Management Strategy and Water Safety Plans for eight threatened rudimentary water systems (RWS) around the country. The TAP overview highlights the ambition of the technology transfer and diffusion, the benefits to stakeholders, actions and activities, responsible entity and timeline to implement the technology diffusion. The associated risks, success criteria, indicators to gauge the implementation and the estimated costs are also presented for a synoptic review of the TAP.

Table 32: TAP Summary overview for facilitating an Integrated Management Strategy and Water Safety Plans for Eight RWS

Sector	Water							
Sub-sector	Rudimentary Water System							
Technology	An Integrated Management Strategy for Water Safety for Eight Rudimentary Water Systems (RWS)							
Ambition	The technology transfer will address eight weak and threatened RWS to upgrade the water delivery services to communities with average population of 150 – 200 families. The intervention will ensure an efficient water delivery service that meets all the health safety and engineering standards to improve the livelihood security of clients. For those unable to pay the minimal fee for the service, GOB will provide a mechanism to defray the cost, so that the RWS remains viable. The benefits include: human health and safety; reduced costs to the national health service; more time for productive activities, improved nutritional intakes and decreased food insecurity, etc., far outweigh the costs. The intervention will engender increased cooperation among key actors in RWS operations and village Water Boards. The proposed management strategy in the form of Water Safety Plans for RWS will be replicable in other communities experiencing similar problems.							
Benefits	The benefits will be in the form of reliable and safer water supply services to improve human health, personal hygiene, food security, better education, job opportunities, reduction in health services costs, etc. for 600 – 800 persons per community							
Actions	**Activities to be implemented**	**Sources of funding**	**Responsible body and focal point**	**Time frame (Months)**	**Risks**	**Success criteria**	**Indicators for monitoring of implementation**	**Budget per activity**
Action1: Expand access to funds for refurbishing RWS	Activity 1.1 Organize Line Ministries/Departments & Water Boards, and form Task Group to implement Project Idea for RWS	GOB	Public Health MOH	1	SR & PR 12	High	Task Group formed and operational	5,000.00 GOB In kind

	Activity 1.2 Procure non-reimbursable or low interest funds for hiring WSP Expert and two (2) technical personnel.	UNDP-GEF, PAHO, GCF, DFC	Public Health MOH	2	CR & SR 9	High	Finance procured for hiring WSP Expert and two (2) technical personnel	125,000.00 WSP Expert…… 35,000.00 Technicians… 15,000.00 per annum for 3-years
	Activity 1.3 Institute training programme for technicians and Water Board members	UNDP-GEF, MOH-GOB	Public Health MOH	2.5	SR & PR 18	High	Training programme drafted and conducted successfully	6,000.00
Action 2: Develop and implement Water Safety Plans	**Activity 2.1** Contract a water expert to draft WSP	UNDP-GEF	Public Health MOH	1	CR & SR 20	High	Water Expert contracted	Already included above in Activity 1.2
	Activity 2.2 Implement SWP in eight RWS simultaneously	UNDP-GEF, GCF	Public Health MOH; Rural Water Dept.	2.5	SR & PR 25	High	WSP implemented in eight (8) RWS	40,000.00
	Activity 2.3 Monitor and evaluate WSP implementation for 3-year period	UNDP-GEF, PAHO	Public Health MOH	6.5	SR & PR 9	High	M&E of WSP carried out	9,000.00 @ 3,000 per annum
Action 3: Procure funds for Operation and Maintenance of Eight RWS for three years	**Activity 3.1** Conduct C/B analysis of RWS including a thorough client survey per community	Public Health Bureau (PHB) MOH, PAHO	Public Health MOH	1	CR & PR 16	High	Cost/Benefit analysis conducted for each threatened RWS	32,000.00 @ 4,000.00 per RWS (8 in all)
	Activity 3.2 Update protocol for water treatment and water delivery service and safety	PHB-MOH, PAHO	Public Health MOH	2	SR & PR 12	High	Protocol for water treatment and water delivery service/safety updated	15,000.00, @ 5,000.00 per annum for 3 years
	Activity 3.3 Establish metered RWS where this is non-existing, and/or upgrade metered systems and collection process	Village Water Boards/ GOB, PAHO	Water Boards	3	SR 15	Mod	Water lines upgraded and metered	16,000.00

	Activity 3.4 Procure spares (e.g. solar water pumps, water meters, pipes and fittings, miscellaneous spares and equipment, etc.).	Village Water Board/ UNDP-GEF	Public Health MOH; Village Water Boards	3.5	CR 20	High	Spares procured for each RWS and stored safely	60,000.00
Action 4: Improve financial and operational management of RWS	Activity 4.1 Improve revenue stream, service provision, collection and financial management	Water Board, GOB	Village Water Boards	1	PR 12	High	Revenue stream and financial management improved	16,000.00 @ 2,000.00 per RWS
	Activity 4.2 Review audit requirement and do audit on regular basis	Water Board & Independent Auditor	Village Water Boards	12	SR & PR 12	High	Audit conducted	40,000.00
	Activity 4.3 Monitor and evaluate WSP on a regular basis (At least once per year)	Public Health-MOH, UNDP-GEF	Public Health MOH	1	SR 12	High	M&E of WSP programmed done on a regular basis	16,000.00 @ 2,000.00 per RWS
Action 5: Review the Village Council Act for Amendment	Activity 5.1 Internally review Village Council Act, and if needed, make recommendation for change via proper channels	Public Health-MOH, PAHO UNDP-GEF	Public Health MOH	2.5	PR 16	High	Revision of Village Council Act done, and recommendation submitted to MLLGRD	8,000.00
	Activity 5.2 Through NAVCO, organize targeted RWS boards to meet regularly and share experiences and best practice.	Water Boards/ PHB	Village Water Boards & Public Health MOH; NAVCO	12 (after first year)	SR 12	High	Threatened RWS are organized and meet regularly under auspices of NAVCO	4,500.00 @ 750.00 per meeting, 2 meetings per year for 3 years
Total							**US$**	**427,500.00**

Chapter 3. Technology Action Plan and Project Ideas for Coastal and Marine Ecosystem Sector

3.1 TAP for Coastal and Marine Ecosystem Sector

3.1.1 Sector Overview

One of Belize's natural and greatest assets is its coastal zone (CZMAI, 2014). About 30% of Belize's gross domestic product is directly linked to commercial activities inside its coastal zone (Cho 2005 in CZMAI, 2014). Belize's coastal zone also has important social and cultural values for its people, considering that about 40% of the population resides along the coast and offshore areas (SIB, 2016).

The past decades have seen rapid economic development and population growth within the coastal zone and inland regions of Belize. Consequently, this has led to increasing pressures on coastal and marine resources, directly affecting the livelihood of stakeholders that depend on these resources.

There is scientific consensus that the changes induced by global warming and climate change are already evident and will intensify in the future (NCCO, 2016; CZMAI, 2014; IPCC, 2007). The effects of climate change will continue to significantly alter coastal ecosystems, coastal hazards, and lifestyle changes for fishers, coastal resource users, waterfront property owners and coastal communities. These changes will have far-reaching consequences on the marine environment and will pose complex challenges for coastal and marine zone planners. As a result, multi-sectoral and integrated efforts are required to guide proactive adaptation actions that can benefit human and natural ecosystems for present and future generations (CZMAI, 2014).

Tourism, Fisheries including Aquaculture, and Commerce (Import/Export) are some of the key productive sector activities that utilize and operate in the Coastal Zone and contribute significantly to the economic development of Belize. Additionally, sensitive and invaluable coastal and marine ecosystem assets such as the Belize Barrier Reef system, numerous coral islands or cays, the Blue Hole, and a myriad of coastal and marine fauna and flora inhabit the coastal zone.

The ability of marine ecosystems and habitats to adapt to climate impacts can be increased by reducing other stressors such as overfishing, land-based pollution and misguided land use changes (CZMAI, 2014). Regulating and reducing these stresses will increase the resilience or ability of the environment to adapt to future natural and anthropogenic hazards and impacts, thus reducing threats to human welfare and the integrity of marine ecosystems.

In compliance with the 1998 Coastal Zone Management Act, the CZMAI, in coordination with key partners, updated and adopted the Integrated Coastal Zone Management Plan in 2013. The Plan recommends actions that ensure sustainable coastal development through a balanced mix of conservation and utilization, which supports economic growth, while promoting long term viability of the country's treasured barrier reef and coastline. The strategic objectives for achieving the vision for a sustainable coastal zone are: i) Encouraging sustainable coastal resources use; ii) Building alliances to

benefit Belizeans; iii) Supporting integrated development planning; and iv) Adapting to Climate Change.

3.1.2 Action Plan for a Coastal and Marine Environmental Monitoring Network and Early Warning System

3.1.2.1 Introduction

The technology for the Coastal and Marine Ecosystem sector through the TNA process aims at increasing the capacity of the Fisheries Department to monitor, assess and report on the physical and anthropogenic-related changes and impacts in the coastal and marine ecosystem, thus contributing to improved management and sustainable use of coastal and marine resources. The proposed technology transfer of an upgraded Coastal Zone monitoring network and Early Warning system is an essential component to this end.

The State of the Belize Coastal Zone 2003-2013 Report (CZMAI, 2014) made several recommendations with respect to the effects of climate change on coastal and marine ecosystems. These included the strengthening of the environmental and marine network; conduct quantitative vulnerability studies of the coastal zone using historic and current data; use results from studies and near real-time observations to develop early warning for climate and anthropogenic impacts on marine ecosystems; and draft policy recommendations to reduce the projected impacts of climate change.

Under the TNA-Belize project, the Fisheries Department is proposing the climate change adaptation technology for the Coastal and Marine sector: Improved Marine Monitoring Network and Early Warning System for Belize's Coastal Zone to Increase Resilience to Climate Change.

The technology transfer will consist of the following:

1. Eight automatic environmental/marine observation platforms (e.g. YSI EXO 2 Sonde) with sensors to record: depth, sea water temperature, pH/ORP (Oxidation/Reduction Potential), salinity, conductivity, turbidity, dissolved oxygen and chlorophyll. Additional above water sensors will be installed to record air temperature, surface wind speed and direction, rainfall, relative humidity, and solar radiation.

2. Eight loggers with transmission facility via smart phone technology.

3. Eight Photo Voltaic solar power equipment to generate, store and energize the observation platforms.

4. Quarterly water quality sampling at four strategic sites for laboratory analysis of nitrates/nitrogen, phosphates, Faecal Coliform, E-coli, etc. during the proposed five years of the project cycle.

5. Develop protocol to retrieve, quality check, archive, and process/analyse data and information for Early Warning Bulletins for stakeholders (including policymakers), and

6. Maintain updated and accessible environmental and marine database to inform research, policy recommendation, management strategy and the annual State of the Belize Coastal Zone reports.

7. Establish a protocol for a timely and reliable Marine Early Warning System. This will require additional institutional strengthening of the Fisheries Department for processing and analysing data, and processing and disseminating Marine Early Warning bulletins.

3.1.2.2 Ambition for the TAP

The eight environmental and marine observation stations will be deployed at eight critical marine management sites in the coastal zone, where Fisheries Department and Marine Reserves co-management partners/stakeholders have field operating centres with adequate security, and within range of the mobile communication network.

Total capital cost: US$177,965.33 for installation of eight only Marine Environmental Monitoring stations at US$22,245.67 per station.

The cost to provide project management, monitoring and evaluation of this technology plus spares is estimated at US$84,491.34 for five years of the project cycle.

Field operation cost at US$8,000.00 per year plus replacement of sensors for two stations over the five-year project cycle. (Source: Factsheet for Coastal and Marine Ecosystem Sector adaptation technologies, TNA-Belize).

Adaptation potential: Warmer sea surface temperatures and increasing ocean acidity is already impacting coastal and marine resources around the world and in the Caribbean. The National Oceanic and Atmospheric Administration (NOAA) has reported an unprecedented third straight year of global coral bleaching to target U.S. and Caribbean reefs in the summer of 2016 (Mooney, 2016). Marine resource and environmental monitoring and early warning can contribute significantly to adaptation measures necessary to address the impacts of climate change.

3.1.2.3 Actions and Activities selected for inclusion in the TAP

A summary of the main barriers and measures for implementation of a marine environmental monitoring network and early warning system is presented in Table 33.

Table 33: Barriers and measures for the diffusion of Marine Environmental Monitoring Network and Early Warning System

Barriers	Measure
High upfront cost of procuring and deploying marine monitoring stations	Identify and procure access to local & international finance
High import tax and limited subsidies for technology components	Lobby for reduced import tax on equipment. Some tax/duties may not be applicable for public goods
High cost of installation	Provide technology companies & suppliers with concession to provide service at reduced service costs (Public-private partnership)
High operational and maintenance cost	(Public-private partnership)
Elevated financial risks to programme due to vandalism and praedial larceny	Improve security and risk transfer (insurance)
Impacts of extreme climatic events	Have an extreme weather plan of action

Rising fuel prices	Ensure line item in annual budget
Inadequate policy and regulatory framework	Review policies and propose recommendations to improve enabling environment.
Import of cheaper, inferior-quality equipment/products	
Networking among professionals and agencies weak and ineffective	Enhance networking/advocacy among key actors and fisher folk
Fragmented and weak water quality/marine ecosystem monitoring programme/ protocol	Establish an operational and effective marine monitoring network and early warning system and delivery protocol
Limited environmental monitoring and enforcement in the face of increasing threat on marine resources and use.	Procure and deploy fully equipped network of marine environmental monitoring stations
Lack of reliable information and data to inform long-term decision	Establish an improved marine database in the Fisheries Department
Institutional capacity of regulating agencies needs strengthening	Upgrade institutional capacity and effectiveness of key agencies (Fisheries Dep, CZMAI, etc.)
Restrictive/weak coordination among regulating agencies / departments/ministries/ NGOs / communities in the coastal zone.	
Ineffective implementation of policies & regulations to monitor and control pollution arising from current agricultural and tourist-centric development	Increase the number of specialized experts/trained personnel in Fisheries & CZMAI
Laws & regulations for coastal zone development and resource use not fully implemented	Enforce regulations to reduce pollution and illegal activity
Change in political administration resulting in change of priority/strategy	Minimized political appointment, ensure hiring of qualified technicians Advocate for continuity & mobility in Fisheries Department and CZMAI
Lack of tangible economic benefits of marine early warning	Sensitize marine and coastal zone stakeholders
Negative attitude & perception of marine ecosystem conservation	Include training component in technology diffusion programme
General lack of interest	
Corruption and kickbacks	Enforce regulations and court action to help reduce illegal activities and corruption

3.1.2.4 Actions selected for inclusion in the TAP

Table 34 is a list of the selected actions and activities for the implementation of the proposed coastal and marine environmental monitoring network and the marine early warning service to be facilitated by the Fisheries Department.

Table 34: Activities to implement selected actions for Marine Environmental Monitoring Network and Early Warning System

Action 1. Procure non-reimbursable finance for Marine monitoring system	**Action 2.** Upgrade institutional capacity and effectiveness of key agencies	**Action 3.** Establish an operational and effective marine monitoring network and early warning system and delivery protocol	**Action 4.** Improve collaboration and networking with other relevant institutions in marine R&D	**Action 5.** Establish an improved Marine database and early warning in the Fisheries Department
1.1 Conduct a rapid assessment on the specifications of marine monitoring system and protocol for an effective Marine Early Warning System	2.1 Develop and implement training programme for key agencies	3.1 Implement monitoring guidelines or protocol	4.1 Working programme with members of Coral Reef Working Group	5.1 Procure hardware and software for database unit
1.2 Contract a consultant to conduct a rapid assessment for setting up a marine monitoring network and early warning service	2.2 Procure hardware and software for database unit	3.2 Develop an operational schedule for maintenance of network	4.2 Strengthen advocacy and field work cooperation among key agencies and partners.	5.2 Conduct a survey among key marine stakeholders for the early warning system.
1.3 Draft and submit bankable project proposal	2.3 Develop environmental marine database	3.3 Design a webpage for marine environmental data and early warning system bulletins	4.3 Organize workshops /seminars on marine research & development	5.3 Set up digital page on Fisheries Department website for the marine early warning, and develop a comprehensive mailing list

Actions to be implemented as Project Ideas

1. Establishment of a modern and efficient marine environmental monitoring network in the Coastal Zone of Belize.

Coastal and marine ecosystems experience innumerable stressors from year to year. This phenomenon will continue to increase as economic activity and land use changes rise with more demands. The effects of climate change will simply add to the problem in the foreseeable future. Precise and reliable environmental information and data is a major requirement to inform policy and regulations that can introduce effective measures to address the stress on coastal and marine ecosystems, and the services they provide. Hence the proposal to upgrade the environmental/oceanographic monitoring of the Belize coastal and marine environment.

3.1.2.5 Stakeholders and Timeline for implementation of TAP

Overview of Stakeholders for the implementation of the TAP

The main stakeholders of the TAP for the marine environmental monitoring network and early warning system include: The Fisheries Department as the implementing and coordinating entity for this intervention. The close partners are the Coastal Zone Management Authority and Institute, NGOs, and representatives of the fishing groups and communities.

Scheduling and sequencing of specific activities

Table 35 is a preliminary chronogram for actions and activities for the first 30 months of the proposed project. Two main activities should be carried out at the onset of the process: i) conduct a rapid assessment on the specifications (instrumentation and sites for deployment) of monitoring stations; and ii) draft, review and submit a project proposal to funding agencies for capital finance for the project.

Table 35: Schedule and sequence of activities for the diffusion of marine Environmental Monitoring Network and Early Warning System

Actions	Activities	Timeline (months)																			
		1	2	3	4	5	6	7	8	9	10	11	12	14	16	18	20	24	26	28	30
Action 1. Procure non-reimbursable finance for marine monitoring system	Activity 1.1 Conduct a rapid assessment on the specifications of marine monitoring system and protocol for an effective Marine Early Warning System																				
	Activity 1.2 Contract a consultant for the rapid assessment																				
	Activity 1.3 Draft and submit bankable project proposal																				
Action 2. Upgrade institutional capacity and effectiveness of key agencies	Activity 2.1 Develop and implement training programme for key agencies																				
	Activity 2.2 Procure hardware and software for database unit																				
	Activity 2.3 Develop environmental and marine database																				

Actions	Activities	Timeline (months)																			
		1	2	3	4	5	6	7	8	9	10	11	12	14	16	18	20	24	26	28	30
Action 3. Establish an operational and effective marine monitoring network and early warning system and delivery protocol	Activity 3.1 Implement monitoring guidelines or protocol																				
	Activity 3.2 Develop an operational schedule for maintenance of network																				
Action 4. Improve collaboration and networking with other relevant institutions in marine R & D	Activity 4.1 Working programme with members of Coral Reef Working Group																				
	Activity 4.2 Strengthen advocacy and field work cooperation among key agencies and partners																				
	Activity 4.3 Organize workshops /seminars on marine research & development																				
Action 5. Establish an improved marine database and early warning in the Fisheries Department	Activity 5.1 Conduct a survey among key marine stakeholders for the early warning system																				
	Activity 5.2 Set up digital page on Fisheries Department website for the marine early warning, and develop a comprehensive mailing list																				

Estimation of Resources Needed for Action and Activities

Estimation of capacity building needs

Establishing a protocol for a timely and reliable Marine Early Warning System will require additional institutional strengthening of the Fisheries Department for processing and analysing data, and processing and disseminating Marine Early Warning bulletins. The preliminary estimate of capacity building needs will be at least three personnel at the Fisheries Department. These will include two

technical personnel working with the data retrieval, analysis and preparation of reports and the early warning bulletins, and one technician to operate and maintain the monitoring network.

Estimations of costs of actions and activities

The estimated costs for the intervention is US$229,000.00, including operational costs for five (5) years. See TAP overview Table 37.

3.1.2.6 Management Planning

Risks and Contingency Planning

Table 36 below is a summary analysis of the proposed actions, activities, risks and contingencies, including costs. In the risk analysis, indices scoring 15 and greater are further evaluated for contingency and cost.

Table 36: Risk and contingency planning for uptake of a marine Environmental Monitoring Network and Early Warning System

Action	Activities to be implemented	Risks	Risk Index	Contingency	Cost US$
Action 1. Procure non-reimbursable finance for marine monitoring system	Activity 1.1 Conduct a rapid assessment on the specifications of marine monitoring system and protocol for an effective Marine Early Warning System	SR and PR	12	If internal effort not adequate, plan to procure an outsider (consultant) with experience to spearhead the assignment	8,000.00
	Activity 1.2 Contract a consultant for the rapid assessment	CR and SP	15	---	5,000.00
	Activity 1.3 Draft and submit bankable project proposal	SR and PR	15	Ensure that the selection process for consultant is conducted in an open, professional and effective manner	40,000.00
Action 2. Upgrade institutional capacity and effectiveness of key agencies	Activity 2.1 Develop and implement training programme for key agencies	PR	12	Resubmit a revised draft to a wider group of donors (GCF, GEF, WB, WWF, DIFID, etc)	4,000.00

	Activity 2.2 Procure hardware and software for database unit	CR	20	Procure the services of expert marine personnel locally	20,000.00
	Activity 2.3 Develop environmental marine database	SR and PR	12	Ensure that the equipment is the best brand and reliable for tropical marine conditions	9,000.00 per annum for five years; total 45,000.00
Action 3. Establish an operational and effective marine monitoring network and early warning system and delivery protocol	Activity 3.1 Implement monitoring guidelines or protocol	PR	12		10,000.00
	Activity 3.2 Develop an operational schedule for maintenance of network	SR and PR	6	Ensure that all sources of information and data reviewed and considered	6,000.00
Action 4. Improve collaboration and networking with other relevant institutions in marine R&D	Activity 4.1 Working programme with members of Coral Reef Working Group	SR and PR	9	---	---
	Activity 4.2 Strengthen advocacy and field work cooperation among key agencies and partners	SR and PR	9	Enhance cooperation through advocacy and good team spirit. Cost for meetings and joint field activities	8,000.00
	Activity 4.3 Organize workshops /seminars on marine research & development	SR	16	Enhance cooperation through advocacy and good team spirit. Cost for meetings and joint field activities	8,000.00
Action 5. Establish an improved marine database and early warning in the Fisheries Department	Activity 5.1 Conduct a survey among key marine stakeholders for the early warning system	SR and PR	16	Ensure that the equipment is the best brand and reliable	40,000.00
	Activity 5.2 Set up digital page on Fisheries Department website for the marine early warning, and develop a comprehensive mailing list	PR	12	Review survey instrument after trials to ensure that the questions elicit adequate responses for analysis	30,000.00

Next Steps

The next step is to mobilize all actors and partners in coastal zone and marine sector and update them on this project concept. A small technical working group (TWG) should be organized and lead by personnel from the Fisheries Department. Local funds from an ongoing project should be allocated for the drafting of a bankable project proposal for the nine (9) marine environmental observation stations, and the TWG should hold a series of meeting to agree on the strategic sites for the deployment of the instruments/sensors to achieve the optimum coverage. A work plan for the project should be drafted and adopted.

3.1.2.7 TAP overview table

Table 37 is a summary of the TAP for the diffusion of a marine environmental monitoring network and early warning system. The estimated total cost of the actions and activities for the uptake of this technology is 229,000.00 USD.

Table 37: TAP Summary overview for the diffusion of a coastal and marine Environmental Monitoring Network and Early Warning System

Sector	Coastal and Marine Ecosystem							
Sub-sector	Monitoring and Early Warning							
Technology	Establishment of a Coastal and Marine Environmental Monitoring Network and Early Warning System							
Ambition	Eight environmental and marine observation stations will be deployed at eight critical marine management sites in the coastal zone, where Fisheries Department and marine reserves co-management partners/stakeholders have field operating centres with adequate security, and within range of the mobile communication network. Total capital cost: US$177,965.33 for installation of eight Marine Environmental Monitoring stations at US$22,245.67 per station. The cost to provide project management, monitoring and evaluation of this technology plus spares is estimated at US$84,491.34 for five years of the project cycle							
Benefits	Marine resource and environmental monitoring and early warning can contribute significantly to enhance necessary actions taken by stakeholders to address the impacts of climate change. This intervention will promote sustainable coastal resource use; build alliances to benefit the productive sectors, such as tourism and fisheries; and support integrated development planning in the coastal zone and marine sector.							
Actions	**Activities to be implemented**	**Sources of funding**	**Responsible body and focal point**	**Time frame Months**	**Risks**	**Success criteria**	**Indicators for monitoring of implementation**	**Budget per activity**
Action 1. Procure non-reimbursable finance for Marine monitoring system	Activity 1.1 Conduct a rapid assessment on the specifications of marine monitoring system and protocol for an effective Marine Early Warning System	GCF, GEF, WB, IDB,	Fisheries and CZMAI	4	SR and PR 12	High	Protocol/Guidelines for marine monitoring network & early warning system drafted and presented to key stakeholders	9,000.00

	Activity 1.2 Contract a consultant for the rapid assessment	GCF. UNDP-GEF, WB	Fisheries Department	1	CR and SP 15	High	Consultant contracted	5,000.00
	Activity 1.3 Draft and submit bankable project proposal	GCF, UNDP-GEF,	Fisheries Department	2	SR and PR 15	High	Project proposal drafted and submitted	40,000.00
Action 2. Upgrade institutional capacity and effectiveness of key agencies	Activity 2.1 Develop and implement training programme for key agencies	UNDP-GEF, GOB, WB, IDB	Fisheries Department	4	PR 12	High	Training programme developed and implemented	4,000.00
	Activity 2.2 Procure hardware and software for database unit	GCF, WB, IDB	Fisheries Department	2	CR 20	High	Hardware and software for database procured and installed	20,000.00
	Activity 2.3 Develop environmental marine database	UNDP-GEF, UNDP-GEF	Fisheries Department	1	SR and PR 12	High	Environmental marine database established	9,000.00 per annum for five years; total 45,000.00
Action 3. Establish an operational and effective marine monitoring network and early warning system and delivery protocol	Activity 3.1 Implement monitoring guidelines or protocol	GCF, UNDP-GEF	Fisheries Department	2	PR 12	High	Monitoring guidelines or protocol developed	10,000.00
	Activity 3.2 Develop an operational schedule for maintenance of network	UNDP-GEF	Fisheries Department	1	SR and PR 6	Mod	Schedule and equipment for maintenance of network prepared	6,000.00

Action 4. Improve collaboration and networking with other relevant institutions in marine R&D	Activity 4.1 Working programme with members of Coral Reef Working Group	UNDP-GEF, GCF	Fisheries Department and CZMAI	1.5	SR and PR 9	High	Programme drafted, reviewed and adopted	---
	Activity 4.2 Strengthen advocacy and field work cooperation among key agencies and partners	Fisheries Department GOB	Fisheries Department and CZMAI	4	SR and PR 9	Mod	Key agencies and partners visited and are committed to work as a team	8,000.00
	Activity 4.3 Organize workshops /seminars on marine research & development	UNDP-GEF, GCF	Fisheries Department and CZMAI	2	SR 16	Mod	Workshops/seminars conducted and well received by marine scientists. Two R&D seminars scheduled in duration of project cycle (five years)	12,000.00
Action 5. Establish an improved Marine database and Early Warning in the Fisheries Department	Activity 5.1 Conduct a survey among key marine stakeholders for the early warning system	GCF, Fisheries Department GOB	Fisheries Department	3	SR and PR 16	High	Survey completed, and results considered in the design of early warning and information sharing	40,000.00
	Activity 5.2 Set up digital page on Fisheries Department website for the marine early warning, and develop a comprehensive mailing list	GCF, Fisheries Department	Fisheries Department	2	PR 12	High	Digital is prepared and incorporated into the Fisheries Department website	30,000.00
Total							**US $**	**229,000.00**

3.2 Project Ideas for Coastal and Marine Ecosystem Sector

3.2.1 Brief summary of the Project Ideas for Coastal and Marine Ecosystem Sector

Initially two project ideas were recommended for the Coastal and Marine Ecosystem sector. These were: i) Soft Engineering and Ecosystem Restoration (SEER) Technologies to address shoreline erosion in three threatened coastal communities in Southern Belize; and ii) Improved marine monitoring network and early warning system for Belize's Coastal Zone to increase resilience to climate change. After further deliberation with key stakeholders, it was decided to select the second of these technology-related project ideas.

3.2.2 Specific Project Ideas

3.2.2.1 Improved Marine Monitoring Network and Early Warning System for Belize's Coastal Zone to Increase Resilience to Climate Change

Introduction

One of Belize's natural and greatest assets is its coastal zone (CZMAI, 2014). About 30% of Belize's gross domestic product is directly linked to commercial activities inside its coastal zone (Cho, 2005 in CZMAI, 2014). Belize's coastal zone also has important social and cultural values for its people, considering that about 40% of the population resides along the coast and offshore areas (Statistical Institute of Belize, 2010). The past decades have seen rapid economic development and population growth within the coastal zone and adjacent inland regions of Belize. Consequently, this has led to increasing pressures on coastal and marine resources, directly affecting the livelihood of stakeholders that depend on these resources.

The State of the Belize Coastal Zone 2003-2013 Report (CZMAI, 2014) made a number of recommendations or actions to address the effects of climate change on coastal and marine ecosystems. These included the strengthening of the environmental and marine network; conduct quantitative vulnerability studies of the coastal zone using historic and current data; use results from studies and near real-time observations to develop early warning for climate and anthropogenic impacts on marine ecosystems; and draft policy recommendations to reduce the projected impacts of climate change.

Additional actions or measures identified in the analysis for the Coastal and Marine Ecosystem technology transfer include, but are not limited to the following:

- Fisheries Department in coordination with partners will continue strengthening the technical capacity of its personnel, thereby increasing the number of specialized expertise/trained staff;
- Through its regulatory mandate, the Fisheries Department & CZMAI will continue to work on implementation of legislative/regulatory framework;
- The Fisheries Department, in coordination with partners, will maintain public campaigns, awareness drives and advocacy for high priority given to marine ecosystem conservation by GOB & stakeholders;

- Fisheries will operationalize a coordinated and effective marine monitoring network and early warning system;
- Fisheries and CZMAI will strengthen human and institutional capacity to write bankable project proposals and continue to identify potential international funding opportunities.

Under the TNA-Belize project, the Fisheries Department is proposing the climate change adaptation technology for the Coastal and Marine sector: "Improved Marine Monitoring Network and Early Warning System for Belize's Coastal Zone to Increase Resilience to Climate Change".

The technology transfer will consist of the following:

- i) Eight automatic environmental/marine observation platforms (e.g. YSI EXO 2 Sonde) with sensors to record oceanographic and environmental parameters; ii) Eight data loggers with transmission facility via smart phone technology; iii) Other accessories and hardware for data transmission and retrieval, database management and analysis and marine early warning protocol for dissemination on a regular basis.

Objectives: Provide timely and consistent availability of marine environmental data and information to inform policies, strategies and actions needed for sustainable management and use of marine resources, increase resilience to climate change, and improve the livelihood security of fishers and other stakeholders.

Outputs: Development of a reliable and continuous marine environmental database. An Early Warning system will be re-established on impending impacts such as coral reef bleaching alerts, algal bloom and increasing pollution levels for informing implementation of preventative measures to reduce the impacts on marine resources and ecosystems. These outcomes will contribute significantly to climate change adaptation measures in the marine sector.

Relationship to the country's sustainable development priorities

Earlier in 2016 the Government of Belize adopted the "National Integrated Coastal Zone Management Plan for Belize: Creating a Blueprint for Sustainable Coastal Resources Use" (CZMAI, 2016). The Framework of the Plan consists of four (4) strategic objectives, namely: i) Ensure the sustainable use of resources within the coastal zone; ii) Support integrated planning and management; iii) Build alliances for the benefit of Belizeans; and iv) Manage and adapt to climate change. Strategic objective four requires that the impacts of climate change on marine resources be closely monitored so cost-effective adaptation measures can be implemented to build resilience.

Project Deliverables

The main project deliverables will be the establishment and development of a reliable and continuous marine environmental database and a protocol and delivery mechanism for a timely, informative and durable marine early warning system. These deliverables are important components for sustainable use and management of marine resources and ecosystems.

Project Scope and Possible Implementation

The eight environmental and marine observation stations will be deployed at eight critical marine management sites in the coastal zone, where the Fisheries Department and Marine Reserves co-management partners/stakeholders have field operating centers with adequate security, and are within range of the mobile communication network.

Project activities

The main project activities include:

1. Drafting and submission of a bankable project proposal for funding to procure eight automatic environmental/marine observation platforms (e.g. YSI EXO 2 Sonde) with sensors to record marine and environmental parameters, and all accessories (e.g. loggers, solar PV equipment for RE generation, communication equipment etc.)
2. Develop protocol to retrieve, quality check, archive, and process/analyze data and information for early warning bulletins for stakeholders.
3. Prepare and disseminate marine early warning bulletins
4. Operation and maintenance of marine monitoring network;
5. Maintain updated and accessible environmental and marine database to inform research, policy recommendation, management strategy and the annual State of the Belize Coastal Zone reports
6. Conduct quarterly water quality sampling at four strategic sites for laboratory analysis.

Timelines

The intervention will run for a 5-year project cycle, with weekly data downloads, and monthly maintenance schedule. The early warming will be on a quarterly basis, or as the circumstances warrant dissemination.

Budget/Resource requirements

Initial cost and benefits: Total capital cost: US$177,965.33 for installation of eight marine environmental monitoring stations at US$22,245.67 per station. Operational costs to provide project management, monitoring and evaluation of this technology plus spares is estimated at US$84,491.34 for five years of the project cycle (and includes field operation cost at US$8,000.00 per year, plus replacement of sensors for two stations over the five-year project cycle).

Measurement/Evaluation

Success criteria will include: i) Establishment of a robust marine environmental monitoring network within 4 months of year 1; ii) Institutionalized marine early warning services in the Fisheries Department by the end of year 1; iii) 40% reduced pollution in the marine environment by year 3; iv) At least a 60% decrease in the incidence of illegal, out-of-season catch by year 2; and v) increase resilience of marine and coastal zone ecosystems to anthropogenic stresses (e.g. Agricultural & waste effluence), and impacts of climate change by year 4.

Possible Complications/Challenges

- Lack of national policies to monitor current agricultural and tourist-centric; development practices to ensure viable Zone of Influence (ZOI).
- Little to no long-term research done in coastal communities.
- Need for meaningful enforcement of national regulations to protect coastal resources.
- Limited knowledge of the impacts of climate change on marine ecosystems.
- Limited institutional and human capacity.
- Lack of reliable and current oceanographic/ marine resources data.

Responsibility and Coordination

The Fisheries Department will be the principal entity spearheading and coordinating this intervention and disseminating regular 'early warning' bulletins among key stakeholders. The Fisheries Department will work with its many partners (CZMAI, Marine NGOs, others) to promote the marine monitoring network and early warning system.

Part II: TAP for Mitigation Technologies

Chapter 4. Technology Action Plan and Project Ideas for the Energy Sector

4.1 TAP for Energy Sector

4.1.1 Sector Overview

In 2015, the Ministry of Public Service, Energy, and Public Utilities (2015) reported that 27% of the primary energy used by Belize was for electricity and that 33.47% came from renewable sources.

In 2016, 92% of the population was supplied with electricity by Belize Electricity Limited (BEL) through the national grid (BEL, 2016). Independent Power Producers (IPP) generate their own electricity and have a standby arrangement with BEL. In 2015, the peak demand reported was 96 MW which is buffered by Mexico's Federal Commission of Electricity (Comisión Federal de Electricidad (CFE). Remote communities generate their own electricity using a mix of generators, small-scale photovoltaic (PV) systems, or small-scale wind turbines (Ministry of Public Service, Energy and Public Utilities, 2015).

In 2015, Belize's electricity came from the following sources: 39% from hydro, 14% from biomass, 5% from fossil fuels and 42% was imported from Mexico through CFE (BEL, 2015). Solar energy also contributes to the grid in small amounts; the University of Belize (UB) has a 480 kW solar PV plant meant as a pilot for the on-grid solar PV system (Ministry of Public Service, Energy and Public Utilities, 2015). Belize's Sustainable Energy Strategy and Action Plan for 2030 proposes that this sector be comprised 85% of renewable energy sources (GOB, 2016).

The Technology Needs Assessment (TNA) identified three technologies for the Energy Sector, which are: i) Off-grid Solar PV; ii) Gasification; and iii) On-grid Solar PV.

During consultation with stakeholders it was concluded that the gasification technology will not be feasible for implementation based on the focus proposed in the TNA Report. The Barrier Analysis and Enabling Framework Report presents some of the challenges users of this technology will need to overcome that make this technology a non-starter. The introduction of these technologies would assist with poverty alleviation objectives by providing remote communities with more sustainable energy options and have available energy for industrial/economic development.

4.1.2 Action Plan for Off-grid Solar PV System

4.1.2.1 Introduction

An off-grid solar PV system is a decentralized system that uses PV technology to produce reliable and cost-effective power (Solar Mango, 2015). Photovoltaics technologies generate electricity from sunlight using solar cells which are semiconductor materials (Solar Energy Industries Association).

The main components of an off-grid solar PV system are: the photovoltaic array, charge controller, battery bank, and inverter. The solar panels which form the photovoltaic array are placed on mounts tilted to optimise the solar energy production throughout the year, or on adjustable mounts to account for the different seasons. The charge controller protects the battery by monitoring the voltage and avoiding it from overcharging (Weis, 2013). The inverter converts the direct current (DC) to alternating current (AC) and helps to regulate the voltage (Civic Solar, 2017). These systems tend to be more economic than establishing transmission lines in isolated areas or areas with low population densities (Solar Mango, 2015).

The diffusion of this technology aims to improve the lives of rural communities by providing additional sources of income, building the capacity of the population to adopt this technology, thereby increasing their chances of improved living conditions and opportunities for educational growth. The TNA mitigation report provides more details of the outcomes expected for this technology.

4.1.2.2 Ambition for the TAP

The ambition is to implement the installation of off-grid solar PV systems for communities that are in remote areas, without access to the national grid. The scope could be extended to hospitals and eco-hotels with similar characteristics. It is the hope that these communities move away from the use of kerosene lamps that pose a hazard to human health and property or the use of diesel generators, improving living conditions, and providing opportunities for educational growth.

4.1.2.3 Actions and Activities selected for inclusion in the TAP

Summary of barriers and measures to overcome barriers

Table 38 below provides the list of barriers and measures that were identified for the off-grid solar PV systems during the Barrier Analysis and Enabling Framework (BA & EF) consultation. The BA & EF Report provides a detailed description of each barrier and the measures proposed to overcome them.

Table 38: Off-grid Solar PV System Barriers and Measures

Barriers	Measures
High cost of PV Systems due to taxes and duties being charged for individual components	Reducing or eliminating taxes to reduce cost of PV Systems
Lack of knowledge of available financial support	Create awareness of financial support through campaigns
Cultural barriers	Eliminate cultural barriers through communication
Low awareness of the technology	Create awareness of the technology through communication campaigns
Limited access to technical support	Increase service offering of certified technicians

4.1.2.4 Actions selected for inclusion in the TAP

The main barrier linked to this technology was the unavoidable high cost of components, thus, tax incentives could be created to mitigate this barrier. In addition, it will also require that technicians, especially in rural areas, be trained to provide servicing of PV systems. There are institutions that provide financial assistance for the adoption of this technology, however, it is not known to targeted stakeholders, and thus awareness campaigns are needed for the diffusion of this technology. The actions listed below have been selected for the TAP and validated by the Energy Unit of the Ministry of Public Service, Energy, and Public Utilities. These actions are:

1. Reduce or adjust taxes to create incentives;
2. Create awareness of technology and financial support;
3. Increase service offerings of certified technicians.

Activities identified for implementation of selected actions

1. Reduce or adjust taxes to create incentives

Cabinet papers need to be prepared with a proposal for the relaxation of taxes on PV system components. The Ministry of Public Service, Energy, and Public Utilities can request the assistance of the Ministry of Trade in the preparation of this document. This proposal will then be presented before the House of Representatives for approval and thereafter implementation. Two activities were considered for implementing this action, namely: 1.1) *Prepare Cabinet Paper for tax reform on PV components*; and ii) *Submit Cabinet Paper for its approval*.

2. Create awareness of technology and financial support

A public relations (PR) team will need to be hired to conduct a study of the target audience. The study will help the PR team to determine the media and message required to make the awareness campaign effective and efficient. The campaign will then be executed based on the plan and evaluated to determine its effectiveness. The activities to realize this action are: 2.1) *Conduct study of target audience*; 2.2) *Develop awareness campaign*; 2.3) *Execute awareness campaign*; and 2.4) *Evaluate effectiveness of awareness campaign.*

3. Increase service offering of certified technicians

A training programme for electrical technicians will need to be developed with the guidance of the Ministry of Public Service, Energy, and Public Utilities. The programme should be developed in phases: initially allowing for already certified technicians to receive a separate training in solar PV systems and in a later phase to incorporate it into the regular programme. Awareness campaigns of the training programme need to be conducted to enlist persons or current technicians interested in the installation of solar panels. The Public Utilities Commission (PUC) will need to be approached to create a level of certification for specialisations in solar technologies. The final activity will be to train and certify

applicants who meet minimum requirements for certification. Training should include theory, practical experience, and business skills. The proposed activities for this action are: 3.1) *Develop training programme*; 3.2) *Develop and execute awareness of training programme*; and 3.3) *Train and certify technicians.*

Actions to be implemented as Project Ideas

Increase service offerings of certified electrical technicians to cope with the demands of the technology.

4.1.2.5 Stakeholders and Timeline for implementation of TAP

Overview of Stakeholders for the implementation of the TAP

The Ministry of Public Service, Energy and Public Utilities, formulates policies for the energy sector and serves as an advisory body for Government of Belize (GOB) relating to this sector, making plans for the long-term and for attracting investors. The policies formulated by the ministry are then made into regulations and implemented by the PUC. This Ministry will be responsible for coordinating the execution of actions identified for this technology.

The PUC, established by the PUC Act (GOB, 2000a), is the regulatory body for utilities (namely, electricity, water and telecommunications) in Belize. The Electricity Sector under the PUC is mandated to ensure fair competition in power generation. They are the body responsible for certifying electrical technicians, therefore they have close relationships with vocational training institutions and thus will ensure the training curriculum and certification of electrical technicians.

The Development Finance Corporation's (DFC) is a financial institution governed by an Act that requires them to provide funding to individuals or groups with the objective of improving Belize's economy. In 2016, DFC introduced their Renewable Energy and Energy Efficiency Financing Programme for businesses, which in 2017 was extended to households. (DFC, 2017). The TAP proposes that this institution partner with the Ministry of Public Service, Energy, and Public Utilities in conducting awareness campaigns.

The Institute for Technical and Vocational Education and Training (ITVET) is a vocational institution for Belizeans to learn skills to make them employable, they offer automotive and electrical courses, among others. They have facilities spread throughout the country making it ideal for the training of technicians.

Scheduling and sequencing of specific activities

The implementation of off-grid solar PV systems will need to commence with the preparation of a tax reform proposal since this action will ease the diffusion and implementation of this technology. Once a tax reform is approved the awareness campaign needs to be planned, following the recommended activities. Training of electrical technicians can occur simultaneously with the awareness campaign; however, it is suggested that it be delayed until the study of the target audience is completed so that the awareness of the technology and training can be done together to synergise efforts in its implementation.

An activity flow diagram, not included, was developed to facilitate the sequence for implementation of the activities. This flow diagram was used to construct Table 39 below, showing the timeline for each activity.

Table 39: Schedule and sequence of activities for Off-grid Solar PV Systems

Action	Activities	Timeline (months)													
		1	2	3	4	5	6	7	8	9	10	11	12	13	14
Reduce or adjust taxes to create incentive	Prepare Cabinet Papers for tax reform on PV components														
	Submit Cabinet Papers for its approval														
Create awareness of technology and financial support	Conduct study of target audience														
	Develop awareness campaign														
	Execute awareness campaign														
	Evaluate effectiveness of awareness campaign														
Increase service offerings of certified technicians	Develop training programme														
	Develop and execute awareness of training programme														
	Train and certify technicians														

Estimation of Resources Needed for Action and Activities

Capacity building needs*:* Capacity building will be required for trainers in the training of technicians, however this is very unlikely (see Table II-2: Risk Assessment for Off-grid solar PV system).Therefore, it is recommended that the trainers have the necessary qualifications to provide technicians with the necessary technical and business skills.

Costs of actions and activities*:* Costs were estimated using the Government of Belize's pay scale to determine the cost of labour and these figures were validated by the Energy Unit of the Ministry of Public Service, Energy, and Public Utilities. A detail of cost estimates per activity are provided in Annex II and are given in USD.

4.1.2.6 Management Planning

Risks and Contingency Planning

Table 40 summarises significant risks identified in the activities to diffuse off-grid solar PV systems and proposes contingencies to mitigate these risks. An estimate of the cost for each contingency is also provided in USD. The scoring methodology for the risk assessment is provided in Annex III where Table II- provides a more detailed assessment for off-grid solar PV systems.

Table 40: Summary of risks that require contingency planning for Off-grid PV system diffusion.

Action	Activities	Risks	Risk Index	Contingency	Cost for contingency
Create awareness of technology and financial support	Develop awareness campaign	Unqualified public relations team	16	Ensure proper screening of PR team	$0.00
Increase service offerings of certified technicians	Train and certify technicians	Low turnout for training due to business start-up challenges	20	Training should include mentoring programme to provide technicians with business skills	$0.00
		Poor delivery of training	20	Ensure hiring of qualified trainers for technology	$0.00
				Ensure that training includes theoretical and practical material	
		Trainees unable to assimilate knowledge	15	Conduct pre-test to screen trainees, provide a pre-training course to give trainees basic skills and knowledge to absorb main course material	$0.00

Next Steps

The National Climate Change Office (NCCO) as coordinator for the implementation of the TAP will initiate a request to the Energy Unit of the Ministry of Public Service, Energy, and Public Utilities. The Energy Unit will need to budget for the awareness campaign and law amendments, presenting proposal to the Financial Secretary, Ministry of Finance for its approval by National Assembly. The Ministry will also need to send a request to the PUC to start the process for certifying electrical technicians with specialisation in solar technology.

4.1.2.7 TAP overview table

Table 41 presents an overview of the TAP for off-grid solar PV systems. The overview determines: the sources of funding, assigning responsibility to appropriate agencies, and the time frame estimated to accomplish each activity, the significant risks, criteria for the success of each action, the indicators that need to be monitored during implementation and the cost that will be incurred.

Table 41: TAP Overview Table for Off-grid Solar PV System

Sector	Energy							
Sub-sector	Power generation							
Technology	Off-grid Solar PV System							
Ambition	Introduce Solar PV Systems to villages in rural communities in order to reduce carbon dioxide emissions from the use of diesel generators and kerosene lamps.							
Benefits	Providing rural communities with access to more affordable electricity.							
Action	**Activities to be implemented**	**Sources of funding**	**Responsible body and focal point**	**Time frame**	**Risks**	**Success criteria**	**Indicators for monitoring implementation**	**Cost**
Reduce or adjust taxes to create incentive	Prepare Cabinet Papers for tax reform on PV components	GOB	Ministry of Investment and Trade/ Ministry of Public Service, Energy and Public Utilities/ Ministry of Finance	2 months		Within 5 months Cabinet have reviewed tax reform and have provided a positive response	Cabinet paper completed and approved by Minister of Trade	$0.00
	Submit Cabinet Papers for its approval	GOB	Ministry of Investment and Trade/ Ministry of Public Service, Energy and Public Utilities/ Ministry of Finance	1 months			Response from Cabinet has been received	$0.00
Create awareness of technology and financial support	Conduct study of target audience	GOB/ External funding	SIB/ Ministry of Public Service, Energy and Public Utilities/	3 months			Report of study is prepared and presented	$12,355.00

	Develop awareness campaign	GOB/ External funding	Ministry of Public Service, Energy and Public Utilities	2 months	Unqualified public relations team	Within 18 months 80% of rural communities are aware of technology and financial support	Awareness campaign plan is prepared and presented	$7,052.00
	Execute awareness campaign	GOB/ External funding	Ministry of Public Service, Energy and Public Utilities	3 months			All aspects of the plan were completed as detailed	$16,078.00
	Evaluate effectiveness of awareness campaign	GOB/ External funding	SIB/ Ministry of Public Service, Energy and Public Utilities/	3 months			Target audience are aware of technology and financial support	$2,539.00
Increase service offerings of certified technicians	Develop training programme	GOB/ External funding	Vocational Training Institutions/ Public Utilities Commission	1 months		Within 2 years 80% of rural communities have access to services from certified technicians	Training programme is prepared and presented	$8,462.00
	Develop and execute awareness campaign for training programme	GOB/ External funding	Vocational Training Institutions/PUC	2 months			Public is aware of training programme	$8,124.00
	Train and certify persons in technology	GOB/ External funding	Vocational Training Institutions/ Public Utilities Commission	2 months	Low turnout for training. Start-up problems		First set of technicians are certified	$10,154.00
					Poor delivery of training			
					Trainees unable to assimilate			
TOTAL							US$	64,764.00

4.1.3 Action Plan for On-grid Solar PV System

4.1.3.1 Introduction

This technology uses solar cells to generate electricity from the sun. An inverter converts the current from DC (direct current) to AC (alternating current) to be used instantaneously by most appliances. Grid connected PV systems have two types of applications: distributed and centralized.

Distributed systems are installed on residential, commercial, or public buildings and generate electricity which is consumed by the customer and the excess is sold to the grid at an established retail rate. This type of systems can range between 1-5 kW in power generation (GOB-NCCO, 2017). A bi-directional meter is used to measure the power entering and leaving the system, that is, the power purchased from the grid and the surplus sold to the grid (Solar Direct). The centralized systems are usually larger and not necessarily on building rooftops but can be designed as solar 'farms', ranging from 10 kW up to a few MW in generating capacity, an example of the latter is the solar farm at the University of Belize (GOB-NCCO, 2017). The PUC is currently finalising the consultation phase to allow for net-metering. Regulations are being finalised and the market scheme completed by the end of 2018.

This technology was selected for further analysis and diffusion in support of Belize's sustainable development strategy to become a low carbon economy by 2033, through the development of Renewable Energy (RE), thus shifting the country's dependency on fossil-fuels (GOB-NCCO, 2016). Ensuring reliable and sustainable energy sources will facilitate the growth of industries in Belize, providing more job opportunities for Belizeans and improving the Gross Domestic Product (GDP).

4.1.3.2 Ambition for the TAP

On-grid Solar PV systems will be targeted for installation on residential, commercial and small industrial buildings. Whether the technology be focused on distribution and/or centralised will need to be defined with their corresponding precautions like ensuring that buildings are structurally sound to support the load of the solar panels or that a limited expanse of land is not exceeded.

4.1.3.3 Actions and Activities selected for inclusion in the TAP

Summary of barriers and measures to overcome barriers

Table 42: Barriers and Measures for On-grid Solar PV System.

Barrier	Measures
High cost of PV Systems due to taxes and duties being charged for individual components	Reducing capital cost by reviewing taxing scheme and increasing offer for services
Lack of regulations on the tariffs and market schemes	Pass regulations on tariffs and market schemes
Lack of awareness of available financial support	Create awareness campaigns of available financial support
Low awareness of the technology	Create awareness campaigns on the technology

Table 42 provides the list of key barriers and measures for the on-grid solar PV systems technology that were identified during the Barrier Analysis and Enabling Framework consultation. The BA & EF Report provides a detailed description of each barrier and the measures proposed to overcome them.

4.1.3.4 Actions selected for inclusion in the TAP

The lack of regulations on tariffs and market schemes is the main barrier linked to this technology diffusion. Secondary barriers are the high costs incurred due to taxes and duties charged for individual components. The cost can also be reduced by increasing the services offered of technicians, for which training in the technology will be required. In order for Belizeans to invest in on-grid solar PV systems, they need to be made aware of its benefits and the possibilities of financial assistance.

The actions listed below have been selected for the TAP and validated by the Energy Unit of the Ministry of Public Service, Energy and Public Utilities:

1. Review tax scheme on solar PV components;
2. Train technicians to increase the offer for services;
3. Pass regulations on tariffs and market schemes;
4. Create awareness of technology and financial support.

Activities identified for implementation of selected actions

1. Review taxing scheme on PV components.

Cabinet papers need to be prepared with a proposal for the relaxation of taxes on PV system components. The Ministry of Public Service, Energy, and Public Utilities can request the assistance of the Ministry of Trade in the preparation of this document. This proposal will then be presented before the House of Representatives for approval and thereafter implementation.

The proposed activities to facilitate this action are: 1.1) *Prepare Cabinet Papers for tax reform on PV components*; and ii) *Submit Cabinet Papers for its approval*

2. Train technicians to increase the offer for services

A training programme for electrical technicians will need to be developed with the guidance of the Ministry of Public Services, Energy, and Public Utilities. The programme should be developed in phases: initially allowing for already certified technicians to receive a separate training in solar PV systems and in a later phase to incorporate it into the regular programme. Awareness campaigns of the training programme needs to be conducted to enlist persons or current technicians interested in the installation of solar panels. The PUC will need to be approached to create a level of certification for specialisations in solar technologies. The final activity will be to train and certify applicants who meet minimum requirements for certification. Training should include theory, practical experience, and business skills. The activities proposed for this action are: 2.1) *Develop training programme*; 2.2) *Develop and execute awareness of training programme*; 2.3) *Train and certify technicians.*

3. Pass regulations on tariffs and market schemes

By-laws are currently being drafted and need to be finalised, along with the establishment of financial measures that need to be determined. These documents must then go through a consultation process with stakeholders and the public. The by-laws and financial measures will then need to be presented before the House of Representatives for approval and be passed into law.

The related activities for this action are: 3.1) *Finalise by-laws*; 3.2) *Establish financial measures*; 3.3) *Conduct public/stakeholder consultation*; 3.4) *Review comments and validate consultation*; 3.5) *Present proposal to Cabinet*

4. Create awareness of technology and financial support

A public relations (PR) team will need to be hired to conduct a study of the target audience. The study will help the PR team to determine the media and message required to make the awareness campaign effective and efficient. A focus group session could be done during the development phase to ensure the effectiveness of the material being developed. The campaign will then be executed based on the plan and evaluated to determine its effectiveness.

Activities proposed for this action are: 4.1) *Conduct study of target audience*; 4.2) *Develop awareness campaign*; iii) *Execute awareness campaign*; and iv) *Evaluate effectiveness of awareness campaign.*

Actions to be implemented as Project Ideas

1. Increase service offering of certified electrical technicians to cope with the demands of the technology.

4.1.3.5 Stakeholders and Timeline for implementation of TAP

Overview of Stakeholders for the implementation of the TAP

The Ministry of Public Service, Energy and Public Utilities, formulates policies for the energy sector and serves as an advisory body for Government of Belize (GOB) relating to this sector, making plans for the long-term and for attracting investors. The policies formulated by the ministry are then made into regulations and implemented by the PUC. This Ministry will be responsible for coordinating the execution of actions identified for this technology.

The PUC, established by the PUC Act (GOB, 2000a), is the regulatory body for utilities (namely, electricity, water and telecommunications) in Belize. The Electricity Sector under the PUC is mandated to ensure fair competition in power generation. They are the body responsible for certifying electrical technicians, therefore they have close relationships with vocational training institutions and thus will ensure the training curriculum and certification of electrical technicians.

The Development Finance Corporation's (DFC) is required to provide funding to individuals or groups with the objective of improving Belize's economy. In 2016, DFC introduced their Renewable Energy

and Energy Efficiency Financing Programme for businesses, which in 2017 was extended to households. (DFC, 2017). The TAP proposes that this institution partner with the Ministry of Public Service, Energy and Public Utilities in conducting awareness campaigns.

The Institute for Technical and Vocational Education and Training (ITVET) is a vocational institution for Belizeans to learn skills to make them employable, they offer automotive and electrical courses, among others. They have facilities spread throughout the country making it ideal for the training of technicians.

Scheduling and sequencing of specific activities

The implementation of on-grid solar PV systems will first need for tariffs to be regulated and market schemes established. Awareness of relevant stakeholders like the Belize Tourism Board, Hotel Owners Association, Belize Chamber of Commerce and Industry, as well as the public will need to be conducted in parallel so that when public/stakeholder consultation is underway these groups are aware and can make informed comments. Awareness action should start when the by-laws are about 80% completed. While conducting the activities to get the regulations and market schemes prepared, a review of the taxing scheme should be conducted so that both sets of documents can be submitted to Cabinet for approval. Once these papers have been approved by Cabinet, the training of electrical technicians can commence.

The flow diagram, not included, was used to visualize the process that these activities should follow to ease the introduction of this technology. This figure was then used to construct Table 43 below, showing the timeline for each activity.

Table 43: Schedule and sequence of activities for Off-grid Solar PV Systems

Action	Activities	Timeline (months)																					
		Q1			Q2			Q3			Q4			Q5				Q6					
Review taxing scheme on PV components	Prepare Cabinet Papers for tax reform on PV components																						
	Submit Cabinet Papers for approval																						
Train technicians to increase the offer for services	Develop training programme																						
	Develop and execute awareness of training programme																						
	Train and certify technicians																						
	Finalise By-laws																						
	Establish financial measures																						

Action	Activities	Timeline (months)																	
		Q1			Q2			Q3			Q4			Q5			Q6		
Pass regulations on tariffs and market schemes	Conduct public/stakeholder consultation																		
	Review comments and validate consultation																		
	Present proposals to Cabinet																		
Create awareness of technology and financial support	Conduct study of target audience																		
	Develop awareness campaign																		
	Execute awareness campaign																		
	Evaluate effectiveness of awareness campaign																		

Estimation of Resources Needed for Action and Activities

Capacity building needs: Capacity building will be required for trainers in the training of technicians, however, this is very unlikely. Therefore, it is recommended that trainers already have the necessary qualifications to provide technicians with the necessary technical and business skills.

Costs of actions and activities: Costs were estimated using the Government of Belize's pay scale to determine the cost of labour and these figures were validated by the Energy Unit of the Ministry of Public Service, Energy, and Public Utilities. The estimated cost for the on-grid technology uptake is US$99,908.00. See a more detailed cost estimate per activity in the TAP overview matrix, Table 45.

4.1.3.6 Management Planning

Risks and Contingency Planning

Table 44 summarises the significant risks, identified through consultation with stakeholders, in the diffusion of on-grid solar PV systems and proposes contingencies to mitigate the risks. An estimate of the cost for each contingency is also provided in USD. An example of the scoring methodology for the risk assessment is provided in Annex II.

Table 44: Summary of risks that require contingency planning for On-grid Solar PV technology.

Action	Activities	Risks	Risk Index	Contingency	Cost for contingency
Train technicians to increase the offer for services	Train and certify technicians	Low turnout for training due to business start-up challenges	20	Training should include mentoring programme to provide technicians with business skills	$0.00
		Poor delivery of training	20	Ensure hiring of qualified trainers for technology	$0.00
				Ensure that training includes theoretical and practical material	
		Trainees unable to assimilate knowledge	15	Conduct pre-test to screen trainees; Provide a pre-training course to give trainees basic skills and knowledge to absorb main course material	$0.00
Pass regulations on tariffs and market schemes	Finalise By-laws	Committee cannot agree on Byelaws	16	Hire specialist to provide guidance	$9,026.00
	Establish financial measures	Committee cannot agree on financial measures	16	Hire specialist to provide guidance	$9,026.00
Create awareness of technology and financial support	Develop awareness campaign	Unqualified PR team	16	Ensure proper screening of PR team	$0.00

Next Steps

By-laws are currently being finalised, however the awareness campaign will need to be budgeted. The National Climate Change Office will coordinate with the different agencies identified for the implementation of this technology. The Ministry of Public Service, Energy, and Public Utilities will need to budget for the awareness campaign, presenting the proposal to the Financial Secretary, Ministry of Finance, for its approval by National Assembly. The Ministry will also need to send a request to the PUC to start the process for certifying electrical technicians with specialisation in solar technology.

4.1.3.7 TAP overview table

Table 45 presents an overview of the TAP for on-grid solar PV systems. The overview determines: the sources of funding, assigning responsibility to appropriate agencies, and the timeframe estimated to accomplish each activity, the significant risks, criteria for the success of each action, the indicators that need to be monitored during implementation, and the cost that will be incurred, including the total cost of US$99,908.00.

Table 45: TAP Overview Table for On-grid Solar PV System

Sector	Energy							
Sub-sector	Power Generation							
Technology	On-grid Solar PV System							
Ambition	Increase renewable energy sources to supply to Belize's national grid through on-grid solar PV connection with commercial, residential, and industrial consumers.							
Benefits	Less dependence on fossil fuels and reduction in carbon emissions. Renewable and cheaper source of energy for end-users.							
Action	**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**
Review taxing scheme on solar PV components	Prepare Cabinet Papers for tax reform on PV components	GOB	Ministry of Investment and Trade/ Ministry of Public Service, Energy and Public Utilities/ Ministry of Finance	2 months	(Delay in review of and response to request for tax reform in Cabinet paper.) Low	Within 6 months Cabinet have reviewed tax reform and have provided a response	Cabinet paper completed and approved by Minister of Trade	$0.00
	Submit Cabinet Papers for approval	GOB	Ministry of Investment and Trade/ Ministry of Public Service, Energy and Public Utilities/ Ministry of Finance	1 month			Response from Cabinet has been received	$0.00
	Develop training programme	GOB/External funding	Vocational Training Institutions/	1 month			Training programme is prepared and presented	$8,462.00

Increase service offerings of certified technicians			Public Utilities Commission			Within 2 years the pool of certified technicians will satisfy the demand for services causing the cost for services to decrease by at least 20%		
	Develop and execute awareness of training programme	GOB/External funding	Vocational Training Institutions/ Public Utilities Commission	2 months	Moderate		Public is aware of training programme	$10,832.00
	Train and certify technicians	GOB/External funding	Vocational Training Institutions/ Public Utilities Commission	2 months	Poor delivery of training		First set of technicians are certified	$0.00
					Trainees unable to assimilate knowledge			
Pass regulations on tariffs and market schemes	Finalise by-laws	GOB	By-laws Committee	6 months	Committee cannot agree on by-laws	Within 1-year regulations on tariffs and market schemes are passed	By-laws finalised	$9,026.00
	Establish financial measures	GOB	By-laws Committee	2 months	Committee cannot agree on financial measures		Proposal for financial measures are finalised	$9,026.00
	Conduct public/stakeholder consultation	GOB	Ministry of Public Service, Energy and Public Utilities/ Office of Attorney General	3 months			Consultation is completed	$3,949.00

	Review comments and validate consultation	GOB	Ministry of Public Service, Energy and Public Utilities/ Office of Attorney General	1 month			Legislation is amended based on comments	$0.00
	Present proposals to Cabinet	GOB	Ministry of Public Service, Energy and Public Utilities/ Office of Attorney General	1 month			Response from Cabinet is received	$0.00
Create awareness of technology and financial support	Conduct study of target audience	GOB/External funding	SIB	3 months		Within 18 months, 80% of population is aware of technology and financial support	Report of study is prepared and presented	$12,355.00
	Develop awareness campaign	GOB/External funding	Ministry of Public Service, Energy and Public Utilities/	2 months	Unqualified public relations team		Awareness campaign planned, prepared and presented	$8,180.00
	Execute awareness campaign	GOB/External funding	Ministry of Public Service, Energy and Public Utilities/	3 months			All aspects of the plan were completed as detailed	$35,539.00
	Evaluate effectiveness of awareness campaign	GOB/External funding	SIB/ Ministry of Public Service, Energy and Public Utilities	3 months			Target audiences are aware of technology and financial support	$2,539.00
Total							US$	99,908.00

4.2 Cross-cutting Issues

Table 46 illustrates the cross-cutting actions between Off-grid and On-grid Solar PV Systems. Reducing or eliminating taxes on imported technology components and increasing service offerings of certified technicians are the two issues of interests for both technologies uptake.

Table 46: Common issues with Off-grid and On-grid Solar PV systems.

		Off-grid Solar PV Systems		
On-grid Solar PV System	**Actions**	Reducing or eliminating taxes	Create awareness of technology and financial support	Increase service offerings of certified technicians
	Reducing or eliminating taxes	√		
	Increase services offerings of certified technicians			√
	Pass regulations on tariffs and market schemes			
	Create awareness of technology and financial support		√	

The Off-grid Solar PV technology can be deployed with the On-grid technology in order to save money and efforts. It is important to note that these technologies have different ambitions, and therefore target different audiences in their awareness campaigns. Nevertheless, the same PR team could be hired for both campaigns. The tax reform could be prepared and presented together. Lastly, technicians for both technologies can be empowered at the same time, especially since they are both solar PV technologies.

4.3 Project Ideas for Energy Sector

4.3.1 Brief summary of the Project Ideas for Energy Sector

Project ideas for the Energy Sector aim to support the realisation of the TAP for this sector. The idea of training and certifying locals will ensure the sustainability of the technology and that clients have the necessary technical support. The project idea arose from a measure to overcome barriers of high operating costs and a deficiency of service providers.

The second project idea focuses on deployment of the technology as a pilot. This project idea was suggested based on an ongoing project the Ministry of Energy is currently implementing in several villages of the Toledo District. The success of this project will also determine whether the technology or its approach will be replicable for other villages with similar demographics.

4.3.2 Training and certification of locals

4.3.2.1 Introduction/Background

The PUC could provide certification for electrical technicians trained to install and maintain this equipment. Training would be developed and provided by vocational training organisations, like ITVET, with the guidance of the Energy Unit within the Ministry of Public Service, Energy, and Public Utilities, for electrical technicians at the assistant technician level. This will develop a larger pool of electrical technicians in the country, increasing the competition among suppliers, and ensuring the safety and quality of the service.

4.3.2.2 Objectives

To offer professional services to users of PV technology and reduce cost by increasing the pool of professional service providers.

4.3.2.3 Project Scope and Possible Implementation

It is envisioned that the project will be implemented countrywide. Currently some vocational institutions in the districts provide training for electrical technicians.

4.3.2.4 Outputs

The output of the intervention for training of technicians is: certified technicians. One indicator of successful completion of the course will be: trained technicians are successful in the final certification test. The risk for unsuccessful implementation of the training programme may include misfit candidates and/or a high rate of dropouts.

4.3.2.5 Relationship to the country's sustainable development priorities

The project idea aims in developing the capacity of locals through capacity building and training. This project idea is in line with Belize's Growth and Sustainable Development Strategy which calls for an integrated and systematic approach for sustainable development and addresses medium-term economic development, poverty reduction, and longer-term sustainable development issues.

4.3.2.6 Project activities

Table 47 shows a summary of project activities, timeline, resources and cost of activities for training and certification of technicians as registered service providers. The estimated costs for specialized training of electrical technicians is US$69,000.00.

Table 47: Project activities, timeline and costs

Activities	Timeline	Resources	Verification	Risks	Budget USD
Develop training programme	1 month	Ministry of Public Service, Energy and Public Utilities	Consult with APEB (Association of Professional Engineers of Belize) or UB	Lack of coordination	$10,000
Conduct study of audience	3 months	SIB	Profiles of audience categorised	Poor participation	$13,000
Develop awareness campaign	1 month	Consultant	Report on media strategy	Media strategy is deficient	$10,000
Execute awareness campaign	2 months	Consultant	Verify effectiveness of campaign with stakeholders	Campaign was ineffective	$36,000
Train technicians	1 month	Vocational Institution	Test results	There are misfits and dropouts	-
Certification of technicians	1 month	PUC	Report of certified technicians	Poor results of certification exams	-
Total					US$ 69,000.00

4.3.2.7 Project Deliverables

Table 48 is a summary of the project idea deliverables, indicators and associated risks.

Table 48: Project deliverables

Deliverables	Responsible	Indicators	Risks
Monthly progress reports	Energy Unit	Report is produced	Item not included in terms of reference/job description
List of certified electrical technicians	PUC	List provides names and detail of certified technicians	Electrical technicians are not interested in the course
Training Programme	Energy Unit	Programme is produced	Not enough trainees enrolled
Report of Target Audience	SIB	Report produced	SIB does not capture data
Report of media strategy	Consultant	Payment made to consultant	Media strategy is deficient

4.3.2.8 Project Outcomes

The project output consisting of a pool of professional service providers is presented in Table 49 below.

Table 49: Training project output

Outcomes	Indicators	Verification	Risks
Increased pool of professional service providers	Decrease in cost for service Decrease in complaints for poorly done works Increase in employment	Consult with APEB or UB in the development of the courses	Electrical technicians are not interested in the course

4.3.3 Installation of small scale solar PV off-grid systems in three villages in the Toledo District

4.3.3.1 Introduction/Background

During the technology prioritization process, it was proposed that 75 small scale Solar PV Off-grid systems be installed in three villages in the Toledo District, Belize as a pilot project. These communities are Conejo Creek, Sunday Wood and Crique Sarco with populations of 210, 285 and 328, respectively, based on the most recent census in 2010. Seventy-five (75) households in these three communities will be the beneficiaries. The project should be launched through the respective village councils. It is estimated that six months will be needed to obtain the necessary approvals and to install the panels. The system will need to be monitored for at least one year.

4.3.3.2 Objectives

Install 75 small scale Solar PV Off-grid systems in three villages in the Toledo District, Belize as a pilot project

Project Scope and Possible Implementation

The project would extend to 75 households in three villages (Conejo Creek, Sunday Wood and Crique Sarco) in the Toledo District. This technology has already been previously implemented in Santa Teresa, Toledo.

4.3.3.3 Outputs

A summary of the project output, indicators and risks is contained in Table 50. The output and indicator for installation of small scale solar PV off-grid systems in three villages in the Toledo District is that 75 homes are equipped with 100W functioning solar PV systems. The risk highlighted is the unavailability of capable electrical technicians for installation and maintenance of the systems.

Table 50: Output, indicators and risks connected with installation of off-grid collar PV systems

Outputs	Indicators	Verification	Risks
75 homes with 100 W solar PV systems	75 homes have solar PV systems	75 systems are installed	Cannot find local electrical technicians for installation and maintenance

4.3.3.4 Relationship to the country's sustainable development priorities

The project idea aims in developing the capacity of locals through capacity building and training. This is in line with Belize's Growth and Sustainable Development Strategy (2014-2017) to take an integrated and systematic approach for sustainable development and encompasses medium-term economic development, poverty reduction, and longer-term sustainable development issues.

4.3.3.5 Project Activities

Table 51 highlights the main project activities, timeline, verification of execution, associated risks of the activities, and estimated costs.

Table 51: Project activities for the off-grid PV installations

Activities	Timeline	Resources	Verification	Risks	Budget
Specification of equipment	2 weeks	Ministry of Public Service, Energy and Public Utilities	List of specifications	Specifications are not well written	$1,000.00
Examination of equipment for compliance with specifications	2 weeks	Ministry of Public Service, Energy and Public Utilities	Certificate of compliance	Equipment does not meet specifications	$2,500.00
Purchase of equipment	6 months	Ministry of Public Service, Energy and Public Utilities	Proof of purchase	Equipment is delayed	$56,300.00
Installation of equipment	3 months	Contractor/Supplier	Equipment installed	Parts do not match	$19,000.00
Commissioning of equipment	1 week	Ministry of Public Service, Energy and Public Utilities	Equipment are functioning properly	Faulty equipment	$ 1, 500.00

4.3.3.6 Project Deliverables

Table 52 is a summary of the project deliverables for the off-grid solar PV installation.

Table 52: Project deliverables in connection with the off-grid solar PV installation

Deliverables	Responsible	Indicators	Risks
Monthly progress reports	Ministry of Public Service, Energy and Public Utilities	Report is produced	Item not included in terms of reference/job description
Purchase order for PV systems	Ministry of Public Service, Energy and Public Utilities	Items received	Items not delivered
Receipts for PV systems	Ministry of Public Service, Energy and Public Utilities	Inventory	No documentation
Equipment specification sheet and warranty	Supplier	Signed warranty by supplier/manufacturer	Warranty does not apply for Belize

4.3.3.7 Project Outcomes

The project outcome and indicator are summarized in Table 53 below. The main outcome will be "improved lives of villagers", and two related indicators are: "Increased level of education for children", and "Children perform better in schools".

Table 53: Project outcome for the off-grid solar PV installation

Outcomes	Indicators	Verification	Assumption
Improved lives of villagers	Increased level of education for children Children perform better in schools	Children enrolled in educational institutions	Villagers are willing to invest in technology

Chapter 5. Technology Action Plan and Project Ideas for Transport Sector

5.1 TAP for Transport Sector

5.1.1 Sector Overview

In 2010, the main energy consumer was the transport sector with a 46.8% of the total secondary energy consumption and generating 49% of total net greenhouse gas (GHG) emissions. Tillett et al (2012) stated that the fuel consumed by this sector is distributed as follows: 47% gasoline, 37% diesel, and the remaining 16% were kerosene, crude oil, and LPG (Tillett, et al., 2012).

The road network consists of 4,490 km of roads, of which 600 km are highways, 778 km are secondary roads, and 3,110 km are rural roads. Only 17.6% of the road network is paved. (GOB-NCCO, 2017).

Carbon dioxide emissions for this sector were 263.58, 275.94, and 330.55 giga grams of CO_2 in 1994, 1997 and 2000 respectively, which shows an increasing trend. By 2030, Belize is aiming to reverse this trend by reducing the amount of conventional fuel used by at least 20%. With this goal in mind, GOB has hired a consulting firm to prepare a National Transport Master Plan. (GOB, 2016).

Two technologies are being proposed. These are:

1. Production of performance based (CO_2 emission) import duties on motor vehicles. [VED – Vehicle Emission Duty].

2. Reduce carbon emissions and vehicle operating cost by retrofitting existing vehicles with LPG Systems.

5.1.2 Action Plan for Production of performance based (CO_2 emission) import duties on motor vehicles [VED – Vehicle Emission Duty]

5.1.2.1 Introduction

Hydrocarbons, carbon monoxide and nitrogen oxides are created during the combustion process and are emitted into the atmosphere through the exhaust pipe. These vehicle exhaust emissions are a significant source of air pollution. These pollutants can be harmful to human health and the environment and lead to the formation of ground level ozone (smog). Some of the more popular emission control devices installed on automobiles are: EGA valve, Catalytic Converter, Air Pump, PCV valve, and Charcoal Cannister. (GOB-NCCO, 2017).

The Environmental Protection Act (GOB, 2003) regulates the permissible emissions concentrations of gases into the environment by motor vehicles and penalizes for its violation. Unfortunately, at the moment, these regulations are not being enforced by the Department of Transport (DOT) nor the Department of the Environment (DOE), emissions are not being measured by these institutions.

Currently, duties in Belize are charged based on the engine capacity for motor cars/sport utility vehicles (SUV), the weight of the vehicle for trucks, and the seating capacity for vans and buses. Due to international agreements that restrict the modification of import duty schemes, it is suggested that licensing fees be based on the amount of carbon dioxide emitted per unit of distance travelled (g CO2/mile). Additionally, this measure will provide a continuous monitoring of vehicle emissions.

This technology will require emissions testing equipment; therefore a reliable and consistent vehicle emission testing protocol will need to be developed. The TNA proposed two different systems that can be used (GOB-NCCO, 2017):

1. A laboratory emission testing facility: is a major infrastructure and institutional investment that requires planning and institutional capacity.

2. Portable emissions measurement system (PEMS): a lightweight 'laboratory' that is used to test and/or assess mobile source emissions (i.e. cars, trucks, buses, construction equipment, generators, cranes, etc.) for the purposes of compliance, regulation, or decision-making.

This technology would reduce GHG emissions, improving the environment and reducing health hazards. More details of this technology are available in the technology fact sheet in the TNA Report.

5.1.2.2 Ambition for the TAP

The production of performance based (CO_2 emission) import duties on motor vehicles [VED – Vehicle Emission Duty] will be implemented throughout Belize by the Department of Transport. Instead of basing the technology on import duties, that is a one-time event, it will be focused on licensing fees that occur on a yearly, cyclical basis. The DOT would be given the responsibility of conducting testing of emissions. The development and implementation of this technology is estimated to take two and a half years.

5.1.2.3 Actions and Activities selected for inclusion in the TAP

Summary of barriers and measures to overcome barriers

Table 54 below provides the list of barriers and measures that were identified for this technology during the Barrier Analysis and Enabling Framework consultations. The BA & EF Report provides a detailed description of each barrier and the measures proposed to overcome them.

Table 54: Production of performance based (CO_2 emission) import duties on motor vehicles [VED – Vehicle Emission Duty] Barriers and Measures.

Barrier	Measure
Duty based on agreement with WTO	Modify the focus of the technology application to licensing of vehicles
Lack of incentives to reduce emissions	Provide tariff incentives based on vehicle carbon emissions
Poor quality of fuel	Enforce fuel quality standards
Lack of vehicle inspection upon re/registration and licensing	Enforce vehicle inspections
Lack of stringent regulations for vehicle importation/licensing	Draft and adopt vehicle regulations dealing with carbon emission
No emissions testing equipment in Belize	Acquiring emissions testing equipment
Lack of certified persons to perform tests	Training programme for DOT and municipalities inspectors
Lack of skilled mechanics in new technology	Train local mechanics in new technology

5.1.2.4 Actions selected for inclusion in the TAP

This technology will require drafting regulations focused on carbon emissions. These regulations will be applied to licensing fees, as was justified in the BA & EF Report. These can be combined with tariff incentives to encourage Belizeans to move away from vehicles that consume high quantities of fuel and emit higher emissions. The procurement of testing equipment is a very important measure for the implementation of this technology to ensure the compliance with regulations. Since testing of vehicle emissions is new in the country, DOT and municipalities personnel will need to be trained in the use of procured testing equipment. This technology will also require the training of local mechanics to ensure qualified technical support to facilitate the compliance of vehicle owners.

The actions listed below have been selected for the TAP and validated by the Department of Transport:

1. Provide tariff incentives based on vehicle carbon emissions;
2. Draft and adopt vehicle regulations dealing with carbon emission;
3. Acquire emissions testing equipment;
4. Train local mechanics in new technology.

Activities identified for implementation of selected actions

1. Provide tariff incentives based on vehicle carbon emissions

A proposal for a licensing scheme needs to be drafted to determine fees. This proposal will need to go through public consultation before it can be submitted to the House of Representatives for approval.

Once approved, a guide needs to be developed for the licensing process. Staff will then need to be trained to be able to execute the process before implementation can commence.

The activities proposed for the implementation of this action are: 1.1) *Prepare draft proposal for licensing scheme*; 1.2) *Public consultation*; 1.3) *Review comments and validate consultation*; 1.4) *Submit recommended legislation to Cabinet*; 1.5) *Develop licensing process*; 1.6) *Train staff in licensing process*; 1.7) *Implement licensing process*.

2. Draft and adopt vehicle regulations dealing with carbon emission

A review of the Motor Vehicle Road and Traffic Act and Environmental Protection Act will need to be conducted and amendments drafted to accommodate for the testing of vehicle emissions. Public consultation will need to be conducted before the amendment can be presented before the House of Representatives for approval and be passed into law.

The proposed activities for this action include: 2.1) *Review legislation and draft amendments*; 2.2) *Public consultation*; 2.3) *Review comments from public consultation*; 2.4) *Submit the amendment to Cabinet for consideration.*

3. Acquiring emissions testing equipment

The purchase of testing equipment will need to go through DOT's procurement process, selecting the equipment best suited for their needs. Since the Department has no experience in this technology, a technical cooperation programme would need to be established with an external agency with knowledge and experience to provide support and certification in the implementation of the technology. Once testing equipment are procured, operations and maintenance manuals will need to be developed and adapted to ensure the proper use and care of the equipment. DOT inspectors and enforcement officers will need to be trained by accredited trainers who will certify their trainees.

The list of activities proposed for this action are: 3.1) *Develop a technical cooperation programme with an external agency*; 3.2) *Procure testing equipment*; 3.3) *Develop Operations Manual*; 3.4) *Train personnel to operate testing equipment*; 3.5) *Develop Maintenance Manual*; 3.6) *Train maintenance personnel to maintain testing equipment*; 3.7) *Conduct evaluation as per established guidelines.*

4. Train local mechanics in new technology

A training programme for mechanics will need to be developed. It is recommended that the Association of Professional Engineers of Belize be approached to provide professional review of the programme. Awareness campaigns of the training programme needs to be conducted to enlist persons interested in the profession. The final activity will be to train and certify applicants who meet minimum requirements for certification.

The proposed activities to implement this action are: 4.1) *Develop training programme for mechanics*; 4.2) *Develop and execute awareness of training programme*; 4.3) *Train and certify mechanics*.

Actions to be implemented as Project Ideas

1) Training of local mechanics for provision of service for technology diffusion.

5.1.2.5 Stakeholders and Timeline for implementation of TAP

Overview of Stakeholders for the implementation of the TAP

The Department of Transportation (DOT) is mandated in section 3(1) in the Motor Vehicles and Road Traffic Act (GOB, 2000b) to register, license and control all vehicles in Belize. In 2008, responsibilities for licensing and registration was shared with the Municipalities as a way for these to collect revenues. The Transport Units within municipalities cooperate with the DOT. The Department would be responsible for the implementation of this technology.

The Belize Bureau of Standards (BBS) is the body responsible for the preparation, promotion, and implementation of standards for goods, services, and processes. (Belize Bureau of Standards, 2013). The BBS would assist DOT in identifying an accredited body to provide training and certification for inspectors and DOT enforcement units.

The Institute for Technical and Vocational Education and Training (ITVET) is a vocational institution for Belizeans to learn skills to make them employable, they offer automotive and electrical courses, among others. They have facilities spread throughout the country making it ideal for the training of mechanics.

Scheduling and sequencing of specific activities

The implementation of "Production of performance based (CO2 emission) import duties on motor vehicles" will need to commence with the review and amendments of legislation and preparing a proposal to modify the vehicle licensing process. Public consultation and submittal of papers can be done together. When approval of Cabinets is obtained the remaining actions can commence. These can be done in parallel: acquiring the testing equipment and developing the licensing process. Training and certification of local mechanics can be done at any time.

Table 55 below shows the timeline for actions and activities for the production of performance based (CO_2 emission) import duties on motor vehicles.

Table 55: Schedule and sequence of activities for Production of performance based (CO2 emission) import duties on motor vehicles.

Action	Activities	Timeline (months)								
		Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9
	Prepare draft proposal for licensing scheme									
	Public consultation									

Action	Activities	Timeline (months)																																	
		Q1			Q2			Q3			Q4			Q5			Q6			Q7			Q8			Q9										
Provide tariff incentives based on vehicle carbon emissions	Review comments and validate consultation																																		
	Submit recommended legislation to Cabinet																																		
	Develop licensing process																																		
	Train staff in licensing process																																		
	Implement licensing process																																		
Draft and adopt vehicle regulations dealing with carbon emission	Review legislation and draft amendments																																		
	Public consultation																																		
	Review comments from public consultation																																		
	Submit the amendment to Cabinet for consideration																																		
Acquiring emissions testing equipment	Develop a technical cooperation programme with an external agency																																		
	Procure testing equipment																																		
	Develop Operations Manual																																		
	Train personnel to operate testing equipment																																		
	Develop Maintenance Manual																																		
	Train maintenance personnel to maintain testing equipment																																		
	Conduct evaluation as per established guidelines																																		
Train local mechanics in new technology	Develop training programme for mechanics																																		
	Develop and execute awareness of training programme																																		
	Train and certify mechanics																																		

Estimation of Resources Needed for Action and Activities

Capacity building needs: The vehicle inspectors and DOT enforcement officers will need to be certified in testing vehicle emissions, for which an accredited institution would need to be sourced and have an individual brought in to provide the training and certification. This cost is estimated to be US$37,768.00.

Municipality and DOT staff will require training in procedures for the new licencing process. This cost is estimated at US$4,232.00.

Costs of actions and activities: Costs were estimated using the Government of Belize's pay scale to determine the cost of labour and these figures were validated by DOT. A detail of cost estimates per activity are provided in in Annex II and are given in USD.

5.1.2.6 Management Planning

Risks and Contingency Planning

Table 56 summarises the significant risks that were identified for the diffusion of this technology and proposes contingencies to mitigate them. An estimate of the cost for each contingency is also provided in USD. The scoring methodology for the risk assessment is provided in Annex III.

Table 56: Summary of risks that require contingency planning for "Production of performance based (CO_2 emission) import duties on motor vehicles" diffusion

Action	Activities	Risks	Risk Index	Contingency	Cost
Provide tariff incentives based on vehicle carbon emissions	Prepare draft proposal for licensing scheme	Cannot find adequate staff to prepare proposal	15	Hire consultant to prepare proposal	$8,462.00
	Submit recommended legislation to Cabinet	Cabinet rejects submission	15	Prepare documentation referencing international commitments by GOB	$0.00
	Develop licensing process	Cannot find adequate staff to develop process	15	Hire consultant to develop process	$12,693.00
	Train staff in licensing process	Poor delivery of training	20	Hire qualified trainers for technology	$5,642.00
		Cannot find adequate staff to train	20	Hire qualified trainers for technology	
		Trainees unable to assimilate knowledge	15	Establish proper description for hiring staff for process	$0.00
	Implement licensing process	Process not implemented	15	Establish reporting schedules of activities	$0.00
		Implementers are not consistent	15	Have DOT conduct emissions testing	$0.00
Acquiring emissions testing equipment	Develop a technical cooperation programme with an external agency	Programme is not suitable for local conditions	15	Programme should be reviewed by local professionals for their feedback	$565.00

Action	Activities	Risks	Risk Index	Contingency	Cost
	Procure testing equipment	Specifications for equipment are not clear	15	Adopt global specifications	$0.00
	Develop Operations Manual	Manual is not disseminated	15	Document existence of manual, placed in e-library Job description should refer to use of manual	
	Train personnel to operate testing equipment	Poor delivery of training	20	Hire accredited trainer to train and certify trainees	$16,924.00
		Cannot find adequate staff to train	20	Hire accredited trainer to train and certify trainees	
		Training is not adopted to local conditions	15	Programme should be reviewed by local professionals for their feedback	$1,411.00
		Trainees unable to assimilate knowledge	15	Establish job description for hiring staff for process	$0.00
	Develop Maintenance Programme	Programme is missing components/activities	15	Hire consultant to develop maintenance programme	$1,411.00
	Train maintenance personnel to maintain testing equipment	Poor delivery of training	20	Hire accredited trainer to train and certify trainees	$8,462.00
		Cannot find adequate staff to train	20	Hire accredited trainer to train and certify trainees	
		Training is not adopted to local conditions	15	Programme should be reviewed by local professionals for their feedback	$1,411.00
		Trainees unable to assimilate knowledge	15	Establish job description for hiring staff for process	$0.00
	Conduct evaluation as per established guidelines	Guidelines are unknown	15	Conduct refresher courses	$0.00
		Evaluations are not conducted	15	Establish reporting schedule of activities	$0.00
Train local mechanics in new technology	Train and certify mechanics	Poor delivery of training	20	Ensure hiring of qualified trainers for technology	$0.00
		Trainees unable to assimilate knowledge	15	Conduct pre-test to screen trainees	$0.00

Action	Activities	Risks	Risk Index	Contingency	Cost
Total				US$	35,826.00

Next Steps

A request from the National Climate Change Office will need to be sent to the Department of Transport for them to initiate the actions detailed in this chapter for the implementation of "Production of performance based (CO_2 emission) import duties on motor vehicles". The Department of Transport will then need to budget these activities and present a proposal to the Financial Secretary, Ministry of Finance for its approval by National Assembly.

5.1.2.7 TAP overview table

Table 57 presents an overview of the TAP for Production of performance based (CO_2 emission) import duties on motor vehicles [VED – Vehicle Emission Duty]. The overview determines: the sources of funding, assigning responsibility to appropriate agencies, and the timeframe estimated to accomplish each activity, the significant risks, criteria for the success of each action, the indicators that need to be monitored during implementation and the cost that will be incurred.

The ambition is to introduce a licensing fee based on carbon emissions for all vehicles imported into the country. This will require a request to GOB for a tariff incentive based on the vehicle carbon emission. A careful review and amendment of the Motor Vehicles and Road Traffic Act (GOB, 2000b) will have to be carried out, and a proposal must be prepared to modify the vehicle licensing process. Public consultation and stakeholder's input would also be recommended as part of the legislative review process. The TAP overview matrix illustrates the key actions and activities and timeline needed to be implemented for the smooth diffusion of this intervention once finance is identified and procured.

Table 57: TAP Overview Table for Production of performance based (CO_2 emission) import duties on motor vehicles [VED – Vehicle Emission Duty]

Sector	Transport							
Sub-sector	Motor carrier							
Technology	Production of performance based (CO_2 emission) import duties on motor vehicles [VED – Vehicle Emission Duty]							
Ambition	Implement a licensing fee based on production of carbon emissions in Belize.							
Benefits	Reduced GHG emissions from vehicles.							
Action	**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**
Provide tariff incentives based on vehicle carbon emissions	Prepare draft proposal for licensing scheme	GOB/ External Funding	Department of Transport/ Department of Environment/ Office of Attorney General	6 months	Cannot find adequate staff to prepare proposal	Within 2 years vehicle owners have adjusted themselves to new process	Licensing scheme has been prepared and approved by Minster of Transport	$8,462.00
	Public consultation	GOB	Department of Transport/ Department of Environment /Office of Attorney General	1 month			Consultation is completed	$1,975.00
	Review comments and validate consultation	GOB	Department of Transport/ Department of Environment/ Office of Attorney General	1 month			Legislation is amended based on comments	$0.00

	Submit recommended legislation to Cabinet	GOB	Department of Transport/ Department of Environment/ Office of Attorney General	1 month			Response from Cabinet is received	$0.00
	Develop licensing process	GOB/ External Funding	Department of Transport	3 months	Cannot find adequate staff to develop process		Licensing process has been developed	$12,693.00
	Train staff in licensing process	GOB/ External Funding	Department of Transport	3 months	Poor delivery of training		Staff are trained in licensing process	$5,642.00
					Cannot find adequate staff to train			
					Trainees unable to assimilate knowledge			
	Implement licensing process	GOB	Department of Transport	4 months	Process not implemented		Licensing process has been implemented	$0.00
Draft and adopt vehicle regulations dealing with carbon emission	Review legislation and draft amendments	GOB	Department of Transport/ Department of Environment/ Office of Attorney General	6 months		Within 18 months emissions testing is legislated to license vehicles	Report of amendments is submitted	$0.00
	Public consultation	GOB	Department of Transport/	2 months			Consultation is completed	$1,975.00

			Department of Environment/ Office of Attorney General					
	Review comments from public consultation	GOB	Department of Transport/ Department of Environment/ Office of Attorney General	1 month			Legislation is amended based on comments	$0.00
	Submit the amendment to Cabinet for consideration	GOB	Department of Transport/ Department of Environment/ Office of Attorney General	3 months			Response from Cabinet is received	$0.00
Acquiring emissions testing equipment	Develop a technical cooperation programme with an external agency	GOB/ External Funding	Belize Bureau of Standards/ Ministry of Foreign Affairs/ Department of Transport	2 months	Programme is not suitable for local conditions	Within 2 years 100% of districts test for emission and 100 % of inspectors are certified	Report of outputs achieved	$9,026.00
	Procure testing equipment	GOB/ External Funding	Department of Transport	6 months	Specifications for equipment are not clear		Testing equipment is procured	$135,385.00
	Develop Operations Manual	GOB/ External Funding	Department of Transport	2 months	Manual is not disseminated		Operations Manual is completed and is available to interested parties	$1,411.00
		GOB/ External Funding	Department of Transport	2 months	Poor delivery of training			$18,335.00

	Train personnel to operate testing equipment				Cannot find adequate staff to train		Personnel is trained to operate testing equipment	
					Training is not adopted to local conditions			
					Trainees unable to assimilate knowledge			
	Develop Maintenance Manual	GOB/ External Funding	Department of Transport	2 months	Programme is missing components/ activities		Maintenance Manual is completed and is available to interested parties	$1,411.00
	Train maintenance personnel to maintain testing equipment	GOB/ External Funding	Department of Transport	2 months	Poor delivery of training		Maintenance personnel is trained	$9,873.00
					Cannot find adequate staff to train			
					Training is not adopted to local conditions			
					Trainees unable to assimilate knowledge			
		GOB/ External Funding	Department of Transport	2 months	Guidelines are unknown		Evaluation report is completed	$0.00

	Conduct evaluation as per established guidelines				Evaluations are not conducted Evaluations are not conducted			
Train local mechanics in new technology	Develop training programme for mechanics	GOB/ External Funding	Department of Transport	1 month		Within 2 years 80% of mechanics are certified	Training programme is prepared and presented	$5,642.00
	Develop and execute awareness of training programme	GOB/ External Funding	Department of Transport	2 months			Public is aware of training programme	$11,171.00
	Train and certify mechanics	GOB/ Vocational Training Institutions	Department of Transport/ Vocational Training Institutions	2 months	Poor delivery of training Trainees unable to assimilate knowledge		First set of mechanics are certified	$0.00
Total							**US$**	**223,001.00**

5.1.3 Action Plan for "Reduce carbon emissions and vehicle operating cost by retrofitting existing vehicles with LPG Systems"

5.1.3.1 Introduction

Dual-fuel vehicles allow for an internal combustion engine to switch manually or automatically between two separate fuels (in separate storage tanks) at a time (J.E. Sinor Consultants, Inc., 1994 p. 24). This technology suggests that a gasoline vehicle can be retrofitted to use LPG as an alternative fuel. LPG is a mixture of butane and propane that have been pressurised to a liquid form. Compared to gasoline and diesel, LPG produces lower emissions of harmful substances, as well as about 11% lower carbon dioxide emissions than that of gasoline (Emer, 2017).

Due to the lower energy density of LPG, its fuel consumption is higher than diesel or gasoline (Energy research Centre of the Netherlands), however, the fuel economy is observed when comparing the overall cost per distance travelled (US Department of Energy, 2017). This technology will give Belizeans a lower costing alternative to gasoline and at the same time a decrease in carbon emissions. More details of this technology are available in the technology fact sheet in the TNA Report.

5.1.3.2 Ambition for the TAP

This technology aims to reduce carbon emissions and vehicle operating cost by retrofitting existing gasoline vehicles with LPG Systems. The scope of its implementation would be countrywide and limited to light weight gasoline vehicles. This technology diffusion will provide Belizeans with a more economical alternative that also reduces carbon emissions. The time frame for implementation is one year.

5.1.3.3 Actions and Activities selected for inclusion in the TAP

Summary of barriers and measures to overcome barriers

Table 58 provides the list of critical barriers and suitable measures to reduce carbon emissions and vehicle operating costs by retrofitting existing vehicles with LPG systems. These barriers and measures were identified during the Barrier Analysis and Enabling Framework consultation. The BA & EF Report provides a detailed description of each barrier and the measures proposed to overcome them.

Table 58: Reduce carbon emissions and vehicle operating cost by retrofitting existing vehicles with LPG Systems Barriers and Measures.

Barrier	Measures
Unregulated market	Regulate market by establishing regulations for LPG Kits
Lack of enforcement of LPG standards	Enforce LPG standards
Lack of public awareness of the technology	Have public awareness campaigns on technology
Lack of skilled labour force	Provide training for mechanics on technology

5.1.3.4 Actions selected for inclusion in the TAP

This technology calls for a policy change to be adopted for LPG Kits with the intention of regulating the market. Although this technology is currently being employed in an informal way in Belize, regulations should be drafted to standardise the operations, thus safeguarding lives, ensuring a competitive market, and providing accessibility for fuelling. Public awareness campaigns will also need to be conducted in order to introduce Belizeans to the technology and its benefits. Lastly, training needs to be provided to mechanics to guarantee proper installations and maintenance of these systems. The actions listed below have been selected for the TAP and validated by the Department of Transport:

1. Regulate market by establishing regulations for LPG Kits;
2. Have public awareness campaigns on technology;
3. Provide training for mechanics on technology

Activities identified for implementation of selected actions

1. Regulate market by establishing regulations for LPG Kits

A review of the Motor Vehicle Road and Traffic Act and Dangerous Goods Act will need to be conducted and amendments drafted to accommodate for retrofitted vehicles. Suppliers of LPG kits should be required to utilize standardised fuel connections and to provide easy access to their products, thus, regulations will also need to be established for retrofitting vehicles. A public consultation will need to be conducted before the amendment can be presented before the House of Representatives for approval and be passed into law. Proposed activities for this action include the following: 1.1) *Prepare amendment of legislation to make provision for retrofitted vehicles;* 1.2) *Conduct public consultation;* 1.3) *Review comments from public consultation;* 1.4) *Submit recommended regulations to Cabinet;* 1.5) *Have public awareness campaigns on technology*

2. Public awareness campaigns on technology

A public relations (PR) team will need to be hired to conduct a study of the target audience. The study will help the PR team to determine the media and message required to make the awareness campaign effective and efficient. A focus group session could be done during the development phase to ensure the effectiveness of the material being developed. The campaign will then be executed based on the plan and evaluated to determine its effectiveness. Related activities for the PR campaign are: 2.1) *Conduct study of target audience*; 2.2) *Develop awareness campaign*; 2.3) *Execute awareness campaign*; and 2.4) *Evaluate effectiveness of awareness campaign*.

3. Provide training for mechanics on technology

A training programme for mechanics will need to be developed. Awareness campaigns of the training programme need to be conducted to enlist persons interested in entering the retrofitting business. The final activity will be to train and certify applicants who meet minimum requirements for certification.

The list of recommended activities is: 3.1) *Develop training programme*; 3.2) *Develop and execute awareness of training programme*; 3.3) *Train and certify mechanics*.

Actions to be implemented as Project Ideas

The action recommended for implementing as a project idea is: “Training of mechanics and providing certification”.

5.1.3.5 Stakeholders and Timeline for implementation of TAP

Overview of Stakeholders for the implementation of the TAP

The Department of Transportation (DOT) is mandated in section 3(1) in the Motor Vehicles and Road Traffic Act (GOB, 2000b) to register, license and control all vehicles in Belize. The Department will be responsible for the implementation of this technology.

The Institute for Technical and Vocational Education and Training (ITVET) is a vocational institution for Belizeans to learn skills to make them employable, they offer automotive and electrical courses, among others. They have facilities spread throughout the country making it ideal for the training of mechanics.

Scheduling and sequencing of specific activities

The first course of action will be to regulate the market by establishing regulations for LPG kits, i.e. preparing amendments for the existing legislation, conducting public consultation and then presenting the draft for approval by Cabinet.

In parallel with the first action, the activities for the awareness campaign should be conducted.

Lastly, once the programme for the awareness campaign has been developed, the activities to train the local mechanics should commence. The delay is so that the awareness campaign helps in promoting the training programme and get more mechanics interested in participating.

Table 59 shows the timeline of actions and activities to be carried out for the successful implementation of the technology for retrofitting existing vehicles with LPG Systems.

Table 59: Schedule and sequence of activities for reducing carbon emissions and vehicle operating cost by retrofitting existing vehicles with LPG Systems.

Action	Activities	Timeline (months)											
		1	2	3	4	5	6	7	8	9	10	11	12
Regulate market by establishing regulations for LPG Kits	Prepare amendment of legislation to make provision for retrofitted vehicles												
	Conduct public consultation												
	Review comments from public consultation												
	Submit recommended regulations to Cabinet												
Have public awareness campaigns on technology	Conduct study of target audience												
	Develop awareness campaign												
	Execute awareness campaign												
	Evaluate effectiveness of awareness campaign												
Provide training for mechanics on technology	Develop training programme												
	Develop and execute awareness of training programme												
	Train and certify mechanics												

Estimation of Resources Needed for Action and Activities

Capacity building needs: Some capacity building may be required for the DOT officer responsible in preparing the amendments of legislation. This person will need to become familiar with the technology in order to ensure all aspects of the technology are contemplated in the revision.

Costs of actions and activities: Costs were estimated using the Government of Belize's pay scale to determine the cost of labour and these figures were validated by DOT. A detail of cost estimates per activity are provided in Annex II and are given in USD.

5.1.3.6 Management Planning

Risks and Contingency Planning

Table 60 summarises significant risks that have been identified for the activities needed to diffuse this technology. Contingencies are proposed for these risks and an estimate of their cost is provided in USD. The scoring methodology for the risk assessment is illustrated in Annex II.

Table 60: Summary of risks and contingency planning for reducing carbon emissions and operating cost by retrofitting existing vehicles with LPG Systems

Action	Activities	Risks	Risk Index	Contingency	Cost
Have public awareness campaigns on technology	Develop awareness campaign	Unqualified PR team	16	Ensure proper screening of PR team	$0.00
Provide training for mechanics on technology	Train and certify mechanics	Poor delivery of training	20	Ensure hiring of qualified trainers for technology	$0.00
		Trainees unable to assimilate knowledge	15	Conduct pre-test to screen trainees	$0.00

Next Steps

A request from the National Climate Change Office will need to be sent to the Department of Transport for them to initiate the actions detailed in this chapter for the implementation of "Reduce carbon emissions and vehicle operating cost by retrofitting existing vehicles with LPG Systems". The Department of Transport will then need to budget these activities and present a proposal to the Financial Secretary, Ministry of Finance, for its approval by National Assembly.

5.1.3.7 TAP overview table

Table 61 presents an overview of the TAP for the reduction of carbon emissions and vehicle operating cost by retrofitting existing vehicles with LPG Systems. The overview determines: possible sources of finance for the proposed intervention, assigning responsibility to relevant agencies, the time frame to accomplish each activity, the significant risks, criteria for the success of each action, indicators that need to be monitored during implementation, and the estimated cost for each activity to complete the actions.

Table 61: TAP Overview Table for 'Reduce carbon emissions and vehicle operating cost by retrofitting existing vehicles with LPG Systems'.

Sector	Transport							
Sub-sector	Motor carrier							
Technology	Reduce carbon emissions and vehicle operating cost by retrofitting existing vehicles with LPG Systems							
Ambition	Convert all light-weight gasoline vehicles to LPG retrofitted vehicles.							
Benefits	Reduced GHG emissions from the Transport Sector. Cost saving in fuel consumption for end users.							
Action	**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**
Regulate market by establishing regulations for LPG Kits	Prepare amendment of legislation to make provision for retrofitted vehicles	GOB	Department of Transport/ Office of Attorney General	6 months		Within 3 years market for LPG kits is regulated	Report of amendments is submitted	$0.00
	Conduct public consultation	GOB	Department of Transport/ Office of Attorney General	2 months			Consultation is completed	$1,975.00
	Review comments from public consultation	GOB	Department of Transport/ Office of Attorney General	1 month			Legislation is amended based on comments	$0.00
	Submit recommended regulations to Cabinet	GOB	Department of Transport/ Office of Attorney General	3 months			Response from Cabinet is received	$0.00
	Conduct study of target audience	GOB/ External Funding	SIB/ Department of Transport	3 months			Report of study is prepared and presented	$12,355.00

Have public awareness campaigns on technology	Develop awareness campaign	GOB/ External Funding	Department of Transport	2 months	Unqualified public relations team	Within 18 months 80% of gasoline vehicle owners are aware of technology	Awareness campaign plan prepared and presented	$8,180.00
	Execute awareness campaign	GOB/ External Funding	Department of Transport	3 months			All aspects of the plan were completed as detailed	$35,539.00
	Evaluate effectiveness of awareness campaign	GOB/ External Funding	Department of Transport	3 months			Target audience are aware of technology	$2,539.00
Provide training for mechanics on technology	Develop training programme	GOB/ External Funding	Department of Transport	1 month		Within 2 years 80% of mechanics are certified	Training programme is prepared and presented	$5,642.00
	Develop and execute awareness of training programme	GOB/ External Funding	Department of Transport	3 months			Public is aware of training programme	$25,386.00
	Train and certify mechanics	GOB/ Vocational Training Institutions	Vocational Training Institutions/ Department of Transport	2 months	Poor delivery of training		First set of technicians are certified	$0.00
					Trainees unable to assimilate knowledge			

5.2 Cross-cutting Issues

Table 62 shows common actions for the diffusion of Transport Sector technologies. The table suggests that these two technologies can be implemented in parallel to coordinate efforts and economic savings. It is suggested that awareness campaigns be executed simultaneously by the same PR team. The training and certification of mechanics/technicians is also an action that could be done concurrently for both technologies.

Table 62: Common issues with "Production of performance based import duties on motor vehicles" and "Reduce carbon emissions and vehicle operating cost by retrofitting existing vehicles with LPG Systems"

	Reduce carbon emissions and vehicle operating cost by retrofitting existing vehicles with LPG Systems			
Production of performance based (CO_2 emission) import duties on motor vehicles	**Actions**	Regulate market by establishing regulations for LPG Kits	Have public awareness campaigns on technology	Provide training for mechanics on technology
	Provide tariff incentives based on vehicle carbon emissions			
	Increase service offerings of certified technicians			√
	Pass regulations on tariffs and market schemes			
	Create awareness of technology and financial support		√	

5.3 Project Ideas for Transport Sector

5.3.1 Brief summary of the Project Ideas for Transport Sector

The project idea for the Transport Sector aims to support the realisation of the TAP for this sector by ensuring access to professional technical support. The aim is to train local mechanics and certify them. This training would support both technologies. The idea comes from the challenges vehicle owners face in sourcing a reliable mechanic.

5.3.1.1 Training and certification of locals

Introduction/Background

The Department of Transport (DOT) could provide certification for mechanics trained to retrofit vehicles with LPG kits and/or to adjust vehicles to comply with emissions requirements. Training would be developed and provided for by vocational training organisations, like ITVET, with the guidance of

DOT. This will develop a larger pool of trained mechanics in the country, increasing the competition among suppliers, and ensuring the safety and quality of the service.

Objectives: Offer professional services to vehicle owners and reduce cost by increasing the offer for services

Project Scope and Possible Implementation

The scope of the project will be countrywide. Currently, some vocational institutions provide training for mechanics.

Output: Table 63 shows the expected output for training and certification of motor vehicle mechanics to provide services to retrofit gasoline engine vehicles with LPG kit conversion. The indicators for training programme, verification and risks are also summarized in Table 63.

Table 63: Project outputs for training and certification of Mechanics

Outputs	Indicators	Verification	Risks
Certified mechanics	Successful completion of course	Mechanics are required to do a test to become certified	There are misfits and dropouts.

Relationship to the country's sustainable development priorities

The project idea aims in developing the capacity of locals through capacity building and training. This is in line with Belize's Growth and Sustainable Development Strategy (2014-2017) to take an integrated and systematic approach for sustainable development and encompasses medium-term economic development, poverty reduction, and longer-term sustainable development issues.

Project activities

A list of project activities, timeline, risks and estimated cost is contained in Table 64 below.

Table 64: Project activities for training and certification of Mechanics

Activities	Timeline	Resources	Verification	Risks	Budget
Develop training programme	1 month	DOT	Consult with APEB or UB	Lack of coordination	$20,000
Conduct study of audience	3 months	SIB	Profiles of audience categorised	Poor participation	$13,000
Develop awareness campaign	1 month	Consultant	Report on Media strategy	Media strategy is deficient	$10,000

Activities	Timeline	Resources	Verification	Risks	Budget
Execute awareness campaign	2 months	Consultant	Verify effectiveness of campaign with stakeholders	Campaign was ineffective	$36,000
Train mechanics	1 month	Vocational institution	Test results	There are misfits and dropouts	-
Certification of mechanics	1 month	DOT	Report of certified technicians	Poor exams results	-

Project Deliverables

Table 65 shows a summary of the project deliverables for training and certification of mechanics.

Table 65: Project deliverables for training and certification of mechanics

Deliverables	Responsible	Indicators	Risks
Monthly progress reports	DOT	Report is produced	Item not included in terms of reference/job description
List of certified mechanics	DOT	List provides names and detail of certified mechanics	Mechanics are not interested in the course
Training Programme	Vocational institution	Programme is produced	Not enough trainees enrolled
Report of Target Audience	SIB	Report Produced	SIB does not capture data
Report of media strategy	Consultant	Payment made to consultant	Media strategy is deficient

Project Outcomes

Outcome and indicators for the training programme are summarized in Table 66. The main outcome is an increased pool of professional service providers for retrofitting LPG systems for gasoline powered vehicles.

Table 66: Project outcomes for training and certification of mechanics

Outcomes	Indicators	Verification	Risks
Increased pool of professional service providers	Decrease in cost for service Decreased complaints for poor service. Increase in employment	Consult with APEB or UB in the development of the courses	Mechanics are not interested in the course

Chapter 6. Technology Action Plan and Project Ideas for Land Use and Forestry Sector

6.1 TAP for Land Use and Forestry Sector

6.1.1 Sector Overview

A recent study indicated that Belize had the highest relative forest cover in Central America and the Caribbean (Cherrington, et. al., 2010). However, during the period 1980 to 2010, Cherrington et al. (2010) estimated that there was a 17.4% loss in the forest cover in Belize, with a deforestation rate of 0.6% per annum. Cherrington et al. (2010) also reported that in 2010, 36% of Belize's land was categorized under some form of protected area. The research found that these protected areas were effective in protecting the forests.

Today, Belize's forests are being deforested to allow for urban expansions; the clearing of private lands for agriculture; and by illegal logging and looting of forests resources. Unfortunately, the extent of these damages is not fully quantified by the local authorities.

In 2015 the estimated yearly carbon dioxide emissions for this sector were 3,300 Gg of CO_2. The GOB has set a goal to reduce these emissions to 410.5 Gg of CO_2 by 2030 (GOB, 2016). The Government hopes to achieve this target by reducing deforestation, upgrading forests management, and increasing the climate change resilience of communities.

6.1.2 Action Plan for Integrated Landscape Forest Management

6.1.2.1 Introduction

Sequestering atmospheric carbon (C) and storing it in the terrestrial biosphere is one of the options, which has been proposed to compensate greenhouse gas (GHG) emissions. Agricultural lands and degraded forests are believed to be major potential sinks and could absorb large quantities of C if trees are reintroduced to these systems and judiciously managed together with crops and/or animals. (Albrecht, et al., 2003).

Integrated Landscape Forest Management technology suggests the implementation of a landscape management strategy involving farmers who are operating within a forest reserve or its buffer zone.

The prioritized technology will focus efforts on areas of the forest reserves that have already been impacted by human activity to reverse the current degradation. The strategy includes: a reforestation programme with native and fast-growing timber species and integrated silviculture practices; an integrated farming system to generate income for farmers operating in the buffer zone; and assisting the farmers in developing business and marketing plans for their produce. The TNA mitigation report provides more details of the expected outcomes for this technology uptake.

6.1.2.2 Ambition for the TAP

This technology aims to reduce emissions arising from land use and land use change through a community forestry program incorporating sustainable livelihood strategies and diversifying local economic opportunities. The extension of its implementation would be countrywide for all forest reserves. Most of its implementation is planned to be completed within approximately six years. This technology would relieve some of the pressures on forest reserves and provide farmers in the buffer zones with an alternative, sustainable livelihood.

6.1.2.3 Actions and Activities selected for inclusion in the TAP

Summary of barriers and measures to overcome barriers

Table 67 below provides the list of barriers and measures that were identified for this technology during the Barrier Analysis and Enabling Framework consultations. The BA & EF Report provides a detailed description of each barrier and the measures proposed to overcome them.

Table 67: Integrated Landscape Forest Management Barriers and Measures.

Barriers	Measures
Limited access to funding	Ensure access to funding
Weak legislations	Amend legislations
Weak institution	Strengthen the Forest Department
Lack of road infrastructure	
Difficulty with marketing of farm products	Form cooperatives or associations to market goods
Technical expertise in agriculture is lacking	Partner with national university to provide technical expertise
Challenges in changing farming practices	Change farming culture

Actions selected for inclusion in the TAP

It was determined that ensuring access to funding is essential to the diffusion of this technology. However, it is also important that the Forest Department (FD) be strengthened to ensure its efficiency and effectiveness in carrying out its mission. The FD also needs to ensure that co-managers of the forest reserves (NGOs, loggers and farmers) protect these areas in a sustainable manner, for which amendments to legislation and actions that work with NGOs and farmers become necessary. Other actions, like changing farming culture of farmers is important but can be achieved through the training that will be given to them in partnership with the University of Belize and other organisations. It is proposed that farmers form cooperatives to market their goods.

Five actions were selected for the TAP. These actions are: i) Access finance for the technology uptake; ii) Amend legislation; iii) Strengthen the Forest Department; iv) Form cooperatives or associations to market goods; and v) Partner with national university to provide technical expertise.

Activities identified for implementation of selected actions

1. Ensure access to funding: A National Needs Assessment will be conducted for the agro-forestry sector. Once these needs are identified a financial proposal must be prepared. The finalised proposal would then be presented to funding agencies for their support. Activities include: i) Conduct a National Needs Assessment in agro-forestry; ii) Prepare a financial proposal; and iii) Present the proposal to PACT (Protected Areas Conservation Trust) and other funding agencies

2. Amend legislation: A review of the Forest Act will need to be conducted and amendments drafted to consider reforestation, agro-forestry, and other issues that may arise from the National Needs Assessment. Public and stakeholder consultation will need to be conducted before the amendment can be presented before the House of Representatives for approval and be passed into law. Proposed activities include: i) Review legislation and draft amendments; ii) Stakeholder consultation; iii) Review comments and validate consultation; and iv) Submit the amendment to Cabinet for consideration

3. Strengthen the Forest Department: A strategic plan is currently being developed. This plan is to ensure that the FD is efficient and effective in accomplishing its activities. However, there may not be enough funds to implement projects within the programme and monitor and evaluate them. Main activities are: i) Develop a Strategic Plan; ii) Implement programmes; and iii) Conduct monitoring and evaluation of programmes.

4. Form cooperatives to market goods: A programme to organise farmers will first need to be developed. The farmers will then be linked with the Cooperatives Department under the Ministry of Agriculture. A constitution for the cooperative will need to be drafted and approved by the farmers. The related activities are: i) Develop programme to organise farmers; ii) Link farmers to the Cooperatives Department; and iii) Draft the constitution for the farmer or farming cooperatives.

5. Partner with national university to provide technical expertise: A Memorandum of Understanding (MOU) will need to be negotiated and drafted between the Ministry of Agriculture and UB or any other organisation. This document will detail how both organisations will work with each other and the farmers. A programme will then need to be developed. UB's new Bachelor's in Agriculture programme has various yearly programmes given that could be introduced to the farmers. Partnerships with UB and other organisations will be sought. Activities for this action are: i) Develop programme for farmers; ii) Implement programme; and iii) Monitor and evaluate the training programme.

6.1.2.5 Stakeholders and Timeline for implementation of TAP

Overview of Stakeholders for the implementation of the TAP

The Forest Department (FD) is the government entity responsible for managing Belize's forests as is mandated in the Forest Act (GOB, 2000c). They will be responsible for the implementation of this technology.

The Agriculture Department, through extension officers, works closely with farmers, providing technical assistance in agricultural techniques. They facilitate the transfer of technology to farmers and promote best agricultural practices. The Department also provides linkage with farmers to potential markets, as well as to other agencies like the Cooperatives Department, Pesticide Control Board, and Belize Agricultural Health Authority. The Agriculture Department will be working closely with farmers, supporting the FD.

Protected Areas Conservation Trust (PACT) is a statutory body that acts as the national environmental trust fund. As stated in the PACT Act, its functions are "... to encourage, promote, and assist the undertaking by suitable persons and bodies of any research, studies or other activities relating to the nationwide effort to establish, operate, maintain and enhance protected areas, and other natural and cultural protected resources for the purposes of conservation, maintenance of biodiversity, protection of ecological processes and for recreational enjoyment". (GOB, 2000d)

University of Belize (UB) is the national university of the country with various campuses distributed throughout the country. The campus at Central Farm provides agricultural instructions to students, farmers and the Ministry of Agriculture.

Scheduling and sequencing of specific activities

The implementation of "Integrated Landscape Forest Management" will need to commence by ensuring that there are funds available. The strengthening of the FD is currently being carried out by other projects, and the submission of a Strategic Plan is scheduled for February 2019. However, there may be a lack of funds for the Strategic Plan and this may require that its implementation be stalled until funds are allocated. Once the National Needs Assessment is finalised a review of legislation can be conducted to ensure all legislative needs are met. With the assurance of funds different programmes can be developed, like organising the farmers into cooperatives and partnering with UB.

The monitoring and implementation phases are not fully represented in the table below as these extend over a period of 5 years, both in the strengthening of the FD and partnering with organisations. Table 68 below shows the proposed schedule and sequence of activities for the proposed Integrated Landscape Forest Management.

Table 68: Schedule and sequence of activities for Integrated Landscape Forest Management

Action	Activities	Timeline (months)													
		Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	Q14
Ensure access to funding	Conduct a National Needs Assessment in agroforestry														

Action	Activities	Timeline (months)														
		Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	Q14	
	Prepare a financial proposal															
	Present proposal to PACT and other funding agencies															
Amend legislation	Review legislation and draft amendments															
	Stakeholder consultation															
	Review comments and validate consultation															
	Submit the amendment to Cabinet for consideration															
Strengthen the Forest Department	Develop Strategic Plan															
	Implement programmes															
	Monitoring and evaluation of programmes															
Form cooperatives or associations to market goods	Develop programme to organise farmers															
	Link farmers to the Cooperatives Department															
	Draft the constitution for the farmer or farming cooperatives															
Partner with UB and other organisations to provide technical expertise	Seek partnerships with UB and other organisations															
	Develop programme for farmers															
	Implement program															
	Monitoring and evaluation of training program															

Estimation of Resources Needed for Action and Activities

Capacity building needs: It is estimated that US$56,354.00 will be required in building the capacity of staff for the strengthening of the FD.

Costs of actions and activities: Costs were estimated using the Government of Belize's payscale to determine the cost of labour and these figures were validated by FD. A detail of cost estimates in USD per activity is provided in the TAP overview in Table 70.

6.1.2.6 Management Planning

Risks and Contingency Planning

Table 69 summarises significant risks identified in the activities to diffuse Integrated Landscape Forest Management and proposes contingencies to mitigate the risk. An estimate of the cost for each contingency is also provided in USD. The scoring methodology for the risk assessment is provided in Annex II.

Table 69: Risk and contingency planning for Integrated Landscape Forest Management diffusion

Action	Activities	Risks	Risk Index	Contingency	Cost USD
Ensure access to funding	Conduct a National Needs Assessment in agroforestry	Department does not have human resource to do assessment	20	Hire a consultant	$33,170.00
	Present proposal to PACT and other funding agencies	Funding agencies reject proposal	15	Work with funding agencies in preparing proposal	$3,159.00
Amend legislation	Review legislation and draft amendments	Amendment takes long in being prepared	15	Identify all relevant existing information for review	$0.00
Strengthen the Forest Department	Develop Strategic Plan	Staff not available to develop programmes		Hire consultant to develop programme	$19,744.00
		Staff do not take ownership of plan		Have many workshops	$4,062.00
		Relevant staff participation is poor	15	Send notifications at least a month in advance Create a calendar of events	$0.00
	Implement plan	Programme is not implemented	15	Establish reporting schedule of activities	$0.00

Action	Activities	Risks	Risk Index	Contingency	Cost USD
		Minister and CEO are not aware of all implications	15	Have more face to face meetings	$0.00
	Monitoring and evaluation of programmes	Programmes are not monitored	15	Establish reporting schedule of activities	$0.00
		Evaluations are not conducted	15	Establish reporting schedule of activities	
		Funds run out before completion date	20	Prepare contracts based on deliverables	$0.00
		Minister and CEO are not aware of all implications	15	Have more face to face meetings	$0.00
Form cooperatives or associations to market goods	Develop programme to organise farmers	Lack of interest from farmers	16	Educate farmers on pros and cons of cooperatives	$1,609.00
Partner with UB and other organisations to provide technical expertise	Implement programme	Programme is not implemented	15	Establish reporting schedule of activities	$0.00
	Monitor and evaluate training programme	Training programme is not monitored	15	Establish reporting schedule of activities	$0.00
		Evaluations are not conducted	15		

Next Steps

The Strengthening of the Forest Department is already underway; however, more funding may be needed for its implementation. The National Needs Assessment will need to be budgeted and presented to the Financial Secretary, Ministry of Finance, for its approval by the National Assembly. The Ministry of Agriculture will need to approach the University of Belize to initiate partnership agreements. The National Climate Change Office will be coordinating key actors for the implementation of the TAP.

6.1.2.7 TAP overview table

Table 70 is an overview of the TAP for Integrated Landscape Forest Management. The TAP examines: sources of funding, assigning responsibility to appropriate agencies, timeframe to accomplish each activity, the significant risks, success criteria for each action, the indicators that need to be monitored during implementation, and estimated costs of activities. The ambition is to be able to implement Integrated Landscape Management good practices in forest reserves across the country. The expected benefits will include curbing the rate of deforestation and enhancing the environmental services these Forest Reserves provide, tapping the RE power generation, and protecting the Mesoamerican Barrier Reef system.

Table 70: TAP Overview Table for Integrated Landscape Forest Management

Sector	Land Use and Forestry							
Sub-sector	Management of Forest Reserves							
Technology	Integrated Landscape Forest Management							
Ambition	Implement technology in forest reserves throughout Belize							
Benefits	Will decelerate the rate of deforestation, ensuring the protection of Belize's water reserves, power generation potential, and the protection of the Mesoamerican Barrier Reef.							
Action	Activities to be implemented	Sources of funding	Responsible body and focal point	Time frame	Risks	Success criteria	Indicators for monitoring of implementation	Budget (USD)
Ensure access to funding	Conduct a National Needs Assessment in agroforestry	BEST Funds/ Japan Aid/ Green Climate Fund/ GEF Small Grants/ MCCAP funds/ Taiwanese govt funds, others	Forest Department	6 months	Department does not have human resources to do assessment	Within 2.5 years the FD obtains 50% of financing from PACT and other funding agencies	FD Management Plan is submitted and approved	$33,170.00
	Prepare a financial proposal	GOB	Forest Department/ PACT/other funding agency	2 months			Financial proposal is prepared and approved	$0.00
	Present proposal to PACT and other funding agencies	GOB	Forest Department	2 months	PACT rejects proposal		Response from PACT is obtained	$3,159.00

Amend legislation	Review legislation and draft amendments	GOB/External	Forest Department/ Office of Attorney General	6 months	Amendment takes long in being prepared	Within 1 year the law is amended	Report of amendments is submitted	$0.00
	Stakeholder consultation	GOB/External	Forest Department/ Office of Attorney General	2 months			Consultation is completed	$2,821.00
	Review comments and validate consultation	GOB/External	Forest Department/ Office of Attorney General	1 month			Legislation is amended based on comments	$0.00
	Submit the amendment to Cabinet for consideration		Forest Department	3 months			Response from Cabinet is received	$0.00
Strengthen the Forest Department	Develop Strategic Plan	GOB/ External Funding	Forest Department	9 months		Within 5 years the FD is in control of the development of the forest reserves; i.e. decreased rate of deforestation		$23,806.00
	Implement programmes	GOB/ External Funding	Forest Department	5 years	Programme is not implemented		Final report is submitted and approved	$0.00
	Monitoring and evaluation of programmes	GOB/ External Funding	Forest Department	5 years continuously	Programmes are not monitored		First evaluation report of training and administration programmes have been submitted, reviewed and implemented	$0.00
					Evaluations are not conducted			
Form cooperatives or associations to market goods	Develop programme to organise farmers	GOB/External	Cooperatives Department	2 months	Lack of interest from farmers		Farmers organisation programme is developed	$1,609.00

	Link farmers to the Cooperatives Department	GOB	Extension Services (Agriculture Department)	1 month		Within 6 months, 80 % of farmers are members of a cooperative or an association	Farmers have signed up with Cooperatives Department	$0.00
	Draft the constitution for the farmer or farming cooperatives	GOB/External	Extension Services (Agriculture Department)	3 months			Constitution has been approved by farmers	$0.00
Partner with national university and other organisations to provide technical expertise	Seek partnerships with UB and other organisations	GOB	Ministry of Agriculture/ University of Belize	3 months		Within 5 years, 80% of farmers have signed up for the programme	Memorandum of Understanding has been signed	$0.00
	Develop programme for farmers	GOB/External	Ministry of Agriculture/ University of Belize	3 months			Training programme has been developed	$11,847.00
	Implement programme	GOB/External	Ministry of Agriculture/ Forest Department	12 months	Programme is not implemented		Final report is submitted and approved	$0.00
	Monitor and evaluation of training programme	GOB	Ministry of Agriculture/ Forest Department	5 years continuously	Training programme is not monitored		First evaluation report of training programmes has been submitted, reviewed and implemented	$0.00
					Evaluations are not conducted			
Total							**US$**	**76,412.00**

6.2 Project Ideas for Land Use and Forestry Sector

6.2.1 Brief summary of the Project Ideas for Land Use and Forestry Sector

6.2.1.1 Establishment of a Micro-Hydro Electricity facility on the Rio On in Mountain Pine Ridge

Introduction/Background

Small-scale hydro schemes can generate up to 500 kilowatts of power. The micro-hydro power station, which converts the energy of flowing water into electricity, provides poor communities in many rural areas around the world with an affordable, easy to maintain and long-term solution to their energy needs. "Run-of-the-river" systems do not require a dam or storage facility to be constructed. Instead water is diverted from the stream or river, channelled into a valley and dropped through a turbine via a pipeline called a penstock.

Micro-hydro power systems are designed to operate for a minimum of 20 years. It is a low-cost way to produce electricity by barrowing the water from the river and returning it back farther downstream. Micro-hydro power is entirely renewable energy and is an alternative climate change mitigation technology that can transform the life of rural communities, who are generally the most severely impacted by climate extremes connected with climate change.

One of the greatest limiting factors in the transformation of the Douglas D'Silva Forest Station (DDSFS) in the Mountain Pine Forest Reserve in the Cayo District into an Eco-Tourism, Research and Education Facility is the unreliable source of electrical energy produced by an old Lister diesel generator. Energy is intermittently provided for a three to four-hour period. For the station to be converted into a tourist resort and education/research centre it would require that the system be upgraded, requiring greater output than can be provided by the present generator and a more reliable source of energy. An assessment of the available alternatives sources of energy indicate that the facility's needs could best be met through a small hydroelectric plant. An EIA study concluded that the hydrology and topography of the area is suitable for this renewable technology of minimal environmental impacts.

The Mountain Pine Ridge Micro-Hydroelectric project is projected to generate electric power of 110/220 V, utilizing the waters of the Rio On river by means of a micro hydroelectric power station with a total installed capacity of 75 -100 kW. The aim is to improve the supply and quality of the electric power in the Douglas D'Silva Forest Station (DDSFS) and the proposed plans to convert the DDSFS into a model Eco-Tourism, Education and Research facility (Tunich Nah, 2004, BET, 2010).

Objective: To provide a reliable and renewal source of electric power to the DDSFS complex that will have minimal environmental impacts on the forest and water ecosystem in the Reserve.

Output: The main output will be a continuous supply of electricity at minimal operational and transmission costs on the medium and long-term, which will enhance the Eco-tourism activities in the MPRFR and the Chiquibul. The benefits will be measurable in daily electric power output and income generation. The FD and Ministry of Tourism will keep records and conduct annual audits.

Relationship to the country's sustainable development priorities

The project will complement strategic actions under the National Sustainable Tourism Master Plan (NSTMP) 2012-2030 "Tourism Destination Plan for the Mountain Pine Ridge Forest Reserve, Chiquibul Forest Reserve, Chiquibul National Park and Caracol Archaeological Reserve."

The NSTMP 2030, developed an overarching tourism policy and strategic planning instrument that embraces the strategic priorities of the national development plan for the country "Horizon 2030", as they relate to building a sustainable and responsible tourism product. The NSTMP 2030 identified tourism as one of Belize's fastest growing industries, averaging 7% growth per annum. It also identified Caracol Archaeological Site and the Chiquibul caverns as standalone iconic destinations.

Project Deliverables

A reliable and renewable electrical energy supply for the DDSFS generated via a run-of-the-river 75 kW micro-hydro power plant will be made available. The intervention will also have economic and social benefits for stakeholders.

Project Scope and Possible Implementation

The micro hydroelectric facility technology transfer under the TNA initiative will be sited locally in the DDSFR Eco-Tourism, Education and Research Facility, serving the wider operations and sustainable forest management of the Mountain Pine Ridge Forest Reserve (MPRFR). The time horizon for the micro hydroelectric facility will be 25 years.

Project activities

Timelines

The timeline for construction, installation and commissioning of the MPRFR micro-hydroelectric facility will be approximately two years. The projected lifespan of the micro-hydroelectric facility is 20 years.

Budget/Resource requirements

The cost of investing in a MHP plant varies depending on the location and hence it is difficult to give accurate figures without knowing the layout of the landscape or site.

- Estimation by GIZ indicates that back in 2010 the installation cost ranged from US$1,000 to more than US$10,000 per kW (Micro Perspectives for Decentralized Energy Supply, http://bit.ly/1vw0dKu/).

- Practical Action cites from their experience that the cost varies from approximately £1,200 to £4,000 (USD 1,831.32 – USD 6,104.40) (April 2013: http://www.xe.com/currencyconverter) per installed kW, when using appropriate technologies, which are much cheaper than using

conventional approaches and technologies (Practical Action: http://practicalaction.org/micro-hydro-power/).

Costs depend on site condition, availability and quality of equipment and construction, and the mode of operation (off grid or grid-connected). Local contributions or in-kind donations can reduce these costs significantly. Estimated cost for this intervention is summarized in Table 71.

Table 71: Estimated costs for micro-hydroelectric power facility at Douglas D' Silva Forest station

The total cost of the project including the items previously described and utilizing 3 x 25 kW turbines, considering a median cost of US$5,000 per installed kW or US$375,000 adds up to:	
US$613,495.00.	
The cost breakdown is presented in Table 1 below	
Total cost of Douglas D'Silva Forest Station project:	
Description Cost (US$)	
Civil works	$ 174,475
Roads and access	$ 20,000
Electro-mechanic equipment	$ 375,000
Construction phase interest	$ 10,275
Project supervision	$ 33,745
TOTAL	$ 613,495
Operational cost for the 3-year project cycle is US $30,000.00 per year or US $90,000	

Measurement/Evaluation

Measurement and evaluation will be carried out by a Project Execution Team with representatives from the Forest Department, Ministry of Tourism & Civil Aviation, Public Utilities Commission, Ministry of Technology, Science and Energy, among others.

Possible Complications/Challenges

Barriers: Some barriers or constraints to the procurement, installation and operation of the proposed 100 – 150 kW micro hydroelectric system for the Mountain Pine Ridge Forest Reserve (DDSFS) Visitors Centre include: initial cost, reliability of the system under extreme conditions, capacity for maintenance, high cost of spares and equipment, life of technology may be too short, technology may become obsolete and need for replacement before projected time horizon, sustainability after 4-years of project cycle, insufficient flow during drought years, tropical cyclone impacts, forest fire damage to the proposed 2.5 km transmission lines.

Responsibilities and Coordination

Table 72 shows a summary of the actions, activities, possible sources of finance, timeline and budget for the diffusion of the micro-hydroelectric facility on the Rio On in the mountain Pine Ridge. The Forest Department Tourism Arm in coordination with the Ministry of Tourism and Ministry of Energy, Science & Technology, and Public Utilities will cooperate to manage the electrification and refurbishment of visitor's and educational facilities at the Douglas D'Silva Forest Station (DDSFS) complex. The FD will have the responsibility for daily operations and maintenance.

Table 72: Actions, activities and costs connected with the installation of a micro-hydroelectric facility for the DDSFS, Mountain Pine Ridge

Action	**Activities**	**Sources of fund**	**Responsible Body**	**Time (Months)**	**Budget (US$)**
1. Civil Works	1.1 Update EIA and C/B 1.2 Engineering design & construction	WB, IDB, GCF	MOW and Contractor	15	174,475.00
2. Road & Access	2.1 Construction phase	WB, IDB, GCF	Contractor and FD	3	20,000.00
3. Procurement of Turbines & Generator	3.1 Negotiate for high quality model, best price and guarantee	WB, IDB, GCF, IUCN	FD	4	375,000.00
4. Construction Phase Interest	4.1 Review construction phase interest and get best bargain	WB, IDB, GCF		2	10,275.00
5. Project supervision	5.1 Procure a reliable and cost-effective engineering group	WB, IDB, GCF		15	33,745.00
Total					US$613,495.00

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Annex I: Structuring finance and potential sources of funding in Technology Action Plan

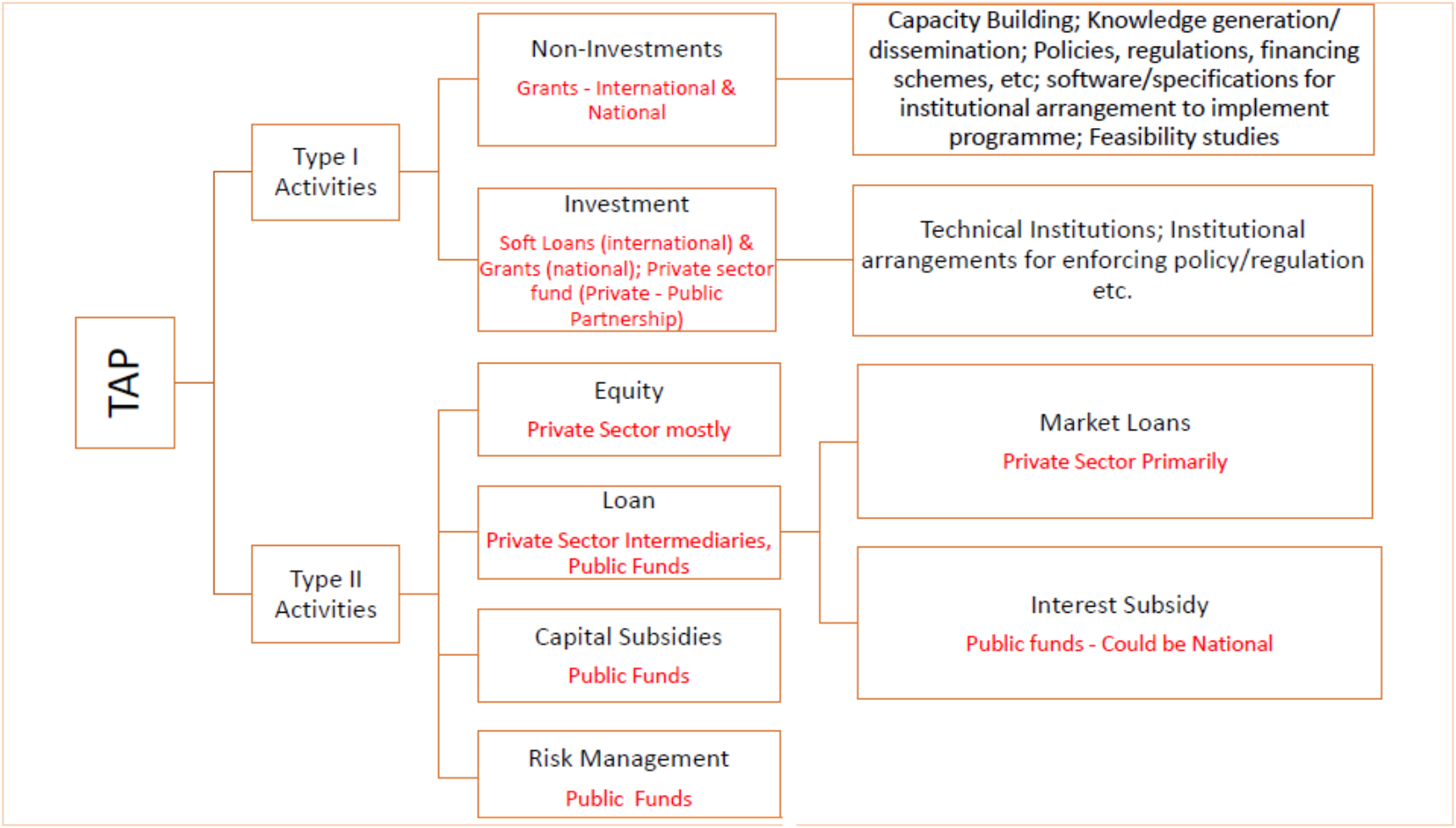

Figure AI-A (i): Structuring finance and potential sources of funding in Technology Action Plan.

(Source: Naswa, P.; Dhar, S.; Sharma, S., 2017)

Annex II-A: Risk Assessment

A Risk Assessment takes into consideration the probability of the threats occurring and the magnitude of consequences. The outcome of the risks may range from very low or insignificant, moderate (minor), high (significant), very high (major risks) to extreme (or severe). The matrix in Figure AII-1 is used to assess the level of risks identified for diffusion of each technology.

			Consequence				
			How severe could the outcomes be if the risk event occurred? →				
			1 Insignificant	2 Minor	3 Significant	4 Major	5 Severe
Likelihood	What's the chance the of the risk occurring? ↑	5 Almost Certain	5 Medium	10 High	15 Very high	20 Extreme	25 Extreme
		4 Likely	4 Medium	8 Medium	12 High	16 Very high	20 Extreme
		3 Moderate	3 Low	6 Medium	9 Medium	12 High	15 Very high
		2 Unlikely	2 Very low	4 Low	6 Medium	8 Medium	10 High
		1 Rare	1 Very low	2 Very low	3 Low	4 Medium	5 Medium

Figure AII-1: Risk Assessment Matrix

The Risk index is determined using the following formula:

$$Risk\ Index = Consequence\ \times Probability\ of\ occurence$$

A Risk Index greater than 15 are considered significant and must be addressed. Contingencies and costing are evaluated for the established significant risks.

Overview of risk categories and possible contingencies

Risk item	Description	Contingency action
Cost Risks (CR)	An activity cost more than originally planned	A line should be created for adding 'contingencies' after consulting with experts in the respective field. This might involve adding 25% to a construction estimate or 15% to the estimate for the cost of running a meeting of the public and private sectors in-country to discuss how to improve "business environment" or 'doing business conditions".
Scheduling Risks (SR)	An activity takes longer to complete than originally planned	Allow for step-by-step schedule slippage. Identify critical path items, whose delay stalls all progress on an Activity or even an Action Item.
Performance Risks (PR)	A technology or human resource does not perform as planned or environmental and social benefits not being delivered	This is the most difficult contingency to plan for, and it is wise to have back up plans. PR can make or break an activity (e.g. water to wire conversion on a micro-hydro facility is only 2/3rds of what is expected) to the trivial (a speaker fails to arrive). Similarly, are the contingency planning responses, for performance of infrastructure ensure the performance risk lies with the contractor or supplier before accepting delivery and commissioning; for missing speakers, get slides in 'note views' well in advance of the meeting.

(After; Guidance for Preparing a Technology Action Plan, UNEP-DTU TEC, 2016)

The following are examples of analysis of Risk Indices for the Adaptation and Mitigation technologies.

Annex II-B: Risks assessment – examples for adaptation and mitigation project activities

Table II-1: Risk Assessment heat and drought resistant varieties of open-pollinating corn and beans seeds.

Action	Activities to be Implemented	Risks Type (CR, SR, PR)	Likelihood	Consequence	Risk Index	Contingency	Cost US$
1. Procure finance to strengthen a certified grain seed production system among farmers' groups	1.1 Conduct a Cost Benefit Analysis for the entire 'quality' seed production chain	CR and PR	3	4	12	--	--
	1.2 Draft and submit bankable project proposal for strengthening resilient, quality grain seed production	SR and PR	5	4	20	Have project steering committee review proposal and submit to several donors and/or financial institutions	6,000.00
	1.3 Establish incentives for farmers (e.g. recognition of 'quality' seed producers and favourable market opportunities)	CR and PR	4	3	12	--	--
	1.4 Review market policy and make recommendations for improved local market access/opportunity	SC and PR	5	4	20	Ensure project steering committee brief CEO and Minister on these issues and prepare policy recommendation paper	4,000.00
	1.5 Revise and implement a national seed policy	SC and PR	4	5	20	Technical Advisory Group (TAG) in MOA conduct revision, advise PSG. Recommendations forwarded to CEO	6,000.00
2. Procure finance to organize and run training programme for seed producers	2.1 Design training programme	CR and PR	3	4	12	---	---
	2.2 Promote added value to seed production and marketing	CR and PR	4	4	16	Ensure budget for programme and Added Value trainers available. Organize trainee groups (four training sessions)	24,000.00

	2.3 Promote improved agronomic practices specific for seed production (e.g. soil conservation)	CR and SR	5	4	20	Identify experts in the specific agronomic practices long before training/ demonstration programme (6 sessions)	36,000.00
3.Public-Private partnership for technical service provision	3.1 Survey of active agriculture technology service provider by district	SR	3	4	12	---	---
	3.2 Design and implement adequate mechanism for information dissemination	CR and SR	3	4	12	---	---
	3.3 Open a small market for locally designed and manufactured seed cool-storage system	CR and PR	4	4	16	Inform farmer's groups or cooperatives of the need and benefit for cool storage facility for quality grain seeds and other crops	12,000.00
4.Strengthen research, development & demonstration of new technology	4.1 Lobby for and procure finance (or budget line item) for R&D in improved technologies	CR	5	4	20	Impress on policymakers the importance of an annual budget for R&D	Internal. GOB in-kind
	4.2 Organized Public and Private sector entities for R&D in Agriculture	CR and PR	5	5	25	Identify a leading Unit or Entity to champion R&D in Agriculture and organized scientific partners. Cost per annum for meetings, seminars, workshops and newsletter.	15,000.00
	4.3 Develop an Agriculture Partners Web Page for R&D	CR and PR	4	3	12	---	---
Action 5. Support the Agriculture infrastructure and management	1.5 Assessing the current seed production methodology to identify needs and gaps (e.g. agronomic practices)	CR and PR	3	4	12	---	---

	5.2 Establish a regulating agency for quality seeds and equipment	CR and PR	4	4	16	Ensure recommendation for a regulating agency for 'quality seed' and equipment performance reaches key policymakers. May require a cabinet paper. Cost may be unusually high	25,000.00
	5.3 Strengthen stock seed source at Central Farm	CR and PR	5	4	20	Ensure finance procured for 'stock seed source' facility (e.g. cold storage and packaging and receptacles)	40,000.00

Mitigation Technologies: Example of Activities Risk Assessment

Table II-2: Risk Assessment for Off-grid solar PV system

Actions	Activities	Risks	Likelihood	Consequence	Risk I	Contingency	Cost US$ Contingency
Reducing or establishing adequate taxes to create incentive	Prepare Cabinet Papers for tax reform on PV components	Cabinet papers take a long time to be prepared	4	3	12		
		Minister of Energy does not accept proposed Cabinet Papers	2	3	6		
	Submit Cabinet Papers to Cabinet for its approval	Cabinet Papers are rejected	3	3	9		
Create awareness of technology and financial support	Conduct study of target audience	Poor participation	2	4	8		
	Develop awareness campaign	Unqualified public relations team	4	4	16	Ensure proper screening of PR team	$0.00

Actions	Activities	Risks	Likelihood	Consequence	Risk I	Contingency	Cost US$ Contingency
	Execute awareness campaign	Poor planning of execution	3	4	12		
	Evaluate effectiveness of awareness campaign	Incorrect indicators are selected	2	4	8		
Increase service offerings of certified technicians	Develop and execute awareness of training programme	Target audience were not engaged	2	3	6		
		Message not understood	2	3	6		
	Train and certify technicians	Low turnout for training due to business start-up challenges	4	5	20	Training should include mentoring programme to provide technicians with business skills	$0.00
		Poor delivery of training	4	5	20	Ensure hiring of qualified trainers for technology Ensure that training includes theoretical and practical material	$0.00
		Trainees unable to assimilate knowledge	3	5	15	Conduct pre-test to screen trainees, Provide a pre-training course to give trainees basic skills and knowledge to absorb the main course material	$0.00

Annex III: List of stakeholders involved and their contacts

Sector-based Technology Group: Adaptation

Name	Organisation	Approach	Time	Topics
Mr. German Novelo	Forest Department	Interview	1 hour	Agroforestry Technologies
Dr. Victorino Pascual	Director, Water Management & Climate Change, MOA	Interview	2 hours	Agriculture prioritized technologies and Actions for the TAP
Mr. Belarmino Esquivel	Director, Extension Services, MOA	Interview	1 hour	Extension Service & Agroforestry
Ms. Inna Sanchez	Coordinator of Research MOA, Central Farm	Interview	2 hours	Actions/Activities for Agriculture Technology for TAP
Dr. Dion Daniels	Director, School of Agriculture, UB	Interviews	2.5 hours	Micro-propagation of potato seed-tubers, UB
Mrs. Zoe Zetina	Acting Supervisor, School of Agriculture, UB	Interview	2 hours	Micro-propagation of potato seed-tubers, UB
Mr. Ricardo Thompson	Director of Projects, MOA	Interviews	1 hour	Agriculture prioritized technologies for TAP. MOA priority crops
Mr. Manuel Trujillo	Director, Fruit & Grain Seed Production Unit, MOA	Interviews	4 hours	Fruit & Grain Seed Production Unit, MOA CF.
Mr. Gary Ramirez	CRDU, MOA	Interview	4 hours	Agriculture prioritized technologies for TAP
Mr. Oscar Salazar	CRDU, MOA	Interview	2 hours	Agriculture prioritized technologies for TAP
Mr. Jonathan Can	Extension Officer	Interview	4 hours	Agriculture prioritized technologies for TAP
Mr. Clifford Martinez	DAO, Cayo, MOA,	Interview	2 hours	Agriculture prioritized technologies for TAP
Mr. Andrew Harrison	CAO, MOA	Interview	1 hour	Agriculture prioritized technologies for TAP
Dr. Steven Williams	Plan micro-propagation laboratory, UB, Central Farm	Interview	4 hours	Micro-propagation of certified potato seed-tubers, University of Belize
Mr. Samir Rosado	Coastal Zone Planner, CZMAI	Interviews		Coastal & Marine environmental monitoring & early warning
Ms. Vivian Ramnarace	Fisheries Officer, Fisheries Department	Interviews		Coastal & Marine environmental monitoring & early warning
Mr. Ernest Banner	Coordinator, Rural Development Department	Interviews		Technology transfer for RWS Strategic Management Plan (Water Safety)
Mr. John Bodden	Public Health Department	Interviews	2 hours	Technology transfer for RWS Strategic Management Plan

Name	Organisation	Approach	Time	Topics
Dr. Marvin Manzanero	Director of Public Health, MOH	Interview	1 hour	Technology transfer for RWS Strategic Management Plan (Water Safety)
Mr. Collin Mattis	Deputy Chief Climate Change Officer, NCCO	Interviews	>6 hours	Agriculture, Water and Coastal & Marine Ecosystems, Agroforestry prioritised technologies for TAP
Mr. Andrew Flowers	Director, PH Water Laboratory	Interview	1 hour	Scheduling of water testing for RWS
Mr. Edilberto Romero	Programme for Belize	Interview	1 hour	Agroforestry

Sector-based Technology Group: Mitigation Technologies

Name	Organisation	Approach	Time	Topics
Mr. Dion Kelly	Energy Unit within Ministry of Labour, Local Government, Rural Development, Public Service, Energy & Public Utilities	Interview	2 ½ hours	Energy technologies, verification of Energy Sector activities and cost
Mr. Peter Williams	Department of Transport	Interview	2 ½ hours	Transport technologies
Mr. German Novelo	Forest Department	Interview	1 hour	Agroforestry Technologies
Mr. Sanches	Department of Environment	Phone Conversation	15 min.	Emissions training
Mrs. Zoe Zetina	Acting Supervisor, School of Agriculture, UB, Central Farm	Interview	30 min.	
Dr. Jenny Garcia-Saqui	Selva Maya	Interview	1 hour	Strengthening of the Forest Department
Mr. Lloyd Orellano	Belize Bureau of Standards	Phone Conversation	10 min.	Certified trainings
Mr. Darrel Audinette	PACT	Interview	30 min.	
Mr. Mark Usher	Public Utilities Commission	Interview	30 min.	
Mr. Ryan Cobb	Energy Unit (Ministry of Public Service, Energy and Public Utilities)	Interview	30 min.	Verification of Energy Sector activities and cost
Dr. Victoriano Pascual	Director, Water Management & Climate Change, MOA	Interview	2 hours	Actions/Activities for Agriculture Technology
Mr. Marcelo Windsor	Forest Department	Interview	30 min.	Forestry Sector