Barrier Analysis and Enabling Framework Report

Ministry of Environment, Rural Modernization and Kalinago Upliftment.

Commonwealth of Dominica

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ACRONYMS

BAEF - Barrier Analysis and Enabling Framework
BGA – Bureau of Gender Affairs
CC - Climate Change
CDEMA – Caribbean Disaster Emergency Management Agency
CIF - Climate Investment Funds
CPACC - Caribbean Planning for Adaptation to Climate Change
CREAD - Climate Resilience Executing Agency for Dominica
CSO - Central Statistics Office
CARIMAN – Caribbean Male Action Network
DNCW - Dominica National Council of Women
DOMLEC - Dominica Electricity Company
DOWASCO –Dominica Water and Sewerage Company
DSWMC – Dominica Solid Waste Management Corporation
DTU - Technical University of Denmark
DVRP - Dominica Vulnerability Reduction Program (DVRP)
ECU - Environmental Coordinating Unit
EV - Electric Vehicle
FA0 – Food and Agriculture Organization
GCF NDA- Green Climate Fund National Designated Authority
GDP - Gross Domestic Product
GHG - Greenhouse Gas
GSP - GEF Small Grants Programme
IDA - International Development Association
IICA - Inter- America Institute for Cooperation on Agriculture
INDC - Intended Nationally Determined Contributions
ISNM - Integrated Soil Nutrition Management
LCCRDS - Low Carbon Climate Resilient Development Strategy
LED – Light-emitting Diode
MCA - Multi-criteria analysis
MACC - Mainstreaming Adaptation to Climate Change
MW - Megawatts
NSAP - Non-State Actor Panel
OECS – Organization of Eastern Caribbean States
PCDL - Petro Caribe Dominica Limited
PPCR - Pilot Program for Climate Resilience
SIDS - Small Island Developing State
SL M - Sustainable Land Management
SPACC - Special Program on Adaptation to Climate Change
SPCR - Strategic Program for Climate Resilience
SUV – Sports Utility Vehicle
TAP - Technology Action Plan
TNA - Technical Needs Assessment
TWG - Technical Working Groups
UN - United Nation
UNDP - United Nations Development Program
UNFCCC- United Nation Framework Convention on Climate Change
VAT – Value Added Tax
WB - World Bank
XCD- Eastern Caribbean Dollar

Executive Summary

This report covers Barrier Analysis on transfer and diffusion of the prioritised technologies for Climate Change adaptation in the Agriculture, Water, Energy and Transportation sectors. In addition, the enabling framework and measures for overcoming the barriers are also addressed. More specifically the report focuses on:

- Preliminary targets for technology transfer and diffusion within the Agricultural sector to include; integrated soil nutrition management and soil conservation – slow forming terrace.
- Preliminary targets for technology transfer and diffusion within the Water Sector to include; Rooftop rainwater harvesting and Installation of water efficient appliances and industrials fixtures – Efficient toilets.
- Preliminary targets for technology transfer and diffusion within the energy sector to include renewable energy (hydro, wind, solar)
- Preliminary targets for technology transfer and diffusion within the energy efficiency sector.
- Preliminary targets for technology transfer and diffusion within the transport sector
- Identification of barriers to the implementation of the selected technologies and the measures that would aid in overcoming these barriers. Cost benefit analysis of the recommended measures were also considered utilizing the NPV and levelized cost approach.

Barrier definition

A barrier is defined as a reason why a target is adversely affected, including any failed or missing countermeasures that could or should have prevented the undesired effect(s). Barriers can be economic and non-economic. Non-economic barriers include, policy and regulatory, institutional capacity, skills, technical support, environmental and, information and awareness (Nygaard I & Hansen U, 2015). A BA is a rapid assessment tool used for identifying causes/determinants hindering the achievement of those desired effect(s). The selected technologies considered within this report are based on the prioritization process and multi-criteria analysis (MCA) undertaken in in step 1 of the TNA process for the Commonwealth of Dominica.

Agriculture Sector

Barrier analysis was conducted for technologies relating to:

- Integrated soil nutrition management (ISNM) focussing on organic fertilizer / ameliorants
- Soil conservation – slow forming terrace.

Preliminary targets for adoption of ISNM and Soil conservation technology was set at approximately 1,800 farmers adopting the recommended technologies by the year 2025 respectively. All identified barriers were grouped into either economic or non-economic categories.

ISNM

Identified economic barriers included: high initial capital cost, high cost and poor credit terms, centralized production centres that are far from raw materials and point of use, high cost for storage, high material application cost and limited mechanization. Some of the non-economic barriers

included: inexperience with production methods, inadequate marketing and technical infrastructure and government policies that negatively impact viability of private sector investment.

Measures recommended to counteract the identified barriers included 1) the establishment of a local pilot composting operation to produce organic nutrients in a manner that will facilitate application, be closer to the point of usage and so reduce cost of transportation and storage. 2) Customize available finance to include the introduction of "index" type insurance products to reduce production risk, and also the introduction of specific product – market chain development and support.

Soil Conservation

The main economic barriers identified included: high establishment cost, availability of financing and other incentives. Non-economic barriers included: producer preferences, technology stigmatization, land tenure status, insufficient information and capacity, lack of appropriate machinery and absence of cohesive legislation.
Measures to combat the identified barriers included 1) Re-purposing existing operations to reduce cost of establishment, customize available financing through increasing confidence in benefits of technology, improve legislative framework to be more all-encompassing and improve extension methodology to transfer and encourage adoption of the technology.

Water Sector

The technologies selected included - Rooftop rainwater harvesting and installation of water efficient appliances. Preliminary targets for technology transfer and diffusion were established at:

- Rooftop rainwater harvesting, storage and distribution at the household level: ensuring that a minimum storage for at least three days of use, allowing an average of 70 gallons / persons / day + 5 gallons / day for house pets within 95% of households over a three-year period. All new household construction to be fitted with appropriate rainwater storage and distribution system specified and included into the building code.
- Installation of water efficient appliances at household and industrial facilities: enable 95% of all household served with portable water to install water efficient features such as low volume flush toilets, water-efficient shower heads and other pipe faucets. This effort was foreseen to be implemented over a period of five years commencing in 2022.

Rainwater harvesting

Economic barriers identified to the implementation of these technologies included - cost of procurement of environmental resilient structures, cost of water treatment to guarantee potability and cost of distribution of this stored treated water. Non-financial barriers included – insufficient local capacity to implement the technology, unavailability of technical information and approved standards.
Measures considered to combat the identified barriers included 1) introduction of low cost ferro-cement storage tanks, water treatment and distribution options. 2) Provision of incentives via import waivers etc. to reduce the cost of imported storage. 3) Undertaking capacity building initiatives to increase production of locally built storage and treatment options 4) Review legislative framework to address standards.

Water efficient appliances

Economic barriers identified included – Cost of efficient appliances as compared to non-efficient appliances and the unavailability of cost effective or subsidized finance to effect change in existing

households. Non-financial barriers included - no policy or regulatory framework for supporting water efficiency measures and or incorporating water efficiency features into the design of new buildings. Further, there were no established standards for water efficiency appliances and so the absence of the legal basis required to define the technical specifications for the various water efficiency appliances that are imported and traded within the island.
Measures identified to counteract the barriers were 1) Implementation of a limited period import tax waiver to encourage the importation and installation of water efficient appliances. 2) Issues such as consumer education, policy and legislative guidelines especially in the establishment of necessary standards were also considered to be priority actions to guide implementation of this technology.

Energy sector

In 1978 over 70% of Dominica's grid electricity was generated by hydro. In 2019, 71.5 % grid electricity is now generated with fossil fuel. The installed generation capacity currently stands at 26.74 megawatts (MW) consisting of 6.64MW (28.5%) of hydropower and 20.1 MW of diesel-powered units. Average base load demand is about 11.5MW, while peak demand is approximately 16MW.

Preliminary targets for technology transfer and diffusion within the renewable energy sector was estimated at 12 MW by 2030.

Identified barriers to renewable energy development includes: limited public awareness and understanding of the possibilities, renewable energy potentials in most areas have not yet been ascertained thus reasonable accurate projections cannot be conjured, limited local technical know-how on commercial energy generation, high initial cost of investment and also storage capacity for solar and wind, high cost of finance, absence of regulation mechanism to promote synchronizing development with grid tie-in, and inequitable tariff system that significantly reduces the difference in selling to the electric utility and buy back.

Hydro energy

The dependability of Hydro power makes it a good source for supplying the energy base load of the island, and a good companion for wind and PV solar, whose supply is not continuous. In 1974, 74% of the island's grid electricity was generated by run-of-the-river hydro. Today that figure is reduced to 28.5%.
A summary of Barriers identified for hydro energy includes:

- Limited effective regulatory policy to guide development of renewable energy to include the expansion of hydro-power
- Unknown energy production capacity of many rivers
- Insufficient local capacity in hydropower development and maintenance
- Limited awareness of energy potential of communal rivers.

Measures to address the identified barriers included:

- National consensus based policy development to guide renewable energy development
- Investigate, document and disseminate hydro potential data to communities.
- Train a cadre of hydro-technicians and university level professionals to engage in transformation
- Conduct of cost benefit public awareness campaigns to raise awareness and increase public support.

Wind Energy

The quantum of wind energy varies and so storage or other means is necessary if energy is needed in periods when the wind is below the minimum threshold. It is thus not utilized for provision of the base load without incorporating some other source.

A summary of barriers identified for wind energy includes:

- Comprehensive policy and legislative guidelines for development of renewable energy to include wind as a viable energy option is not developed. This policy should provide for public education, licensing and management.
- Limited existing technical capacity and knowledge which affects the determination of wind potential, wind turbine installation and upkeep.
- Limited public awareness of potential to reduce electricity bill and impacts of climate change. Installation and maintenance cost is also unknown and so cost limits interest.

Measures identified to address the identified barriers included:

- Policy development and enactment to investigate and promote wind energy benefits, wind energy monitoring and mapping nationally and the encouragement of investments by lowering import duties which currently stands at 30%.
- Increasing technical capacity through training and collaboration with other jurisdictions with more mature wind energy sector
- Conduct of cost benefit analysis on varying scale of installations to increase interest in technology
- improved national consciousness to reduce dependence on fossil fuels by increasing advocacy through government controlled institutions.

Solar energy

Solar energy is the renewable energy source that has achieved the highest degree of penetration within the country. Much of street lighting have been migrating to solar with many residents expressing a desire to include some level of solar at their homes to counteract their high monthly energy bills supplied through fossil fuel.

A summary of barriers identified includes:

- Relative high initial capital cost, especially so for off-grid or other systems where storage is required
- Absence of regulatory and policy framework to guide and encourage importation (quality) and also regulate the sale of renewable generated electrical energy.
- Limited capacity and technical knowledge in solar power installation and maintenance.
- Limited public awareness of the pay back cost, and emission benefit of solar photovoltaic energy generation.

Measures identified to address the barriers includes:

- Creating financial products suitable for access by small businesses and households to fund installation and maintenance
- Addition of a low carbon requirement to the building code to encourage energy efficiency and on-site renewable energy generation in new and retrofitted buildings.
- The reduction in import duty on solar installation equipment and spares.
- IRC to regulate tariffs and measuring schemes between small-scale producers and the utility company to ensure greater equity and transparency.

- Introduction of net metering between producers and electric utility company
- Introduction of renewable energy educational courses at the college and vocational level
- Increase advocacy by special interest groups and schools to increase consciousness of the general population.

Energy efficiency

The energy efficiency initiatives advanced are relatively easily implemented and could yield significant GHG mitigation dividends. The technologies prioritized under energy efficiency includes: Automatic Light Controls: (Photocells, Light Level Sensors, Motion Detectors, Occupancy Sensors), Air-Conditioning: Ground Source Heat Pumps, Windows, Green Roofs, and Urban Heat Island Effect.

Summarized barriers and proposed measures include:

Barrier Type		**Barrier**	**Proposed Measures**
Financial and Economic	Lighting controls Air-Conditioning: Ground Source Heat Pumps Windows Green Roofs	Unknown economic and other financial benefits to reconcile installation cost	Reduce import taxes on these units for an introductory period to encourage their installation. Reduce import taxes on these units for an introductory period to encourage their installation. The state should provide part grant financing to encourage its uptake. Financial institutions to offer concessionary loan terms to their customers to encourage its uptake. State should provide part grant financing to encourage its uptake. Engagement of financial institutions by relevant authorities to encourage the offering of special loan products with terms that encourages uptake.
Regulatory Policy and Action	Lighting controls Air-Conditioning: Ground Source	Energy efficiency is not a requirement for an installation certification. Automatic lighting controls viewed as an unnecessary additional upfront cost. Policy guidelines to encourage adoption	Require the installation of automatic lighting control devices as a requirement for the certification of new installations. Reduce import taxes on these controls for an introductory period to encourage their uptake. Include Ground Source Heat Pumps as a requirement where it is applicable in the

Barrier Type		Barrier	Proposed Measures
	Heat Pumps (GSHP)	of GSHP.	approval process of significant new buildings.
	Windows	Regulations on energy efficiency	Require energy efficient windows as part of building plans approval.
	Green Roofs	Regulations on energy efficiency	Require green roofs on concrete roofs of new buildings as part of building plans approval.
Technical	Lighting controls	Technical knowledge of energy saving and other merits.	The energy saving merits should be included in the education of electricians. Electrical supplies stores should also inform electricians and customers of the savings potential lighting controls. A 20W fixture controlled by a photocell for darkness only activation would save the user $26 per year.
	Air-Conditioning: Ground Source Heat Pumps	Technicians' capacity in installation and upkeep	Introduce Ground Source Heat Pumps skills development at the technical schools and youth development technical program on island.
	Windows	Unknown technical barrier	
	Green Roofs	Capacity of technicians to design and manage green roofs	Install demonstration installations and introduce Ground Source Heat Pumps skills development at the technical school and youth development technical program on island.

Barrier Type		Barrier	Proposed Measures
Awareness and Knowledge	Lighting controls	Local knowledge and understanding of benefits - saving and GHG emissions reduction	Have public awareness campaigns to enlighten consumers on the financial and greenhouse gases savings that can be accrued with these devices. Understanding that the transition from filament or compact fluorescent light bulbs can save between 25% to 70% on consumption, which translate to about EC$0.4 to EC$1.2 per 40W bulb per month resulting a payback for the controls within 18 months.
	Air-Conditioning: Ground Source Heat Pumps	Local experience with their utility and benefits	Launch an awareness campaign with public demonstration site
	Windows	Local inexperience with their utility and benefits	Launch an awareness campaign with public demonstration site
	Green Roofs	Local experience with their utility and benefits	Launch an awareness campaign with public demonstration site

Transport sector

Transportation contribution to greenhouse gas emissions increased from 46.8Gg to 71Gg between the years 2005 to 2014. This period saw an additional 4543 vehicles being brought into operation, with only 1 being an electric vehicle, (INDC, 2015). The uptake of electric vehicles is assessed to be a viable alternative to reduce emissions, on the basis of utilizing renewable energy charging stations. Further, their cost benefit as it relates to maintenance relative to fossil fuel vehicles increases their attractiveness. Successful implementation of a program to replace at least public transportation with electric vehicles will have significant impact on GHG emissions.

Summary of barriers identified for electric vehicles included:

- High purchase cost and also cost of operational architecture without the existence of appropriate fiscal incentives to encourage uptake.
- High cost of energy required for charging that is currently produced predominately from fossil fuels. This also limits the GHG reduction gains that the technology offers.
- Absence of coherent nationally accepted implementation plan for low carbon policy and reduction of GHG related to the substitution of combustion engines with electric motors.
- Inappropriate regulatory guidelines to encourage uptake.

Measures identified to address the barriers includes:

- Introduction of tariff incentives based on a vehicles' carbon emission.
- Tie the vehicle annual licensing fees to its GHG emission.
- Lobbying of financial institutions to incentivise interest rates on loans for vehicle purchase based on GHG emissions.

- Augmentation of existing battery disposal program of the DSWMC to accept batteries from electric cars.
- Encourage the installation of charging facilities. Facilitate the training and know-how for the installation of public and private charging systems.
- Encourage the formation of greenhouse gas mitigation champions / groups to, among other things, advocate the virtues of electric vehicles and the various incentives to go electric.

Chapter 1 Agriculture Sector

Integrated Soil Nutrition Management and Soil Conservation were the two top agricultural technologies selected after the MCA process in step 1 of the TNA for the Commonwealth of Dominica. The ranking of the other technologies considered against the top performers are indicated in table 1-1 below.

The inextricable complementary link between the agricultural technologies - soil nutrition management and soil conservation coupled with the similarity in scores attained could possibly provide a justification for pursuing the investigation of the barriers and enabling framework for implementation as a single unit. Improved soil nutrition which is a major objective of soil nutrition management seeks to mitigate against land degradation thereby the need for soil conservation. Soil conservation activities benefits soil nutrition improvement by reducing erosion, leaching, regulation of soil organic content and soil ecology.

Table 1-1: Final ranking of selected agricultural technologies

Ranking	Technology	Total
1	Integrated soil nutrition management	74
2	Soil conservation	81
3	Drip irrigation	70
4	Indoor farming	23
5	Aquaponics and hydroponics	10

1.1 Preliminary targets for technology transfer and diffusion in the Agricultural sector

The development objectives of the National Resilience Development Strategy (NRDS) and the Low-Carbon Climate Resilience Development Strategy (LCCRDS) actualized in the sectors strategies and action plans forms the basis for the determination of the preliminary targets for the selected technology transfer and diffusion.

The target for ISNM and Soil Conservation technology adoption is set at 1,800 farmers by the year 2025 respectively. This target is based on the Agricultural Strategic Plan 2020-2025 (Final draft) articulated strategic objectives that includes inter alia, "Increase production and productivity of land, marine, renewable resources and enterprises using climate resilient resources" - the implementation of suitable soil and water management practices.

1.2 Barrier analysis and possible enabling measures for integrated soil nutrition management (ISNM)

1.2.1 General description of integrated soil nutrition management

Also referred to as integrated soil fertility management, this technology is intended to promote the efficient use of both synthetic and natural plant nutrient sources to enhance soil fertility towards improving and preserving soil productivity. The success of ISNM relies on the appropriate application and conservation of nutrients and transfer of knowledge to farmers, so to do. ISNM consists of a set of

best practices, preferably used in combination, including the use of appropriate germplasm, the appropriate use of fertilizer and of organic resources, and good agronomic practices.
Integrated soil nutrient management (ISNM) is a means to enhance crop productivity while maximizing the agronomic efficiency of applied inputs, and can thus contribute to sustainable intensification and climate change adaptation.
It is important to note that the approach adopted within the fact sheet in part 1 and interpreted throughout this document, characterizes ISNM from the viewpoint of *the production and utilization of locally produced soil ameliorate - organic compost / manure*. This depends largely on locally sourced inputs as raw materials, decomposition, fermentation and distillation processes to extract beneficial elements to improve soil fertility. The benefit accrued from application of organic soil ameliorate such as improved nutrient availability, water holding capacity, pest management, soil structure & stability is considered to be most significant to the overall productivity of crops. The technology requires a well-resourced research and extension organization for its effective promotion and use. Further, there is the need for appropriate extension approaches and methodologies that provides opportunity for farmer experimentation and adoption of the technology.

Other benefits of ISNM includes:

- Contributes to reduction of vulnerability to climate change through improvements in soil health and increases in productivity.
- The technology can contribute to generation of employment at the community level sales of transformed organic sources e.g., compost
- Requires low investment in tools and equipment; and training of farmers for transforming organic sources into easily usable forms.
- Reduce public and private expenditures in terms of expenditure on the use of inorganic soil nutrients in the long term.
- Creates opportunity for increased group and individual learning at group and community level
- Opportunity for reducing health risks within communities from improved sanitation achieved from processing of organic waste.
- Contribute to reduction in the use of inorganic fertilizers hence reduce dangers of water pollution from poor handling and over use of chemical fertilizer.

Various components of integrated soil fertility management have been widely promoted in Dominica. The combination of components for application to particular sites has however not been institutionalized.

1.2.2 Technology category and market characteristics

The ISNM Technology as described in the technical fact sheet and summarized in section 1.2.1 can be categorized as a typical Market - Consumer good. It is however recognized that the successful implementation of this technology will require behavioural changes that may be categorized as being non-market. However, the technology focus as described, fits the description of having a relatively significant distribution chain with a large number of customers, though it can also be adopted by individual households.

1.2.3 Identification of barriers for integrated soil nutrition management

A literature review on the adoption of ISNM in Dominica revealed that aspects of this technology were present to varying degrees in the early production era (1959 - 1979) in Dominica; where shifting cultivation involving moving plots from site to site to take advantage of available nutrients stores accumulated through natural decomposition or composting and low pest threshold. Crops would be produced in the same area until productivity decreased through reduce nutrient availability or increase pest threshold levels. The technology was however never fully incorporated into the production system. Possible reason for this may be rooted in the structure of the agricultural sector within the region, which is characterized by small mixed farms comprising of vegetables, fruits and livestock often located on steep terrain that is not conducive to mechanization and efficient use of inorganic inputs. As a result, production in the region, except for the traditional plantation crops (sugar, citrus, rice), has always been subjected to high labour intensity and costs. This therefore, significantly impacts the ability to compete on the basis of price, and so has increasingly dictated that competitivity be on the basis of product differentiation, value chain refinement and environmental sustainability, (COTED 2012). A fundamental differentiation strategy advocated involved the production and marketing of organic products.

COTED (2012) also reported that there was general scepticism about the possibilities of success of organic agriculture, difficulties in obtaining inputs, and issues of certification, policy, and regulation. Access to markets was also noted as the greatest deterrent for farmers to engage in organic production. The issue of policy and regulations could be addressed easily enough by the adoption of existing standards from similar jurisdictions. Certification would need to be specific to the targeted market. Organic inputs would be required to be produced within the production areas utilizing local inputs to keep cost to a minimum.

Other barriers identified by the Consultants and TNA team through expert knowledge and consultation with stakeholders and brainstorming sessions include:

- High capital cost for the establishment of organic fertilizer producing facilities
- Lack or inadequate access to financial resources
- Absence of production standards / quality assurance systems for production
- Low volume and consistency of raw materials
- Production centres tend to be centralized increasing transportation cost to point of use
- Absence of local testing facilities / certified labs for finishes compost, soil etc.
- Application of compost / manure is labour intensive
- Insecure land tenure status often affects the ability of farmer from utilizing land as security to access finance
- Limited localized information on available technology
- Lack of appropriate technical support and human resource
- Environmental pollution concerns around storage and production sites
- Contracting zoonotic diseases from using animal waste as a raw material

The identified barriers were further grouped into broad categories (table 1-2) and specifically defined to allow for further screening.

Table 1-2**: Identified barriers to adoption of ISNM**

Barrier Category	**Barrier**	**Barrier Description**
Economic and Financial Barriers	Initial capital and on-farm application cost.	• Cost associated with construction of processing & storage facilities, equipment procurement and associated on farm practices
	Access to financial resources	• Cost, unfavourable terms & conditions of credit limits. Associated interest rates and loan security guarantee requirements, etc.
	Location of production centres	• Cost of production due to increased transport cost for raw materials. • Transport cost of finished product to point of use.
Social cultural and behavioural	Producer preferences and social biases	• Producers are familiar with, and may prefer conventional production systems utilizing inorganic input sources that are capable of delivering higher more potent doses per volume or weight
	Social acceptance	• Technology's efficacy may be question and rejected due to its popularity among the marginalized farmers and not based on scientific merit.
	Technology stigmatization	• Faecal refuse, a major raw material input, may be considered to be unclean- taboo-prohibited by certain religious beliefs.
	Traditions and habits	• Resistance to change, due to cultural, religious and other reasons. Production is not science based
	Gender participation	• Participation of women in decision making and implementation. Aspects of this system are labour intensive, placing women at a disadvantage.
	Informal land tenure	• Informal land-holding arrangements that affects the development of infrastructure, soil conservation measures or utilizing of land as collateral for credit

Barrier Category	Barrier	Barrier Description
Information and awareness	Limited capacity among the local community	• Local human resource to impact change in attitude of producers and provide technical support is limited
	Quality of available information	• Limited knowledge of the technology options available and associated benefits among Extension agents
Technical	Appropriate testing facilities / certified labs	• Reliable testing facilities to determine product requirement from soil and plant test and to maintain quality control of finish product. Ability to provide certification of process, an essential feature for branding
	Appropriate application equipment for soil ameliorant / conditioner	• Application equipment for compost and other ameliorants/conditioners that are intrinsic to this technology and applicable to local conditions. The ergonomics of the few that are available; effective utilization by women.
Environmental	Localized pollution hazard due to poor sanitation and management	• Potential for pollution (odour included) from overstocking of raw material, poor management or sanitation.
	Zoonotic disease potential	• Risk of transfer of disease (e.g., Salmonella spp) between livestock species and humans as waste from livestock is a major source of raw materials.
	Localized geology	• Environmentally sensitivity of site. Is geological profile susceptible to contamination if production activities occur thereon, ecology of site?
	Breeding grounds for disease vectors including mosquitoes, rodents and flies.	• Depending on the technology option utilize to produce compost, raw materials can encourage and act as breeding site for vectors like mosquitoes, flies, rodents etc.

1.2.3.1 Economic and financial barriers

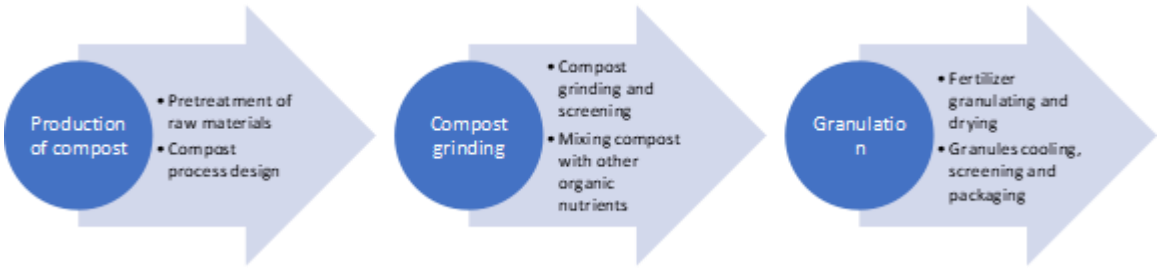
A literature review revealed very little information on the comparative economic and financial analysis of ISNM, which is described together with organic, conservation agriculture, mixed crop/livestock, and perennial grass as an alternative farming system to conventional agriculture (Rockström J, et al. 2009; National Research Council 2010). These were developed as more environmentally benign farming systems due to concerns about the sustainability of conventional agriculture, which is a major contributor to greenhouse gases, biodiversity loss, agrochemical pollution and soil degradation (International Assessment of Agricultural Science and Technology for Development, 2009).

Crowder and Reganold (2015) describe organic agriculture as the most popular of the alternative farming systems and together with a study prepared for FAO on the economic and financial comparison of organic and conventional citrus-growing systems in 2000, represents the other alternative farming systems as intermediary stages towards organic agriculture and so some of its attributes will be utilized to assess ISNM.

1.2.3.1.1 Cost of organic fertilizer production

There are numerous variables involved in the production of organic fertilizer / soil ameliorant that would significantly vary the production set-up and hence the cost. The scope of the operation will also impact the capital cost. The final product is either in liquid or solid form, and so field application will be so constrained. Notwithstanding the different methods of production, the general process that is followed to produce organic fertilizers is documented in figure 1-1.

Figure 1-1:Organic compost preparation process



Source : https://www.fertilizer-machine.net/solution_and_market/organic-fertilizer-production-process.html

The majority of organic fertilizer utilized on island currently is imported and cost approximately $2,867 – $3,308 per metric tonne, whereas chemical fertilizers cost approximately $2,000 – $3,120 per metric tonne (Interview with Agri Sales & Services and Bethel farms).

Information on two small-scale regional compost facilities previously constructed on island, namely the DOAM managed facility at Bellevue Chopin and the larger Fair-trade Facility at Castle Bruce indicates that they are currently not functional. Both sites were constructed with timber supported gable roofs, open sides and open sloping concrete floors (no bins). Compost piles were formed and processed on floors with leachate from the piles being directed via a collector drain and pipe to a below grade tank.

Micro on-farm structures were also established as pilots within various agricultural regions within the country. These consisted of semi-enclosed reinforced cinder block structures with concrete floors separated into 3 bins and Aluzinc shed roof covering. Given the low- tech, nature of the operation of

these facilities, it is estimated that the facility cost represented a significant (over 60%) proportion of the establishment cost. Unfortunately, all of these structures were severely damaged and destroyed during the passage of Hurricane Maria.

1.2.3.1.2 Cost of processing facility

The actual costs for establishment of the regional structures are unknown but the Bellevue site was established with a grant of approximately Eighty thousand (XCD 80,000.00) dollars (Caribbean open trade support program report, Nov 6th 2007). The facility in both locations measured approximately one thousand five hundred square feet (1500 ft^2) and had a capacity of approximately six thousand pounds of compost per cycle (6,000 lbs) or 2.7 metric tonnes.

The small on-farm pilot structures measuring approximately 128 square feet cost approximately Nine Thousand five hundred (XCD 9,500.00) dollars to establish, with an output volume of approximately eight hundred pounds (800lbs) or 0.36 metric tonnes. The cost of locally produce compost range from one thousand six hundred fifty-four dollars to Two thousand two hundred and five dollars (XCD 1,654 – 2,205.00) per tonne.

1.2.3.1.3 Cost of transportation, storage and application

Finished compost generally has an analysis of about 1-1-1 (N-P2O5-K2O), but will vary depending on the original materials that were incorporated into the pile and how they were composted. Nitrogen availability, which often forms the basis for fertilizer classification, will become less available as the compost matures with nitrogen rich feed stock, but more available with carbonaceous feed stock.

Approximately ninety percent (90%) of nitrogen in mature compost are converted to stable organic compost that are resistant to decomposition and slowly become available for plant growth over a prolong period (Mangan, et al. Jan. 2013) This translates into larger volumes of compost being required to meet crop nutrition requirement, with a corresponding higher storage, transportation and application cost for compost as compared to conventional fertilizers. Table 1-3 summarizes Further, the volumes required to completely meet crop requirements also requires a significant investment in land space and raw materials for production. Financial information on the incremental cost mentioned was unavailable at the time of reporting but through specialist knowledge is believed to be significant.

1.2.3.1.4 Financial resources

Global Financial Development Report 2019 / 2020: Bank Regulation and Supervision a Decade after the Global Financial Crisis, espouses finance as one of the relevant vehicles to achieve growth in the agricultural sector. Availability and the cost of finance (interest rate, loan security, etc.) have been a major limiting factor to the development of the agricultural industry in small developing states, Dominica being no exception. Farmers' decisions to invest and to produce are closely influenced by access to appropriate financial instruments to procure planting material, inputs, machinery and also to pay for labour and transportation. The available financial instruments, must also be designed to match farmers' needs, thereby encouraging the adoption of better technologies, or consideration of alternate decisions that can improve the efficiency of their enterprises.

The majority of local producers who would be the consumers of ISNM technology are considered to be inadequately financed and or experience tremendous difficulty in accessing financing. They are

thus unable to implement ISNM in a manner that generates optimal benefit. The average market interest rate for agricultural borrowing locally is 11% per annum, compared to 5-7 % for mortgages.
The inherent risk characteristics of agricultural activities remains a major limiting factor inhibiting financial institutions from providing credit to the agricultural sector in Dominica. Natural hazards such as adverse weather conditions, market conditions etc., are all factors that can adversely affect the farm enterprise, impacting the owner's ability to repay finance. Further, the fact that these conditions typically affect a large number of farm enterprises simultaneously makes it more challenging for financial providers to diversify their portfolio, since when one client fails to pay, many others will be in the same situation. This problem is also further aggravated by the policy direction / political motives that governments may have in place to address such situations such as bailouts to relieve households from their debt obligations, to other incentives to the sector that may distort farmers' interest and discourage financial providers from entering the market.
Another challenge faced by financial institutions serving the agriculture sector is the informality of farming infrastructures existing within the rural areas. The system of farm identification and access significantly affects the ability to monitor production outcomes for financed loaned. This situation leads to difficulty in monitoring non-performing or under-performing loans which often result in default. Potential lenders therefore often decide not to engage with the sector altogether, or to respond by excessive credit rationing or over-reliance on traditional forms of collateral, which many farmers lack.

The status of farmlands with regards to ownership or leasing / renting also affects the producer's ability to access credit. The few financial institutions that engage with the sector require traditional forms of collateral such as land and others assets that are readily convertible into cash.
It must be noted that the limiting impact of financing is not only experienced at the farm or production unit level, but also at the other market / value chain components.

1.2.3.2 Non-financial barriers

The non-financial barriers to the implementation of ISNM identified by the TWG accorded closely to that indicated by Halberg et al., (2007), when investigating barriers to growth of organic agriculture, namely:

- Inexperience with production methods,
- Inadequate marketing and technical infrastructure,
- Disadvantageous government policies.

1.2.3.2.1 Inexperience with production system

At a simplistic level, ISNM speaks to the management and interactions within a production system inter alia, the growing media; soil ecology, soil moisture, soil nutrients, and organic matter and as such its success will be based on appropriately scaled localized knowledge that can only be achieved through research and experimentation. The local institutions that would usually conduct this research is experiencing continued decreasing capacity in required resources, limiting the extent of their efficiency. The approach of utilizing regional institutions (e.g., CARDI) to replace / augment local research capacity as a means of effecting greater efficiency is also failing due to severe shortfall in resource allocation from participating countries (COTED 2012). The ensuing complexity, which results from this under financing are among some of the main reasons that there appear to be a scarcity of information relating to the economic and financial assessment of the ISNM technology.

This in turn limits the uptake of the technology as farmers are unsure about the economic benefits to be accrued. Instead, they persist with choices directed by known preferences and biases.

1.2.3.2.2 Inadequate marketing and technical infrastructure

Market access is critical for sustained agricultural growth to occur nationally. Organized market access for Banana production in place during the 1980's – 2000 ably supported by an effective value chain, that offered credit, agronomic support, transportation, marketing and sales in large markets and other logistical support have all been dismantled. This organization demonstrated what was possible when the different critical factors of the product chain were all put in place. The impacts of this organization benefited not only the crop sector for which it was developed, but also other agricultural enterprises. It also assisted in enabling decision makers to undertake the strategic alignment of available resources to key development areas. The dismantlement of this system resulted from what applies globally as the "rules of the game" – restrictions, standards and subsidies of wealthy states – down to local-level factors, such as poor organisation and influence of producers, weak transport and communications infrastructure and limited market information.

The unavailability of a certified testing facility locally to determine soil and plant nutrient levels and so soil ameliorant requirement is a notable omission that significantly hampers adoption of ISNM technology of organic manuring. The fact that larger volumes of organic material are often required, to meet plant nutrient requirement when compared to in-organic fertilizer formulations, makes the testing facility invaluable to ensure that storage facility and application manpower is sufficient and applicable. Personal communications with officials within the Dominica Agricultural Organic Movement (DAOM), suggests that recommendations for application of locally produced organic compost / manures for vegetable production in the Bellevue area is approximately five (5) kilograms per square metre (Kg/m^2). This information was also confirmed by other vegetable producers who utilize organic compost within the Bellevue and Morne Prosper area. They reported attaining favourable results with this recommendation. The recommendation was based on analysis of soils and compost vis $\grave{a}$ vis crop requirement, completed during the organic banana project in 2013.

Environmental concerns such as pollution from overstocking of compostable raw materials and also breakdown in overall management of compost production system is not uncommon. The facilities previously implemented on island were relatively small-scale compared to the available raw material volume. Facilities often seek to reduce cost of production by taking advantage of raw material harvested from other activities such as roadside clearing and livestock farm clean-out. The raw material acquired through these avenues often exceeds the processing capacity and designed storage of the facilities resulting in the production of odorous leachate from pre-process breakdown during storage. Further, the leachate produced can also become an even greater pollution risk to surrounding water courses, ground water and other vulnerable profiles if managed improperly.
Animal waste, which is also a raw material input, can also become a breeding ground for disease vectors such as flies and rodents if managed improperly. Designed storage areas within processing facilities are expected to provide for managed secure storage up to a given volume. Volumes acquired during occurrences of farm clean-up etc. often exceed this capacity, and so the excess are often store in temporary holding areas that are not as well protected, thus increasing the risk of pollution.

1.2.4 Identified measures

Adoption of integrated soil nutrition management (ISNM) in Dominica presents a comprehensive approach in addressing critical issues of food security that are currently being exacerbated by the impacts of climate change and the global Covid 19 pandemic.

Measures identified in discussions with relevant stakeholders to address the perceived barriers to the adoption of ISNM, can be summarized into opportunities for the innovative application of science and technology to arrest challenge of soil degradation and ensure improved soil fertility, promoting use of new and improved crop varieties through experimentation with the outputs from plant breeding and biotechnology, adoption of new production technologies such as hydroponics, indoor cultivation with environmental control, adoption of the value chain approach to ensure that investments in agriculture are profitable and facilitating farmers' access to credit, financing and risk reduction facilities.

1.2.4.1 Economic and financial measures

1.2.4.1.1 Reduction in cost of organic fertilizer

The table below highlights the approximate cost of fertilizer in Dominica. According to Knoema world data atlas, approximately 1,471 tonnes of NPK fertilizer was imported into Dominica in 2019. Anecdotal data supports that a significant volume (>70%) of the imported fertilizers were inorganic. Liquid formulations are also imported and utilized but information on volumes are not segregated from total fertilizer imports. It is however believed that liquid formulations represent an insignificant volume of total fertilizer usage on island.

Table 1-3**: Approximate cost of fertilizer in Dominica**

Description	Cost range XCD/tonne
Organic imported	2,867 - 3,308
Organic local	1,654 - 2,205
Inorganic (imported)	2,000 - 3,120

Locally produced organic fertilizers are the most cost-effective fertilizer product currently available. Implementation of pilot composting venture at the Dominica Solid Waste Corporation facility may provide the most significant response to increasing the volume of locally produced compost. Currently the DSWC collects in excess of 25 metric tonnes of solid waste with almost 50% being organic (personal communication with General Manager of DSWC). This approach can significantly reduce the cost of production as collection and transportation cost can now be shared with established systems and cost structures for overall solid waste disposal. The additional accrued benefits such as increase job creation, improved ecosystem and increased longevity of the land fill makes it an attractive option for further development and substitution of imported organic products.

Application cost for granular fertilizer is estimated to be XCD100.00/ acre for inorganic / mineral fertilizer formulations and XCD140.00 / acre for organic formulations with farmers having an average farm size of 3.5 acres. The cost of application for organic formulations can be reduced significantly if steps are taken to pelletize and bag the locally produced soil ameliorant in easy to lift units, (e.g. 25

kg). This will make for easier handling and more efficient application, potentially even the use of mechanical applicators. The facility considered in conjunction with solid waste should therefore also include a pelletizing machine.

Other actions that can be considered to further reduce cost of application include:

1. Development of more liquid preparations that can be applied via back pack sprayers.
2. Research and development into appropriate applicators.

Appropriately scaled production facilities located in major agricultural production districts to allow for the development of more specifically tailored options for the agro-ecological zone is also essential. The proximity of the product to the consumers will serve to reduce the cost of transportation, need for extensive specialized storage, and loss of efficacy.

The establishment of a production schemes where there is a trade-off of raw materials from the farmers' holdings for processed compost to be applied to crops will also lower the production cost and generate greater interest in the use of the products.

1.2.4.1.2 Customized available financing

Proper risk management strategies are of extreme relevance to the agricultural sector. Instruments such as index and other insurance products succeed in minimizing moral hazard and adverse selection, and under some circumstances can incentivize farmers to take riskier but more profitable investments (Ruiz, 2014).

The establishment of commodity or sub-sector product chains as exemplified by the Banana Industry in the 1980 – 1990's (The Dominica Banana Marketing Corporation (DBMC), initiated an alternate financing system for risk management that concentrated mainly on non-cash pay-outs, being designed instead to provide cash equivalent support services and input support) was identified as an innovative strategy to facilitate producers' access to finance for various sectors within the product chain. It is anticipated that this will be particularly helpful to smaller producers with little experience with dealing with financial institutions. The pineapple association is already substantially organized and could be targeted as a pilot with appropriate technical support to detail the product chain and requisite resource requirement. Marketing of produce can be directed through the association to facilitate payback for resources loaned and also payment for insurance services.

1.2.4.2 Non-financial measures

1.2.4.2.1 Increase experience with production system

Development and application of training modules for farmers in ISNM is a critical factor in engendering increase knowledge and confidence in the application and accrued potential benefits of this technology. Whatever measures that are selected to demonstrate and transfer the benefits of this technology, it is critical that a participatory approach involving as many stakeholders as possible be adopted to ensure all parties participate directly in the problem-solving process needed to adapt nascent technologies into solutions adapted to real-world conditions and constraints. Ramisch, (2004) posits that such processes can be both a knowledge generation and knowledge refining process that absolutely benefits the locale where it is pursued.

To increase experience with the selected production system, it is envisaged that a participatory approach such as the farmer field school will be adopted by the relevant Division of agriculture

personnel within agricultural regions throughout a period of at least 2-3 crop cycles utilizing different combinations of ISNM such as referenced in the table 1-4. In all cases controls will also be established consisting of current practices with the resulting outcomes compared and contrasted.
A total of approximately Thirty (30) farmers should be targeted in each region for a total of two hundred and forty (240) beneficiaries nationally or twelve percent (12%) of the total farming population. Based on previous experience with a recently completed field school on improved technologies in cassava production, which costed XCD 43,470 over an eight (8) month period, it is estimated that each field school will cost approximately XCD 28,000.00.

Table 1-4**: ISNM proposed trials**

	CONTROL	***Field school 1***	***Field school 2***	***Field school 3***	***Field school 4***
A	***Vegetable production in Roseau valley and West Coast***				
1	Open field Tomato (or Bell pepper, eggplant, cucumber, lettuce, Herbs etc) with Irrigation + inorganic fertilizer (liquids + solids)	Open field Tomato (or Bell pepper, eggplant, cucumber, lettuce, Herbs etc) with Irrigation + Imported organic compost (liquids + solids)	Open field Tomato (or Bell pepper, eggplant, cucumber, lettuce, Herbs etc) with Irrigation + Imported pelleted organic compost (liquids + solids)	Open field Tomato (or Bell pepper, eggplant, cucumber, lettuce, Herbs etc) with Irrigation + local organic compost (liquids + solids)	Open field Tomato (or Bell pepper, eggplant, cucumber, lettuce, Herbs etc) with Irrigation + locally produced pelleted organic compost (liquids + solids)
2	Green House Tomato (or Bell pepper, eggplant, cucumber, lettuce, Herbs etc) with Irrigation - local compost at planting + inorganic fertilizer (liquids + solids)	Green House Tomato (or Bell pepper, eggplant, cucumber, lettuce, Herbs etc) with Irrigation - local compost at planting + imported organic fertilizer (liquids + solids)	Green House Tomato (or Bell pepper, eggplant, cucumber, lettuce, Herbs etc) with Irrigation - local compost at planting + imported pelleted organic compost (liquids + solids)	Green House Tomato (or Bell pepper, eggplant, cucumber, lettuce, Herbs etc) with Irrigation - local compost at planting + local organic compost (liquids + solids)	Green House Tomato (or Bell pepper, eggplant, cucumber, lettuce, Herbs etc) with Irrigation - local compost at planting + local pelleted organic compost (liquids + solids)

	CONTROL	*Field school 1*	*Field school 2*	*Field school 3*	*Field school 4*
B	***Citrus & Cocoa production in Central & Western Region***				
1	Citrus or Cocoa + inorganic fertilizer (liquids + solids)	Citrus or Cocoa + imported organic compost (liquids + solids)	Citrus or Cocoa + imported pelleted organic compost (liquids + solids)	Citrus or Cocoa + local organic compost (liquids + solids)	Citrus or Cocoa + local pelleted organic compost (liquids + solids)
C	***Banana & Plantain production in East, Northeast, South & Southeast region***				
1	Banana & Plantain + inorganic fertilizer (liquids + solids)	Banana & Plantain + imported organic compost (liquids + solids)	Banana & Plantain + imported pelleted organic compost (liquids + solids)	Banana & Plantain + local organic compost (liquids + solids)	Banana & Plantain + local pelleted organic compost (liquids + solids)
D	***Dasheen production in Central, South and Western region***				
1	Dasheen + inorganic fertilizer (liquids + solids)	Dasheen+ imported organic compost (liquids + solids)	Dasheen + imported pelleted organic compost (liquids + solids)	Dasheen + local organic compost (liquids + solids)	Dasheen + local pelleted organic compost (liquids + solids)

1.2.4.2.2 Upgrade in marketing and technical infrastructure

The fostering of social capital from the establishment of commodity producer organisations and value-added chains as in the case of bananas, coconuts and other key crops should be targeted as the main vehicles to upgrade the marketing arrangements that exists for agricultural products produced locally. The current implementation of the Cocoa cluster plan which involves the development of a listing of two hundred core producers in the first instance and providing agronomic and technical support to bring approximately eight hundred (800) acres of cocoa orchard into production is one such commendable effort. Agronomic support will be in the form of provision of planting material and fertilizer, and technical support will be provided in the form of pruning teams to maintain already established overgrown orchards.

Central processing facility will also be established to allow produce to be purchased island-wide on set days and transported to the facility for processing. The facility and purchasing operation will be owned and managed by the producers supported by other nationally appointed marketing agencies. This organization can be capitalized from Grants received from the World Bank climate change agricultural mitigation project. The estimated operationalization cost is estimated at three hundred

thousand (XCD300,000.00) with estimated returns of one hundred and seventy thousand dollars (XCD170,000.00) by year four of operation.

Development of the local technical capacity to implement and sustain these initiatives within other key sectors is critical to the overall success and longevity. The assignment of personnel to understudy and work along with the Cocoa cluster implementation team will be an advisable capacity building initiative.

The development of capacity to complete soil nutrient testing and plant leaf analysis is central to the success of the proposed transition to ISNM technology. The establishment of a certified testing facility though ideal is extremely costly. The National Centre for Testing Excellence capacity locally is incrementally being developed to perform this function. It is however necessary to put an action plan in place with itemized equipment specifications, costing and source and also a time-frame for procurement. The possibility of sourcing grant funding from the Green Climate Fund and other funding agencies for procurement should also be investigated further. In the interim however, the procurement of cost-effective, high-quality field labs should be pursued. These kits cost approximately XCD 30,000.00. It is proposed that one kit be procured for each of the eight (8) regions to accomplish this objective. Another option may be to procure and utilize remote sensing technology via the route of leaf imaging to estimate the overall health and nutrients balance of the plant. The associated drone technology was priced at XCD 90,000.00.

1.2.5 Cost benefit analysis of applied measures

Conduct of cost benefit analysis of the measures recommended for implementation was considered to be important in gauging the overall feasibility of the proposed measures. Benefits of conducting a CBA include:

i) Determination of feasibility of a particular technology
ii) Externalities such as social/environmental and other measurable impacts and 'private' economic costs and benefits are incorporated into the decision-making.
iii) Considers the economics of time (discounting)

Net present value (NPV) is the difference between the present value of cash inflows and the present value of cash outflows over a period of time. NPV is used in capital budgeting and investment planning to analyze the profitability of a projected investment. A positive NPV usually indicates a financially viable project while.the reverse is also true. NPV is calculated via the formula:

$$NPV = \sum \text{Net Benefit}_t / (1 + i)^t$$

NPV = Net Present Value
Net Benefit = Benefit - costs
t = year
i = Discount rate

CBA of Compost facility at Solid waste to produce organic compost – 1800 farmers utilizing material by 2025

During the 1st year it is assumed approximately 100 farmers will utilize local organic compost instead of mineral fertilizers. This action targets the replacement of 5 bags of 16-8-24 fertilizer with organic manure.

Table 1-5: Cost of fertilizer – Mineral formulation

	No of Bags/ farmer	**No of farmers**	**cost of fertilizer**	**Total cost**
Year 1	5	100	67.00	33,500.00
Year 2	5	200	67.00	67,000.00
Year 3	5	500	67.00	167,500.00
Year 4	5	1000	67.00	335,000.00
Total		**1800**		**603,000.00**

Table 1-6: Cost of fertilizer – Organic formulation

	No of Bags/ farmer	**No of farmers**	**cost of fertilizer**	**Total cost**
Year 1	13	100	55.00	71,500.00
Year 2	13	200	55.00	143,000.00
Year 3	13	500	55.00	357,500.00
Year 4	13	1000	55.00	715,000.00
Total		**1800**		**1,287,000.00**

Table 1-7: Application cost Mineral fertilizer

	Average farm size	**No of farmers**	**cost / acre**	**Total cost**
Year 1	3.5	100	100.00	35,000.00
Year 2	3.5	200	100.00	70,000.00
Year 3	3.5	500	100.00	175,000.00
Year 4	3.5	1000	100.00	350,000.00
Total		**1800**		**630,000.00**

Table 1-8: Application cost – Organic fertilizer

	Average farm size	**No of farmers**	**cost / acre**	**Total cost**
Year 1	3.5	100	250.00	87,500.00
Year 2	3.5	200	250.00	175,000.00
Year 3	3.5	500	250.00	437,500.00
Year 4	3.5	1000	250.00	875,000.00
Total		**1800**		**1,575,000.00**

Table 1-9: ***Net benefits of selected ISNM technology***

	Unit	Current situation	Measures implemented
Fertilizer cost		603,000.00	1,287,000.00
Application cost of fertilizer		630,000.00	1,575,000.00
Cost of land filling	XCD 147/ton	3,675,000.00	1,470,000.00
Total cost		4,908,000.00	4,332,000.00

Net benefit = Current – implemented measure = XCD$ 576,000.00
Year = 1
Discount rate = 13% = 0.13

$576,000.00 / (1 + 0.13)^1$ = XCD$ 509,734

Table 1-10: ***NPV for Compost facility at Solid Waste***

Year	Calculation	PV in XCD$
1	$576,000 / (1+ 0.13)^1$	509,734.51
2	$576,000 / (1+ 0.13)^2$	451,092.49
3	$576,000 / (1+ 0.13)^3$	399,196.89
4	$576,000 / (1+ 0.13)^4$	353,271.59
5	$576,000 / (1+ 0.13)^5$	312,629.72
6	$576,000 / (1+ 0.13)^6$	276,663.47
7	$576,000 / (1+ 0.13)^7$	244,834.93
8	$576,000 / (1+ 0.13)^8$	216,668.08
9	$576,000 / (1+ 0.13)^9$	191,741.66
10	$576,000 / (1+ 0.13)^{10}$	169,682.89
	TOTAL (10yr) NPV	**3,125,516.24**

NPV>0 generally indicates that the transfer and diffusion of the selected ISNM technology is profitable with the selected combination of measures. The significant savings in landfill cost that is presented in table 1-9 when recommended measures are implemented ably covers the anticipated increase in cost of nutrient and application. Further, other benefits such as increase employment, increase longevity of the Landfill, reduce pollution risk and chemical contamination from petroleum base fertilizers, increase food safety are all potential benefits of the recommended technology.

1.3 Barrier analysis and possible enabling measures for soil conservation – Slow forming terrace

1.3.1 General description of soil conservation

Slow-forming terraces, so called because they take between three and five years, (in some cases up to ten years), to fully develop, are constructed from a combination of infiltration ditches, hedgerows and earth or stone walls. This technology decreases water run-off, increasing water infiltration and intercept the soil sediments moving downslope (Valdivia R, 2002).

Slow-forming terraces can be built where the land is marginally to steeply inclined and where the soil is sufficiently deep to create a drag effect. This leads to the formation of steps as sediment accumulates due to rainfall and natural gravity. Level ditches are traced and excavated along the contour line of a slope and then an embankment of earth, stones or plants is constructed at given intervals based on the steepness of the slope; the steeper the slope, the closer the intervals. Eroded soil accumulates in these buffer strips every year and terraces slowly form.

Where plants (lower cost option) are utilized to form the terrace, they should be resistant to local conditions and grow well and fast. Where possible, plants should be used that can provide some alternate benefit such as being feed for livestock or leguminous as so contribute to soil nitrogen content. These different live-barrier methods of terracing reduce erosion from half to just two (2) per cent of the level without the live-barriers. Rainfall infiltration into the soil is also significantly improved.

1.3.1.1 Technology category and market characteristics

The Slow forming terrace Technology can be categorized as other non-market goods. The technology fits the description of not being transferred as part of a market but within a public non-commercial domain to serve the overall objectives, of reducing soil lost, increased soil fertility and crop productivity.

1.3.2 Identification of barriers for soil conservation – Slow forming terrace

Increasing global population coupled with the need for food production has significantly contributed to the situation where lands originally designated as woodlands/forest due to their susceptibility to erosion being converted into food crop production further increasing their vulnerability. The loss of productive capacity and the impact on water quality are two of the main reasons for the sustained focus on soil conservation, which has remained largely voluntary instead of being regulatory locally.
The main barriers identified by stakeholders for the lack of implementation of erosion control technology includes:

- Absence of updated regulatory policy framework and where available the absence of mechanisms to implement existing legislations
- Access to available finance to fund implementation of technology
- Farmer preferences and social biases
- Local capacity to design, implement a manage the technology
- Institutional disconnection at various levels on issues related to land, soil and water management.
- Unavailability of cost benefit analysis data to encourage adoption
- Informal farm management structure and income / debt constraint
- Reluctance of farmer to change production methodology
- Lack of perception that erosion is a major problem

- Inadequate land tenure rights that precludes the implementation of certain practices to include landscape shaping and other "permanent" features.
- limited land resources and absence of land-use planning and monitoring, which leads to a reluctance to forego short-term income for uncertain benefits
- The shortage and high cost of labour, working capital and capital assets, such as machinery.
- The availability of appropriate (capable of operating on undulating slopes) machinery to reduce labour intensity

Hoover and Witala (1980) posits that the age and level of education of the farmer also affected the uptake of soil conservation technology and so will also be examined as a potential barrier locally. A summary of the identified barriers is categorized and listed in table 1-11

Table 1-11**: Identified barriers to adoption of soil conservation – slow forming terrace**

Barrier Category	**Barrier**	**Barrier Description**
Economic and Financial Barriers	Initial establishment cost	• Cost and time associated with construction of drainage channels and establishment of live borders, equipment procurement and associated on farm practices
	Cost and access to financial resources	• Access, cost & terms of credit. This is associated with the interest rates and loan security guarantee, etc.
Social cultural and behavioral	Producer / farmer preferences and social biases	• Producers are familiar to and may prefer conventional production systems that do not involve incorporating soil conservation
	Social acceptance	• Perceived effectiveness due to long period of implementation. Results are not immediate but long termed
	Technology stigmatization	• Lower cost and long-term nature of technology may be viewed negatively as compared to other traditional mechanical soil conservation methods where benefits are more immediate but cost are higher
	Informal land tenure	• Informal land-holding arrangements that influences the development of infrastructure, soil conservation measures or utilizing of land as collateral for seeking finance

Barrier Category	Barrier	Barrier Description
Information and awareness	Local community capacity	• Human resource to impact change in attitude of producers and provide technical support
	Information to make informed technology selection decision	• Technical knowledge of the technology options and potential benefits among extension agents
	Cost benefit information	• Localized cost benefit information that can justify access to credit and implementation
Technical	Appropriate equipment for operating on undulating terrain	• Lack of mechanized equipment to construct and maintain on farm drains on sloping terrain. Application is often manual and labour intensive
Environmental	Appropriate plant species to establish green barriers	• Most plant species that have been proven to be effective as live barriers often have limited alternate uses, themselves have deleterious impacts e.g., sometimes harbors other disease / pest vectors.
Legislative	Cohesive legislative framework	• Lack of, and legislative disconnect as it relates to regulations concerning soil and water management. This is also a paucity of institutional mechanism to implement the legislation where they are present.

1.3.2.1 Economic and financial barriers

1.3.2.1.1 Cost of establishment

The main objective of the retaining structures employed within this technology is directed to reducing the velocity of surface water flows to limit the erosive power of the flowing water. The placement of the retaining structures will thus vary depending on the steepness of the slope that is being considered; the steeper the slope, the closer the retaining structures and vice versa. Table 1-12 adopted from Suarez Castro, (1980) provides some guidelines of spacing requirements of retention features along the counter with varying slopes.

Table 1-12**: Spacing of counter barriers according to slope**

SLOPE (%)	ANNUAL CROPS	PERRENIAL CROPS
	Distance (m)	Distance (m)
5	20	25
10	15.1	20.1
15	10.1	18.2
20	9.2	15.3
25	8.2	15.5
30	6.8	12.5
35	6.4	12.7
40	6.5	9.7
60		7

The majority of agricultural lands in Dominica falls within the category of 30 – 60% slope. This translates to approximately 2900 – 7560 square feet of land devoted to conservation measures per acre. The cost of this effort is considered significant to a resource poor farmer both in terms of actual labour cost for establishment of counter drains and retention features, and loss of direct income due to "lost" production area. The cost for manual establishment of on-farm drainage is estimated to be XCD 2.60 - 4.80 per cubic feet on loose non- stony - compact non stony soil, i.e., XCD 6,240.00 – 11,520.00per acre for establishment. Mechanical excavation cost approximately XCD 150.00 – 200.00 per hour. Further investigation is required to estimate volumes of material that can be mechanically excavated per hour. When these costs are compared to income generated in the short term it is generally the consensus of most small-scale farmers that there are insufficient returns on the investment and where high value crops are produced and economic payback are improved, benefits are too delayed.

1.3.2.1.2 Financial resources

The majority of local farmers would accrue positive benefit from the implementation of soil conservation technology – more precisely slow forming terrace since the majority of farms are located on sloping land with erosive tropical soils that are predisposed to adverse climatic conditions that favours erosion. Soil conservation technologies are seldom financed within itself except for the establishment of drainage structures which are generally associated with the implementation of external funded larger scale production enhancement projects. The ability of individual farmers to access funding to undertake soil conservation activities, like other agricultural activities are negatively impacted by an inadequately financed environment and or particular difficulty in accessing the limited finance available brought about by the high cost of the finance (normally - 11% interest rate for agricultural borrowing)) and the requirement for traditional forms of collateral which many farmers lack.

1.3.2.1.3 Incentives

Bunch R, (1999) makes the observation that a large number of government- and UN-funded institutions worldwide utilize artificial incentives [1], to continue to apply the traditional soil conservation (SC) technologies[2], e.g., FAO program in some countries of Sub-Saharan Africa that provides food-for-work for bench terracing, and some soil conservation programs in India. The "adoption" of technology was frequently an economically rational action by the farmers to maximize the quantum of incentives acquired, and was unrelated to the inherent merit of the technology. Conversely, technologies that avoid artificial incentives for adoption must either be inherently attractive, with visible measurable benefits, or face non adoption by farmers. Even in cases where the proposed technologies are "adequate," farmers may choose to adapt the technology to improve efficiency and or better suit local conditions. They may even develop new technologies entirely; a situation that is often absent in situations where technologies are supported by artificial incentives.

In the late 70's in Dominica, soil conservation activities were commonly supported by central programs, providing labour and other monetary incentives. These artificial incentives brought about a significant decline in new adoptions and also affected sustainability of the establish plots after the program was halted post Hurricane David in 1979.

1.3.2.2 Non-financial barriers

The non-financial barriers to the implementation of soil conservations technology identified by the TWG as summarized in table 1-5 include:

- Farmer preference and social biases
- Technology stigmatization
- Informal land tenure situation
- Information and capacity among the local community
- Appropriate machinery to operate on steeper slopes
- Cohesive legislation

1.3.2.2.1 Farmer preference and social biases

Farmers are generally unfamiliar with all of the benefits of soil conservation activities. While erosion control is a major consideration and is generally well understood by farmers, targeted conservation effort is not the general norm. Soil conservation activities are usually reactive to problems identified and not mainstreamed into the production system. This is thought to be the direct result of decreased returns on agricultural investments experienced by farmers. Further, there is the tendency for farmers to utilize the predominant production approach and components employed by other producers as long as these are perceived to produce the desired results. These are often passed down through successive generations of farmers and can often be used to identify production from particular zones or communities. There is general resistance to adopt new approaches away from these norms without the necessary success guarantees.

[1] Artificial incentives are defined here as any material donation, subsidy, or service (other than training) that is provided by the project designed to makes technology adoption less costly or less difficult for the farmer than it would otherwise be after the project ends.

[2] Traditional SC technologies are considered to be those such as terraces, stone/dead barriers, drainage ditches etc.

1.3.2.2.2 Technology Stigmatization

Slow forming terraces take many years to provide full benefit and also require continued management. When this is considered within the context of addressing an on-going situation or deficiency, many farmers view this technology as ineffective and a waste of time. The costlier traditional options of mechanical land shaping, terracing, stone walls etc. are most often pursued where cost support or credit are available.

1.3.2.2.3 Informal land tenure

Haitian migrants make up a significant percentage of small farmers operating within many agricultural catchments in Dominica. Land cultivated are often leased via informal agreements that usually only speaks to periodic payment for land use, wholly ignoring critical issues of land management and other acceptable cultural practices. The focus of these leasers therefore is on maximizing production to ensure that maximum income is generated. The cultural practices thus employed, tends towards the amplification of susceptibilities to various hazards, notably soil erosion and ecosystem degradation. In cases where conservation activities are desirable or urgently required, the operators often do not have the authority or wherewithal to source the required financial resource to effect more traditional methods of soil conservation.

1.3.2.2.4 Information and capacity among the local community

Information and soil conservation capacity developed during the 60's and 70's in Dominica have for the most part disappeared, leaving minimal capacity on island even within the traditional conservation methods. This situation is particularly bizarre given the high erosion risk associated with cultivation of agricultural lands in Dominica. Inadequate agricultural extension methodologies that were only required to show sustainable increase in adoption of soil conservation technology in the presence of ongoing agricultural extension support, being defined as successful, limited the development of innovation on the part of the farmers and so the development of measurable capacity within the farming population, (Bunch R, 1999).

Localized information on the economics of implementation of slow forming terrace are not directly available. This limits the ability of farmers to make informed decisions and so serve as a disincentive to risk adverse individuals.

1.3.2.2.5 Appropriate machinery to operate on steeper slopes

The implementation of soil conservation methods in Dominica has been largely manual because of the absence of soil-moving machinery with the ability to operate safely on steep slopes. This situation significantly increases the cost of implementation and also impacts female farmers' ability to extensively employ these measures without the use of external assistance. With the wider availability of mini-excavators, attempts have been made to utilize them to construct on farm drainage and other soil conservation structures. Usage of these machines on previously established small farms that often consists of intercrops combinations of tree crops, row and root crops invariably result in crop damage that causes farmers to select manual construction methods instead.

1.3.2.2.6 Cohesive legislation

Soil conservation within small farms located on mountainous terrain is most effectively implemented on a catchment level. This is especially true if erosion control from water run-off is a major factor.

The undulating terrain and the relatively small area characteristic of farms in Dominica results in farm management and practice on one area/plot having direct impact on neighbouring farms. Two such examples are related to water emanating from higher elevations being directed to farms located within the lower reaches, and poor land clearing and cultivation practices generating severe erosion or landslides that also impact lower farm along the slope. This situation often breeds discord, especially in cases where the lower farm owner is not consulted and involved in activities that may concentrate water flows in sensitive areas of their farms. Additionally, other issues, such as poor solid waste management emanating from upstream, can result in waste being transported during high rainfall events and deposited within the lower farm areas.

Existing legislation relating to receiving water quality are covered under the environmental health act with enforcement by the Environmental Health Department (EHD). The solid waste act covers the disposal and management of solid waste with enforcement by the EHD; the forestry act manages and regulates activities on state owned but not privately owned lands. Dominica Water and Sewerage Company (DOWASCO) the lone potable water provider on the island is mandated to manage all water resource on island but do not provide any enforcement for protection of waterways.

The legislative compass in force do not provide for the cohesive management and enforcement of potential impacts resulting from, or requiring the implementation of soil conservation activities. Enforcement relating to solid waste management on privately own farmlands are also extremely problematic except in cases where there is an assessment of a clear, present and immediate threat to public health.

1.3.3 Identified measures

The sustained adoption of most of the traditional soil conservation measures by Dominican farmers has generally been disappointing notwithstanding the significantly benefit to long-term production that is foreseen. Grass roots innovations and breakthroughs in soil recuperation and management, such as green manure, cover crops, conservation tillage, mulching, crop management, improved fallows and water harvesting technologies etc., coupled with improvements in extension methodology to include farmer to farmer transfer of technology, presents an excellent opportunity in achieving objectives established for sustainability / improvement in soil conservation and management. The TWG also highlighted the need to investigate and consider approaches with the ability to address multiple productivity concerns thereby increasing the likelihood of farmer adoption and sustainability.

1.3.3.1 Economic and financial measures

1.3.3.1.1 Reduction in cost of establishment

The various methodologies employed for the establishment of slow forming terraces, by their very characteristics are design to be low-cost soil conservation alternatives. Targeted cost reduction will therefore be achieved from the repurposing of other essential farm activities for multiple benefits.

A program to encourage the disposal of refuse / crop litter from land clearing, which is traditionally accomplished by piling in locations not utilized for production, to be redirected and laid in trash lines along the slope counter (fig 1-2). The crop debris will serve as a barrier to the downslope movement of soil by intercepting and filtering overland flow. The continued deposit of soil at this barrier if well maintained will eventually form more permanent terraces that can possibly extend up to 50 - 60 cm in height. The spacing of the trash lines will depend on the steepness of the slope and can follow the

recommended spacing for counter barriers. Other structures such as counter drains can also be added to improve efficacy.

Cost of terrace establishment utilizing this approach is thought to be negligible given that cost would have already been appropriated for disposal of trash/ litter. The added benefit of organic matter and soil nutrient improvement from the breakdown of the plant waste material is an added benefit that can also be accounted. The deposit of organic matter often encourages the colonization of some pests' species such as snails and slugs. Baiting and other forms of control to reduce pest population is recommended as a management activity.

Figure 1-2:Trash line with harvested corn plants (Reproduced from WOCAT, www.wocat.net)

1.3.3.1.2 Customized available financing

Proper risk management strategies as highlighted in section 1.2.4.1.2 can be pursued as a means of increasing the confidence of the traditional financial institutions to provide financing at more conciliatory rates and also design packages that are more representative of needs. Instruments such as index and other insurance products are being viewed as being intrinsic to the achievement of this objective. The development of relevant farmer's organisation with commodity or sub-sector market chains can be pursued and utilized as a means to initiate alternate financing system for risk management that concentrated mainly on non-cash pay-outs, being designed instead to provide cash equivalent support services and input support.

Notwithstanding the significant cost of establishment and management of commodity chains, they have proven to be very effective and beneficial to agricultural production within Dominica. Funding for these initiatives have been known to be provided from Grant funding evidenced by the ongoing cocoa cluster initiative currently being implemented by the Dominica Export and Import Agency (DEXIA). A grant of US $200,000 received from Compete Caribbean Partnership Facility (CCPF) is being utilized to address five improvement areas of data management, pre- and post-harvest operations, change management, marketing and labelling and product transformation and development.

1.3.3.2 Non-financial measures

Bunch R (1999), posits that the standard currently utilized to evaluate soil conservation work has evolved to the expectation that conditions for permanent and even increasing adoption of technologies

in the absence of further interventions are created. This has been shown to be possible and may lead to sustainability of the technology if beneficiaries / farmers are able and willing to constantly innovate.

1.3.3.2.1 Improved extension service

In a paper presented at the 12th Symposium of the International Society of Tropical Root Crops, Howeler, (2000) forwarded the following reasons for farmers' failure to implement many cultural practices that are very effective against soil erosion:

1. The recommended practices are not suitable to local conditions,
2. lack of knowledge of loss of soil and productivity due to erosion, and or
3. the practices themselves are too costly or time consuming to implement.

An extension methodology that focuses on participatory development of technology by aiming to motivate and teach farmers to experiment, so they can adopt and adapt technologies and develop new ones through hands on learning such as the 'Farmer field school approach' is recommended to provide training and information on this technology. The identified extension methodology must allow farmers to select from a wide range of conservation options they consider most useful for their own situation; these are tested in experiments conducted by themselves on their own fields, in collaboration with Extension Officers. Results obtained are adapted further by continued experimentation, to make necessary adaptations or to adopt the best practices on their own fields.
The extension methodology must also prioritize improving the capacity of farmers to build organisations to engender the sharing of information and the overall management of the technology development process. It must be recognized that no one farmer can navigate and manage the entire technology development process by themselves and so a mechanism of sharing information is critical.

1.3.3.2.2 Improved legislation and enforcement

Institutionalization of soil conservation management, as a major component of food security policy, is essential in this era of climate change and variability. This aspect can be joined to the ongoing effort to develop a national land use policy, legislation and guidelines for farm certification. The existing legal framework having jurisdiction over this component under other themes also requires review to engender clarity and develop an effective hierarchal structure.

Legislative review is already a component of the land use policy development and farm certification that is currently on-going. The implications of implementing and enforcing legislative reforms and guideline within communally managed lands as within the Kalinago Territory requires special attention. The TOR however limits the scope of the review. A modification of the TOR to allow a more comprehensive review to include sustainable land management should be possible without significant cost increase. Alternatively, the recommended legislative review can be undertaken by the Ministry of Legal affairs with allowances from the national budget.
Enforcement of legislation can be strengthened through the assignment of magisterial powers to the Director of Lands and Survey as per the Director of Forestry. The Land Rangers can then be trained and empowered as agents, with added responsibility of enforcement.

1.3.4 Linkages of Barriers

Economic and financial barriers for the identified technologies within the agricultural sector are all impacted by the common link of relatively high implementation cost and access to affordable financing to offset the cost. It must also be considered, that the recommendation to implement these technologies are being made within the framework of declining farmers' income and associated inefficiencies within the value chain structure of many of the commodities being produced. The intrinsic characteristics of farms within the Commonwealth of Dominica, indeed within the region, of being relatively small, producing a variety of commodities (diversified) with low mechanisation (predominately manual), translates to the understanding that any action to address issues such as access to affordable finance, input cost and other production cost is most efficiently addressed collectively for the entire sector. Notwithstanding, it is also believed that any comprehensive action targeted at any one commodity will invariably positively impact many other technologies throughout the sector.

The characteristic small population of Dominica coupled with its associated GDP also often places limitations on human resources and technical capacity development to address a number of the identified barriers. Actions to address this limitation are often through the establishment of appropriate skill set development programs that are often associated with the national education system. The quality of that system therefore, in achievement of the correct balance between the development of academic and vocational programs, will allow for appropriately trained capacity development within the population, allowing for the addressing of a variety of cross sectoral capacity inadequacies. It is unlikely that the skill set develop at the local level will be sufficient to address all expressed limitations. However, the initial preparation provided by the education system should provide adequate preparation for more specialized training.

Another noteworthy linkage between the technologies prioritized within the agricultural sector is the issue of perceived ineffectiveness of the technologies based on social characteristics of the beneficiaries of requiring positive results in the short or immediate term. This general attitude has been explained to be related to limitation in alternate income streams and also limited land area to carry out production. Transcending this barrier often requires the provision of assurance of eventual success, sufficient to cover initial investment. The ability to progressively implement changes over the area owned, while allowing for continued traditional production is also a beneficial approach.

1.3.5 Cost benefit analysis

$NPV = \sum \text{Net Benefit}_t / (1 + i)^t$

NPV = Net Present Value
Net Benefit = Benefit - costs
t = year
i = Discount rate

CBA of Soil conservation technology – Slow forming terrace – 1800 farmers implementing technology by 2025. Technology implementation assumed to follow the following pattern:

Year 1 – 100 farmers; Year 2 – 200 farmers; Year 3 – 500 farmers; Year 4 – 1000

Benefits foreseen includes; reduction in erosion and washing away of plant nutrients, reduced silt load in water courses during moderate to high rainfall events, increase water infiltration into the soil, zones of increase moisture retention, increase organic matter added to soil as debris decomposes and overall increase in production of crops. Isaiah I.C. Wakindiki, B.O. Mochoge, Meni Ben-Hur, (2009) writing on: "Advances in Integrated Soil Fertility Management in sub-Saharan Africa: Challenges and Opportunities" noted that Maize production increase threefold on fields utilizing this technology.

A major potential disbenefits within the local agriculture setting include increased concentration incidence of pest such as snails and slugs which often uses the litter material to conceal themselves. This however facilitates easier treatment, which now can be applied over a smaller more targeted area. Other common pests specific to the litter material being utilized e.g., nematodes in *Musa spp* also have the potential to colonize the litter material and infect new establishments. Thus, utilizing healthy uncontaminated litter material is essential.

Cost of trash line establishment

	Average farm size	**No of farmers**	**cost / acre**	**Total cost**
year 1	3.5	100	100.00	35,000.00
year 2	3.5	200	100.00	70,000.00
year 3	3.5	500	100.00	175,000.00
year 4	3.5	1000	100.00	350,000.00
Total		**1800**		**630,000.00**

Cost of trash/debris disposal – No measures

	Average farm size	**No of farmers**	**cost / acre**	**Total cost**
year 1	3.5	100	125.00	43,750.00
year 2	3.5	200	125.00	87,500.00
year 3	3.5	500	125.00	218,750.00
year 4	3.5	1000	125.00	437,500.00
Total		**1800**		**787,500.00**

Cost of Pest treatment – Measures implemented

	Average farm size	**No of farmers**	**cost / acre**	**Total cost**
year 1	3.5	100	70.00	24,500.00
year 2	3.5	200	70.00	49,000.00
year 3	3.5	500	70.00	122,500.00
year 4	3.5	1000	70.00	245,000.00
Total		**1800**		**441,000.00**

Cost of pest treatment – without measures

	Average farm size	**No of farmers**	**cost / acre**	**Total cost**
year 1	3.5	100	140	49,000.00
year 2	3.5	200	140	98,000.00
year 3	3.5	500	140	245,000.00
year 4	3.5	1000	140	490,000.00
Total		**1800**		**882,000.00**

Net Benefit of selected Technology

	Unit	**Current situation**	**Measures implemented**
Trash line formation		787,500.00	630,000.00
Increase productivity -Additional moisture organic matter	/Acre		6,600.00
Baiting for pest - Snail & slugs	/acre/treatment	882,000.00	441,000.00
NPV = Net benefits		1,669,500.00	1,077,600.00

Year	**Calculation**	**PV in XCD$**
1	$591,900 / (1+ 0.13)^{1}$	523,805.31
2	$591,900 / (1+ 0.13)^{2}$	463,544.52
3	$591,900 / (1+ 0.13)^{3}$	410,216.39
4	$591,900 / (1+ 0.13)^{4}$	363,023.35
5	$591,900 / (1+ 0.13)^{5}$	321,259.61
6	$591,900 / (1+ 0.13)^{6}$	284,300.54
7	$591,900 / (1+ 0.13)^{7}$	251,593.40
8	$591,900 / (1+ 0.13)^{8}$	222,649.02
9	$591,900 / (1+ 0.13)^{9}$	197,034.53
10	$591,900 / (1+ 0.13)^{10}$	174,366.84
	TOTAL (10yr) NPV	**3,211,793.51**

NPV > 0, indicates that the transfer and diffusion of the selected soil conservation- slow forming terrace technology is profitable with the selected combination of measures. The combinations of measures included in the analysis are certainly not exhaustive and others should be included where costs are available.

Chapter 2. Water Sector

Rainwater Harvesting and Efficient Appliances were the two top water sector technologies selected after the MCA process in step1 of the TNA process for the Commonwealth of Dominica. The performance of the other technologies considered against the top performers are indicated in table 2-1below.

*Table 2-1**:Final ranking of selected water technologies***

Ranking	Technology	Total
1	Rainwater Harvesting	95
2	Efficient fixtures & appliances	77
3	Water resource mapping & assessment	39
4	Leakage detection and management	38

The implementation of both technologies speaks to an overall reduction in water quantities that will be required via the public distribution system.

2.1 Preliminary targets for technology transfer and diffusion in the water sub-sector

Dominica is known as the land of many rivers with an abundance of surface water resources in the form of rivers, streams and springs which are used to supply potable water to the population. The Dominica Water and Sewage Company Limited (DOWASCO), which operates like a quasi-governmental corporation is solely responsible for water and sewerage management on island. DOWASCO operates a supply network divided into 43 water areas, fed by 38 intakes. An average of 7.1 million imperial gallons of water is harvested daily. Approximately 25,000 households are provided with potable water via water intakes that are constructed in the upper reaches of the water catchments with connecting gravity supply pipelines to storage tanks for onward distribution to consumers.

The projected impact of climate change in Dominica is for increased frequency and intensity of hurricanes, storms and other climatic events. The loss of forest cover resulting in increased incidence of land slippage and erosion experienced during hurricanes and storms continues to negatively impact water quality, significantly increasing treatment requirement and cost. The prohibitive cost of treatment (XCD 10 million for WA1 system with capacity of 900 m^3/hr) limits the ability of DOWASCO to address all of the water systems treatment needs. The net effect of this situation is shutdown of water distribution systems to households during any significant rainfall event that results in increase water turbidity. Within this context the following targets were proposed by the technical working group (TWG). The targets also accorded with recommendations provided by the DOWASCO:

1. **Rooftop rainwater harvesting, storage and distribution at the household level:** DOWASCO encourages households to maintain a minimum storage for at three days of use. The storage size will be dependent on size of household with an average of 70 gallons / persons / day + 5 gallons / day for house pets within 95% of households over a three-year period. All new household

construction to be fitted with appropriate rainwater storage and distribution system specified and included into building code.

2. **Installation of water efficient appliances at household and industrial facilities:** The objective is to enable 95% of all household served with portable water to install water efficient features such as low volume flush toilets, water-efficient shower heads and other pipe faucets. This effort to be implemented over a period of five years commencing in 2022.

2.2 Barrier analysis and possible enabling measures for Rooftop rainwater harvesting (RWHS)

2.2.1 General description of Rooftop rainwater harvesting

Collection of rainwater from rooftop catchment and storing it in a tank or barrel is a well-established practice in Dominica. Rainfall runoff from metal sheeting or concrete roofs is directed to a gutter system that is metallic or made with PVC placed around the drip edge of the roof. The gutters are gentle sloped to direct the flow of water collected towards a funnel to downpipes. The downpipes are often terminated within storage structures that can be made of metal, PVC, concrete or polyethylene with appropriate measures to prevent uncontrolled overflow. The size of storage is dependent on user preference and also the size of the collection surface. These are usually located at an elevated location to allow for gravity distribution to point of use or where they are at lower elevations, are fitted with water lifting mechanisms such as pumps and or other manual means for distribution.

2.2.1.1 Technology category and market characteristics

Rooftop rainwater harvesting is classified as a consumer technology. The technology fits the description of being distributed by mass market and purchased by private consumers, including households, businesses and institutions. As is typical of consumer goods, the demand for rainwater harvesting systems depends on consumer awareness and preferences, and on commercial marketing.

2.2.2 Identification of barriers for rain water harvesting.

The main barriers identified as limiting the optimal adoption of rainwater harvesting technology can be categorized into financial and technical considerations. Issues related to the determination of the size and type of storage, cost of secure storage, the quality of the water harvested and the type and cost of the distribution system from the storage were identified.

2.2.2.1 Economic and financial barriers

Most building structures throughout the island are completed with a rainwater guttering system irrespective of whether rainwater harvesting is practised or not. In cases where rainwater harvesting is not practised, the purpose of the guttering system is to collect and direct rainfall from the roof safely to ground, limiting the erosion hazard of water free falling to the ground in an uncontrolled manner. The cost of the harvesting surface and the conveyance guttering system will be therefore discounted from the overall cost of the system.

The new costs introduced for the development of the RWHS includes the sizing and procurement of the storage to include location, cost of rain diverter, cost of treatment of water stored, and cost of distribution system.

2.2.2.1.1 Procurement cost of storage

Traditionally, a variety of barrels, drums and other vessels that were repurposed from other uses were utilized for storage. These varied in sizes but were usually between 45 – 60 gallons. The water stored was mainly utilized for non-potable applications such as laundry, flushing of toilets, watering of garden, etc. In some instances, small concrete tanks were also constructed especially in areas not effectively served by the portable water system.

Greater adaptation of the RWHS as a direct response to climate change impacts on the potable water supply has resulted in greater emphasis being placed on storage of larger capacity capable of maintaining potable water quality. These storage tanks have been adapted to increase their lifespan, being exposed to the elements, and increase the safety of the stored water by excluding disease vectors such as mosquitoes. These adaptations have significantly increased the cost of the storage vessel. The average cost of a 400-gallon tank XCD600 - 800 whereas 1000-gallon cost approximately ***i***XCD1800 – 2200.The situation where many of the major local hardware stores sell storage tanks from the same manufacturers also limits price competitiveness.

The additional cost associated with securing the storage structure from the impact of hurricanes and storms that affect the island annually also increase cost. Many households have opted to build concrete protective structures around the tanks or install variant solutions that utilize metal bracing and retaining metal guying string to help anchor the tank during high wind events.

Newly constructed households are currently opting to construct underground storage that then requires the installation of a pumping system for water distribution. While this option offers the greatest protection to high winds during storms, they also require greater capital outlay for establishment due to the higher level of technical expertise required for construction and avoidance of leaks. These often prove to be difficult to identify and address in subsurface storage compared to above ground storage.

2.2.2.1.2 Cost of water treatment

The quality of water harvested from the roof is affected by sediment accumulation, turbidity due to suspended particles, and also insects and birds. The need to generate water of potable quality dictates that some form of treatment is employed. This includes the implementation of first rain flush, filtration devices and also some form of microbial treatment. The type, number and specifications of flush system employed is dependent on the size of the harvesting surface (roof) and guttering system in place. Typical cost varies from XCD350 – 1000. There is also an additional installation cost, which starts from XCD250 per unit for single storey structures. Multi-storey structures will require the use of scaffolding and so will be slightly costlier This significantly increase the cost of the technology, putting it out of the cost range of many households with low income.

2.2.2.1.3 Cost of distribution

Water distribution from the storage has evolved from being a manual activity, where buckets were filled from the tank and manual transferred to point of use to the situation where the tank is plumbed into the water system of the home or facility and piped to the point of use. In cases where storage is intentionally raised above the point of use, gravity powers the transfer and the cost of distribution is minimized. In cases where the point of use is higher than the storage, pumps are required for the transfer requiring additional electrical energy. The high cost of electricity within Dominica significantly increases the operating cost of the technology.

2.2.2.2 Non-financial barriers

2.2.2.2.1 Technical capacity

There are many small contractors operating within the local landscape constructing housing throughout the island. Notwithstanding their capability in completing concrete works, limited capacity exists within this pool with the specialize knowledge for concrete water storage tank construction. The result of this limitation is evident in the occurrence of many such tanks with leaks and cracks leading to a general reduction in confidence in their utilization and also costly repairs. This situation also leads to the procurement of other type of storage tanks with a shorter lifespan and greater susceptibility to the impacts of strong winds during storms.

Information on features that can enhance the technology such as the treatment processes available for improving quality, and other options for powering transfer pumps such as wind and solar are notably absent within the commercial sector. Further, technical capacities for developing rainwater harvesting systems are limited because of a lack of approved or adopted technical standards, guidelines and best management practices. This limits the degree of innovation that can be applied in adapting the technology to best suit the needs of households and so makes the technology less sustainable.

2.2.3 Identified measures

The measures prioritized by the TWG were selected specifically for their potential to sustainably promote the adoption of RWH technology. It was the general consensus that given that this was a consumer good, incentives to "artificially" increase attractiveness should not be employed as this would discourage adaptation which is essential to sustainability.

2.2.3.1 Economic and financial measures

The cost of water storage structure needs to be made more affordable for the average household. This needs to be accomplished simultaneously with the development of storage that demonstrates greater resilience to the natural hazards affecting the island. It is also important that the selected options are easily sourced or are available locally.

The reduction of import tariffs on the storage component of the RWHS is a recommended strategy to reduce the cost of storage and increase uptake within the short term. Increase uptake of rainwater storage will benefit the increase urgency with which DOWASCO needs to implement cost limiting potable water treatment upgrades as a result of the impacts of climate change.

The establishment of a low interest rate (1-2%) revolving loan fund facility at the credit unions and also at the Government loan board (for new home owners) to fund the establishment of water storage systems will certainly encourage and direct the adoption of this technology. The development of resilient water supply network has been identified as a priority action in the National Resilient Development Strategy and so funding allocation for this action can possibly be allocated from this associated budget.

Low-cost filtration and treatment options were advocated and taught to some households in certain parts of the country post hurricane Maria to ensure safe drinking water was available. This effort was spearheaded by NGOs with limited resources and operational boundaries. It is encouraged that this training be revived and applied nationally as an option to treat rainwater to improve potability. The Dominica Red Cross, Samaritans Purse and other such non-governmental organisations retain the

capacity for such trainings and so, can be encouraged to include these areas of interests into their annual program. The increase in capacity in the area of low-cost water treatment will present more cost-effective viable options for consideration in addition to the higher cost commercially packaged treatment options.

2.2.3.2 Non-financial measures

Reinforced concrete tanks have displayed the greatest resilience to the impacts of hurricanes and other environmental conditions. The longevity of the tanks also allows for the amortization of cost over a number of years, often in excess of 20. The predominant shape of tanks that end up leaking are rectangular, whereas well-constructed circular shaped tanks display superior longevity. (Nation, 2001)
A proposal to increase the capacity of local contractors in the construction of low cost, reinforced circular concrete tanks by undertaking training workshops while simultaneously constructing demonstration storage units is recommended. This initiative should be spearheaded by the local government Authority within the various communities with support from central Government. This effort can be coordinated and funded as a post disaster adaptation pilot.
Up-scaling of the thin-walled water storage tank options like the ferrocement tanks pioneered for on-farm water storage will increased cost effectiveness and so attractiveness as a storage option. The average cost of one of the thin-walled tanks introduced into Dominica is approximately XCD$ 0.69 per gallon of water stored. The formwork for this type of tank can also be utilized multiple times.

Establishment of an appropriate policy framework to guide the implementation of RWHS will be invaluable in mainstreaming the adoption of the technology for provision of an alternate source of water to households. It is recommended that this policy speaks to issues of the relevant management authority; type, quality and treatment of collection surfaces; conveyance system, storage, treatment and distribution system; acceptable output water quality and potential uses. The ministry of Housing Lands and water resource management is responsible for coordinating the development of this policy in line with the national integrated water resource policy. The critical value of this activity warrants the utilization of local resources in order to implement this activity in the short term. Other possible funding source can be from the financial support offered by the British government to address water supply issues post hurricane Maria. DOWASCO must also play a major role in the development of this policy framework.

2.3 Barrier analysis and possible enabling measures for installation of water efficient appliances at household and industrial fixtures

2.3.1 General description of installation of water efficient appliances at household and industrial fixtures

Water efficient appliances uses less water while yielding comparable performance to other non-efficient appliances and fixtures, (e.g., short flush low volume toilets, low-flow showerheads and other tap faucets etc.). These include dish and clothes washers, popular fixtures including toilets, showerheads and other tap faucets.
The Massachusetts Water Resource Authority indicates that the toilet is the single biggest water user within the household, with flushing accounting for about one-third of the daily water use. Replacing an old model toilet with a new low-consumption toilet could automatically and permanently cut your home water consumption by 25% or more. The proposed action to implement water savings will be

concentrated on updating the toilet stock available locally with low flow toilets in the first instance. Water savings are expected to be at least 25% if the general objectives of the efforts are met.

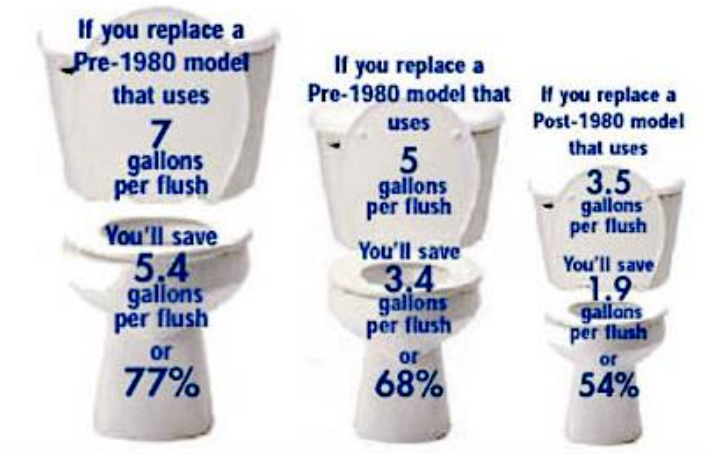
Most toilets installed locally utilize approximately 3.5 gallons per flush. Replacing a typical 3.5-gallon toilet with a 1.6-gallon model will save a family of four 11,096 gallons of water annually. That's a 54% reduction in toilet water use (fig 2-1) and a significant reduction in tariffs especially for commercial users, who normally pay a higher tariff bracket

2.3.1.1 Technology category and market characteristics

Water efficient appliances are classified as consumer technology. The technology fits the description of being distributed by mass market and purchased by private consumers, including households, businesses and institutions. As is typical of consumer goods, the demand for this technology depends on consumer awareness and preferences, local code, and on commercial marketing.

Figure 2-1:Water savings with low flush toilets

HOW MUCH WATER DOES A LOW-FLOW TOILET SAVE?



Source : https://www.mwra.com/comsupport/conservation/toilets.htm

2.3.2 Identification of barriers for installation of efficient appliances and household and industrial fixtures.

Dominica has utilized its abundance of rainfall (50 – 300 inches annually) and numerous drainage channels to good effect in marketing the island as the land of many rivers (365). This image of a bountiful supply of water, evidence of which is seen with every significant rainfall event, has also contributed to a local mindset of an unlimited supply. This established mindset was identified by the TWG as being a major contributor to the non-implementation of water efficient fixtures. The generous water tariff structure, that charges a fixed Domestic tariff of XCD$ 21.62 for the first 1000 gallons of consumption and XCD$ 10.12 per 1000 gallon for any additional consumption within a period of 1 month for domestic consumers and commercial consumers paying XCD$ 36.57 for the first 1000

gallons and 13.57 per 1000 gallon for any additional consumption within the period of 1 month was also highlighted.

The average domestic customer consumes between 3200 – 3500 gallons of water monthly. This translates to an annual cost of XCD$ 560.00, which is about the cost of a low-end water efficient toilet. It is a tough sell to convince household to conserve water beyond established comfort level, when such conservation does not result in any significant additional financial saving to the household.

2.3.2.1 Economic and financial barriers

Water efficient appliances generally cost more than less-efficient ones. It was however very interesting that the flow volume of the appliances queried at the local hardware stores was not a selling point. In fact, few of the businesses were able to provide information on flush volumes for the toilet models they carried or possible water savings over traditional appliances. Price differentiation occurred mainly around the brand and whether the toilet was P-trap or S-trap, with P-trap being more expensive.

Estimates of tank volume of the toilets available suggested that most of the stock at the hardware's visited were low flush volumes. E.H Charles hardware was able to confirm that the entire stock was in fact 1.5 gallons' flush capacity and so would be categorize as low flush volume. The prices of the low flush toilets ranged from XCD 450.00 – 798.00 as compared to XCD 295.00 - 569.00 for regular units, whereas savings from reduced water consumption is estimated at XCD 180.00 annually.

The unavailability of cost effective or subsidized finance to specifically target efficiency improvements is also a major barrier to the immediate implementation of water efficient appliances. Stakeholders were of the opinion that transition to efficient appliances should be approached and effected after the useful life of existing appliances within the households had elapsed, since the cost of the various appliances were significant when compared to current disposable household income.

2.3.2.2 Non-financial barriers

A national water policy to guide the development of the water sector is currently being addressed in an ongoing consultancy managed by DOWASCO. At the time of reporting however, there were no policy or regulatory framework for supporting water efficiency measures and or incorporating water efficiency features into the design of new buildings. Further, there are no established standards for water efficiency appliances and so the absence of the legal basis required to define the technical specifications for the various water efficiency appliances that are imported and traded. within the island.

Within the context of limited household income exacerbated by the Covid 19 pandemic, and the relatively significant cost of water efficient appliances, swapping of fixtures for more efficient models is certainly not a priority to the majority of households and small business that are struggling to stay afloat.

The absence of information on the flush volume and other efficiency rating of the water appliances at the hardware stores visited, speaks to a general lack of awareness or even interest by the general public on the impact that water efficient appliances can exert on reducing their bills and the overall impact on the water resources on island. There is a paucity of public education on this issue and also an absence of demonstration sites where hands on knowledge can be transmitted.

2.3.3 Identified measures

The measures considered to address the barriers to the implementation of water efficiency appliances identified can be characterized mainly into the non-financial category. Issues such as consumer education, policy and legislative guidelines were considered to be priority actions to guide implementation of this technology.

2.3.3.1 Economic and financial measures

All of the water efficient appliances required for the implementation of this technology are manufactured out of Dominica, and must be imported into the country. They are thus subjected to the various import taxes and also VAT. Though it is believed that the effect of subsidies can have the impact of skewing adoption to the dis-benefit of adaptation, an essential feature of sustainability, the market characteristic of this technology makes it ideal for application of a tax waiver to encourage timely adoption.

The proposal is for a tax waiver on importation of all toilets into the island meeting the criterion of requiring 1.5 gallons of water or less for flushing. This is expected to result in a cost reduction in excess of 36%. This waiver can be maintained for a period of two years, after which the impact will be analyzed and the decision made whether to continue for a third year. This tax subsidy is expected to motivate business owners to sell off all old stock at reduce cost and restock with new water efficient appliance. This action will also be ably supported by the necessary policy and regulatory guidelines, which are discussed in the next section.

The cost of this subsidy is estimated to cost the state approximately XCD 44,000.00 (Approximately 100 new residential construction annually + 100 upgrades; with duty waiver of 38%). The expected cost saving in direct water fees is estimated at approximately XCD 33,000.00

2.3.3.2 Non- financial measures

The tax waiver discussed in the section above must be supported by a public information campaign that clearly articulates the purpose of the waiver and the associated benefits to consumers and utility company resulting in an overall reduction in the average cost paid for potable water. The current ongoing reassessment of the water tariff structure must be informed by this effort and can be so structured to provide added benefit to households who embrace the implementation of water efficiency technology through tangible reductions in bills. The current minimum charge level can be revised lower to apply on a maximum of 800 gallons as compared to the 1000 gallons. A second-tier rate can also be applied up to 1500 gallons and surcharge usage rate increase for any additional usage.

Public education campaign targeting the primary, secondary and tertiary education institutions should be launched targeting the specific benefit of implementing water efficient technologies to the country on a whole. The overall savings in energy cost for water treatment and distribution, the savings in the provision of storage facilities and the overall benefit to reducing the carbon footprint are features to be highlighted.

Policy and legislative guidelines to support and direct technical specifications for appliances to be used on island are required very early in the process. Accepted certification standards and appropriate industry labelling – to include information on estimated cost of operation, will need to be decided and communicated to all stakeholders to ensure that imported appliances are of the minimum standards.

2.3.4 Linkages of Barriers

There are no obvious direct linkages between the identified barriers for the two technologies selected within the water sector. Notwithstanding, it must be noted that implementation of water efficient appliances can serve to reduce water storage requirements for households. This can also have a positive impact on the initial implementation cost of a rainwater harvesting system. The expected savings in water storage requirement by a factor of approximately 1/3 is estimated for such households. This reduction can result in the procurement of a smaller sized tank or meeting household water needs for a period greater than the 3 days recommended by DOWASCO.

2.3.4.1 Cost benefit analysis

$NPV = \sum \text{Net Benefit}_t / (1 + i)^t$

NPV = Net Present Value
Net Benefit = Benefit - costs
t = year
i = Discount rate

CBA of Water efficient appliances at household and industrial fixtures – 200 households (100 new and 100 existing with an average of 2 units per household) implementing technology by 2025
Technology implementation assumed to follow the following pattern:

Year 1 – 100 households; Year 2 – 200 households; Year 3 – 200 households.

Net Benefit of selected Technology

	Unit	Current situation	Measures implemented
Unit procurement		319,200.00	204,288.00
Cost of subsidy			114,912.00
water cost		112,000.00	76,176.00
NPV = Net benefits		431,200.00	395,376.00

Year	Calculation	PV in XCD$
1	$35824 / (1+ 0.13)^1$	31,702.65
2	$35824 / (1+ 0.13)^2$	28,055.45
3	$35824 / (1+ 0.13)^3$	24,827.83
4	$35824 / (1+ 0.13)^4$	21,971.53
5	$35824 / (1+ 0.13)^5$	19,443.83
6	$35824 / (1+ 0.13)^6$	17,206.93

Year	Calculation	PV in XCD$
7	$35824 / (1+ 0.13)^{7}$	15,227.37
8	$35824 / (1+ 0.13)^{8}$	13,475.55
9	$35824 / (1+ 0.13)^{9}$	11,925.27
10	$35824/ (1+ 0.13)^{10}$	10,553.33
	TOTAL (10yr) NPV	**194,389.75**

NPV > 0, indicates that the transfer and diffusion of the selected water efficient appliances at household and industrial fixtures is profitable with the selected combination of measures. The combination of measures included in the analysis are certainly not exhaustive and others should be included where costs are available.

Chapter 3. Energy sector

3.1 Low carbon energy development in Dominica

The execution of measures to overcome barriers to low carbon development in Dominica is heavily reliant on financing, institutional leadership, and public awareness of the various low carbon options. The guidance for the implementation of many of these measures has already been provided in the various climate change and low carbon development reports.

Providing that the proposed energy technologies prioritized from the MCA process for households and businesses are cheaper over their expected lifetime than what presently obtains (fossil fuels), and their amortization periods are often ten years or less, enlightenment of financial institutions should encourage better understanding that provision of financing for these mitigation technologies actually improves the user's ability to meet financial obligations, thereby encouraging greater lending. Greater awareness by the population of the merits of these mitigation measures can also lead to upward pressure and action.

An overview of barriers to low carbon development as agreed after consultation with the TWG and stakeholders is provided in Table 3.1. Many of these barriers are also captured in Dominica Third National Communication to UNFCCC.

The sectors and corresponding technologies selected for barrier analysis are:

a. Renewable energies, (Run-of-the-River Hydro, Wind, and Photovoltaic Solar),

b. Energy efficiency (LED lights, automatic light controls, ground source heat pumps, windows, green roofs, energy efficient appliances, minimizing urban heat).

Table 3-1: **Overview of barriers to low carbon development in Dominica**

Barrier Type	**Barrier Descriptions**
Regulatory Policy / Legal	The development of renewable energy and energy efficiency technology are not currently incorporated in planning projections. Guidelines and standards to encourage the consideration of energy efficiency status of appliances prior to importation and installation are limited. National utility-driven cap (2.5MW) on Independent Power Producer's (IPP) renewable energy development, not consistent with higher renewable energy penetration to the national grid and Existing policy on feed-in tariff does not safeguard cost recovery of IPPs' energy supplied to the national grid.
Institutional / Technical	Key institutions within the Government which include the Ministry of Energy and Ports have prioritized, and are primarily focussed on geothermal energy development. A query of the process of energy generation prioritization used to establish Geothermal as the most optimal energy source for Dominica and the criteria used did not provide results. The Ministry of Environment, Rural Modernization and Kalinago Upliftment drives a broad but important climate resilience agenda that includes energy-related climate change actions. This impacts government's capacity to encourage

Barrier Type	Barrier Descriptions
	focused development of affordable low carbon power which is essential to provide, the commercial and residential sectors relief from the high energy costs.
Awareness / Knowledge	Insufficient exposure to the transformational possibilities of renewable energy for the financial sector, energy designers, and architects. There are few technicians in Dominica with vocational skills to install renewable energy and retrofitting equipment for energy efficiency. Low public awareness of renewable energy alternatives for reducing the high cost of electricity. Renewable energy and energy efficiency is outside of the core expertise of most public sector entities.
Market / Financial	Barriers that restrain the public sector from making investments in renewable energy and energy efficiency include: • Apart from geothermal energy, investments and expenditure in renewable energy and energy efficiency are very limited extent • high upfront cost of renewable energy • Extended payback period for many energy efficiency investments. Payback is usually over a period of years rather than more immediate that traditional forms of technology. • Alternate public sector financing vehicles for renewable energy and energy efficiency such as Energy Performance Contracting and Third-Party Ownership models that are able to accept greater risk and so support innovative technology development are not operational within the jurisdiction

3.1.1 Preliminary targets for technology transfer and diffusion within the renewable energy sector

The preliminary renewable energy target for technology transfer and diffusion from fossil fuel to renewable energy - geothermal, run-of-the-river hydro, onshore wind, and residential and commercial standalone photovoltaic solar is estimated at over 12 MW by 2030. These technologies have good potential in Dominica and can exceed the country's energy needs with the excess available for export. (Dominica Third National Communication to UNFCCC 2020)

3.2 Barrier analysis and enabling measures for the Renewable Energy Sector

In 1978 over 70% of Dominica's grid electricity was generated by run-of-the-river hydro. The country's low carbon electricity generation has regressed significantly to the extent that the electricity generation mix has flipped so that 71.5% of its grid electricity is now generated with fossil fuel. The DOMLEC 2019 report indicated that the country has an installed capacity of 26.74 megawatts (MW) consisting of 6.64MW (28.5%) of hydropower and 20.1 MW of diesel-powered units. Average base load demand is about 11.5MW, while peak demand is approximately 16MW.

According to World Bank 2014 estimates fossil fuel imports consume about 12% of Dominica's GDP, a figure that is expected to increase as the country transitions into a more service-oriented economy. The current energy mix, with the predominance of fossil fuel energy generation, also significantly increases susceptibility to the nuances of fluctuations in fuel prices, having the potential to negatively impact national development. Heightened urgency in advancing low carbon energy development on

island is one way of directly counteracting this issue. The replacement of the business-as-usual on energy generation investments, to include investigation and selection of other suitable renewable sources by institutions and the general population will yield improved returns to the country's development from the reduction in greenhouse gas emissions and foreign exchange savings.

Tables 3-2 and 3-3 rates the key barriers facing the four main renewable energy technologies locally and the estimated levelized cost of development. The response recorded was generated after consultation with the TWG, and represented a consensus of their perceived barrier levels of the various technologies when compared with each other.

Table 3-2: **Barriers Facing Selected Energy Technologies**

Technology	**Regulatory/Institutional**	**Awareness**	**Financial**	**Technical**
Geothermal Energy Development	4	2	5	4
Further Development of Hydro Energy	3	4	4	3
Further Development of Wind Energy	2	4	3	3
Expansion of residential & commercial standalone Photovoltaic Solar Energy	2	1	2	2

Barrier Scoring: Highest Barrier = 5 to Lowest Barrier = 1

Table 3-3: **Levelized costs for geothermal, run-of-the-river hydro, wind, and photovoltaic solar development in Dominica.**

RE Type	**Projected Development Costs** /kW	**Projected Levelized[3] Costs**/kWh
Geothermal	US$2500 per installed kW	US $0.073/kWh
Run-of-the-river Hydro	US$1200/kW to US$2500/kW[4]	US $0.047/kWh
Wind (onshore)	US$1360/kW	US $0.053/kWh
Photovoltaic Solar (residential & commercial standalone)	US$2436 /kW	US $0.08/ kWh

(US Energy Information Administration) (IRENA 2019)

[3] Levelized Cost of Electricity (LCOE) is a measure used to compare the lifetime costs of generating electricity across various generation technologies. The costs can be categorized into Capital Costs, Operation and Maintenance (O&M) Costs, and Disposition Costs. LCOE allows comparison of various generation technologies with different capital costs, Operation and Maintenance Costs, Disposition Costs, and useful life, etc. LCOE can be viewed as an "average" electricity price that must be earned by a generation source to break even. LCOEs are used as a relative scale to compare various technologies rather than an absolute measure.

[4] Run-of-the-river hydro power cost is very site specific, with cost variation largely influenced by the site characteristics. The electro-mechanical equipment cost varies significantly less than civil engineering costs. Thus, the variation in the installed cost per kilowatt for a hydropower project is largely determined by the civil works needed to access and develop the site. It is therefore difficult to use historical trends to predict development costs and Levelized Cost of Electricity (LCOE) for a hydropower project.

3.3 Barrier Analysis and enabling environment for hydropower plants

3.3.1 General Description of Hydro Energy development

Dominica is called the land of 365 rivers. While the high rainfall and high degree of forestation yields a good water resource, the prevailing mountains and valleys create significant challenges to convert that resource into usable energy. The dependability of hydropower makes it a good source for supplying the energy base load of the island and a good companion for wind and PV solar whose supply is not continuous. In 1974, 74% of the island's grid electricity was generated by run-of-the-river hydro. Today the percentages are reversed as the hydro energy development stagnated while the country's energy requirements increased.

3.3.2 Economic and Financial Barriers to hydro energy development

The economic and financial barriers to widespread diffusion of hydro energy technologies in Dominica were assessed to be largely driven by:

- access to and cost of financing required to cover the relatively high upfront cost to develop run-of-the-river hydro energy; and
- the current significant price difference between the relatively low selling price by independent power producers and high buy-back tariff from the electric utility, DOMLEC.

3.3.2.1 Cost of Run-of-the-River Hydro Energy

Run-of-the-river hydropower cost is very site specific, with cost variation largely influenced by the site characteristics. The two major cost components for hydropower projects are:

• The civil works (including the project development costs); and

• The electro-mechanical equipment.

The civil works costs include, site access infrastructure, dam and reservoir construction, canal construction, powerhouse construction, Grid connection, engineering, procurement and construction (EPC), and developer/owners costs (including planning, feasibility, permitting, etc.).

Other project development costs include planning and feasibility assessments, water quality monitoring and mitigation, environmental impact analysis, wildlife/biodiversity mitigation measures, licensing, and historical and archaeological mitigation all add up to make for a substantial initial investment cost.

Some of the main electro-mechanical equipment cost include cost of the turbines, generators, transformers, cabling and the control systems. While these cost are also significant, they vary less between sites as compared to the civil engineering costs. The electro-mechanical equipment falls into the class of relatively mature, well-defined technology, making the variation in the installed costs per kilowatt for a hydropower projects almost exclusively determined by the local site considerations that determine the civil works needed. It is therefore difficult to use historical trends to predict development costs and Levelized Cost of Electricity (LCOE) for a hydropower project. Estimated projected run-of-the-river-hydro energy development cost and levelized costs are listed in Table 3-4.

Table 3-4: **Projected development and levelized costs for run-of-the-river hydro energy development in Dominica.**

RE Type	**Projected Development Costs** /kW	**Projected Levelized Costs** /kWh
Run-of-the-river Hydro	US$1200/kW to US$2500/kW	US $0.047/kWh

(US Energy Information Administration 2019) (IRENA 2019)

3.3.3 Non-Financial Barriers to Hydro Energy

Some of the non-financial barriers assessed for hydro energy technology included:

- Low general awareness and understanding of the possibilities and scope of the technology. With a better understanding of the savings and benefits, some private entities considering self-generation for their enterprises (business, manufacturing, resorts, hotels, cooperatives, NGOs, etc.) would opt for hydropower instead of fossil fuel generation if hydropower generation was more economical in their vicinity. This would also allow for further decentralisation of facilities into locations not served by the grid.

- Local technical competences to plan, design, implement, evaluate, and manage the technology is limited. This competence lies with a few who are usually employed within the utility company

- Public access to information on assessed energy production potential of rivers in Dominica.

To achieve the goal for greenhouse gas emissions expressed in various official documents like Dominica's Low Carbon Climate Resilient Development Strategy and the Intended Nationally Determined Contribution (INDC) of the Commonwealth of Dominica, renewable energy implementation and uptake remains a critical element in the transitioning. The importance of government and business institutions adoption of an advocacy role to create the required shift from the business-as-usual (fossil fuel generation) mind-set that pervades local energy development is acknowledged. Though the water volume and flow rate of 29 rivers were analysed in a Hydropower Potential Analysis in 2013, there remains the absence of structured programs promoting increase installation and utilization of hydro energy. This is evident with increased electrical energy demands over the pass 2 decades, being resolved by the installation of fossil fuel generators notwithstanding that hydro power or other renewable sources would be cheaper in the long run. The significant experience and relative ease with which these fossil fuel generators can be implemented is believe to be the primary justification for their continued dominance. While the general population is sensitive and desirous of having lower energy bills, consensus on the means to achieve this reduction is not obvious. For the most part, this decision is often left to Government, with most of the population paying minimal attention to technical issues such as the energy potential of the river flowing in the vicinity of their community. It was therefore reasoned that increase education and awareness of the technology will increase consideration of its viability. Hydro energy development and maintenance education as part of an overall strategy to address renewable energy within the tertiary education program will begin to address this technology in a more significant way. The overall objective should be to make these renewable energy and energy efficiency technologies knowledgeable options when energy supply is being considered.

3.3.4 Proposed measures for addressing Hydro Energy economic and financial barriers

Since hydro energy and geothermal energy are the renewable energy sources that can provide significant baseload to the electricity grid, it is very important that these sources get the necessary financing to replace fossil fuel energy as the baseload energy anchor. Given that an adequate supply of cheaper renewable energy baseload supply would also allow the widespread transition from gas stove cooking to electric stoves with the corresponding greenhouse gas emission reduction and foreign exchange savings, facilitating financial access would be beneficial to everyone. The retention of the fossil fuel foreign exchange would allow for the diversion into the development of other creative sectors.

Table 3-5 summarizes measures to address the economic barriers and measures identified by the technical committee.

Table 3-5: **Proposed Measures for Hydro Energy Economic and Financial Barriers**

Type	Barrier	Proposed Measures
Economic and Financial	Cost and access to finance to develop new plants. Venture capital services is non-existent locally.	Let the feasibility study on hydropower development guide development. (CREDP/GIZ 2013) Provide government grant or concessionary funding to alleviate the high overhead cost to launch a local or regional hydro power plant. Or alternatively, assign dedicated earth moving equipment to assist developers and communities reduce the cost of the civil works required for construction of hydro power plants. This incentive can be as per machinery investment at the public works corporation which would also be utilized for other national development projects and infrastructure maintenance especially after natural disasters. Potential beneficiaries of this service will still be expected to pay for the service, albeit at more competitive rates and payment schedules. Since the cost implication to the beneficiary will be site specific, the extent of the assistance would be likewise.

3.3.5 Proposed Measures for Hydro Energy Non-Financial Barriers

Proposed measures for overcoming non-financial barriers for hydro energy are summarized in Table 3-6

Table 3-6: **Proposed Measures for Hydro Energy Non-Financial Barriers**

Type	Barrier	Proposed Measures
Regulatory Policy and Action	Inconsistent renewable energy development focus	Policy development to address the development of hydro power and other renewable energy wherever the potential exist. This policy should address, regulate and empower the development of all viable energy sources and inclusion of venture capital services into the financing of the various technologies. The policy development should be facilitated through the Ministry of Energy and Ports with input from the Ministry of the Environment, Department of Physical Planning, Dominica Water and Sewage Company (DOWASCO), and other relevant departments to include mapping off-grid areas that would most benefit from implementation of the various renewable energy technology. Clear guidelines to allow seamless implementation to indicate licensing requirements, responsible authority, environmental considerations etc. This effort will require the engagement of specialized knowledge to conduct the required assessment and detail the guidelines. It is anticipated that this assignment can be completed within 3-6 months. Financing of this activity can possibly be considered under one of the components of the GCF readiness project.

Type	Barrier	Proposed Measures
Technical	Energy production possibility or capacity status of rivers within close proximity to communities is usually not known by potential developers. Their applicability for implementation of mini and micro hydropower significantly increases available areas for development. Few technically competent and knowledgeable operators in hydro installation and management	Disseminate the hydro energy potential report to communities so hydro energy can be considered when new or increased energy generation is being considered. Train a cadre of hydro technicians and introduce and maintain hydro power courses at the educational and vocational institutions. Also provide educational opportunities to train university level professionals to engage in transformation of the energy sector. This can be done by prioritizing knowledge development in renewable energy technology by making students interesting in this area entitled to compete for funding within the scholarship programs. The introduction of a renewable energy program at the state college. This can be facilitated by the Ministry of Education and like agricultural training, be funded from the national budget.
Awareness and Knowledge	Public unawareness of the energy potential of the river(s) flowing in their vicinity, and what it would take to generate electricity from the resource.	Renewable energy advocates, and schools must raise the renewable energy consciousness of the population by conducting cost-benefit public awareness campaigns and basic instructions of the key elements of hydroelectricity. This would apprise the public of the pros and cons of the full range of energy options rather than the current default option of fossil fuel generators.

3.4 Barrier analysis and enabling framework for wind energy

Dominica has good onshore wind resources on its east coast (Winergy, 2004)). There are also good wind energy possibilities scattered in other parts of the island but turbulence may be a limiting factor in some of these areas. Beyond the application of larger commercial scale wind turbines, smaller household turbines can complement photovoltaic solar energy systems as off-grid energy sources.

3.4.1 General Description of the Development of Wind Energy

Energy from wind can be harvested using horizontal or vertical axis wind turbines. Wind can also generate propulsion energy via sails on vessels. The use of sails has been around for centuries and have somewhat disappeared in recent times, replaced by fossil fuel motors. The possibility of hurricane force winds affecting the Island necessitates that installed turbines should either have mechanisms so they can be lowered when high winds are eminent, or be massive enough to withstand hurricane force winds.

Wind energy is proportional to the cube of the wind speed. Energy storage or other means is necessary if energy is needed in periods when the wind is below the minimum generation threshold. Since wind energy varies with the wind speed it cannot be used as baseload. It must be coupled with a baseload system like hydro, geothermal, or fossil-fuelled generation in the low wind speed periods. Currently a number of street lights along the islands roadways are powered via a solar/wind hybrid generator.

3.4.2 Economic and Financial Barriers to the Development of Wind Energy

The main economic and financial barriers, supported by the TWG are:

- Lack of financing to investigate the potential and implement the technology. The high cost of financing also serves as a major barrier;
- Finance to provide the control scheme to synchronize wind energy to grid tie-in, and
- a net-billing tariff system based on avoided cost of fuel, which is a disincentive to independent power production.

3.4.2.1 Cost of Wind Energy

Wind energy development cost can be segmented into:

(1) Units for a standalone operation be it a home, farm, commercial, or industrial operation; and (2) dedicated to providing power to the grid.

The cost for the former is essentially the cost of the wind turbine, its erection, and connection to the consumption destination. Local knowledge of the site and a sense of the wind energy potential thereon is also essential. For implementing wind turbines for commercial operations, a comprehensive study of the proposed site is required. It is generally recommended that this study should be at least 9 months if correlated to another area site with similar wind conditions. A wholly virgin site would require at least a year of wind information to include wind speed, consistency, direction, and turbulence. (Winergy (2004))

The projected wind energy production and levelized costs are listed in following table 3-7

Table 3-7**: Projected development and levelized costs for wind energy development in Dominica**

RE Type	**Projected Development Costs** /kW	**Projected Levelized Costs** /kWh
Wind (onshore)	US$1360 / kW to US$2000/kW	US$0.053/kWh to US$0.078/kW

(US Energy Information Administration 2019) (IRENA 2019)

3.4.3 Non-Financial Barriers for the Development of Wind Energy

The non-financial barriers to the widespread diffusion of wind energy as prioritized by the TWG are:

- The general public has low awareness and understanding of the possibilities and scope of the technology. With a better understanding of the savings and benefits, some private entities (business, manufacturing, resorts, hotels, cooperatives, NGOs, etc.) would opt for wind power instead of fossil fuel generation if wind power generation was more economical in their vicinity.
- Wind energy measurements in most areas have not been investigated, thus reasonable accurate projections are not available at present for location that have not been studied; Projections are based on tested site.
- Local technical know-how on commercial wind energy generation is limited.

Windmills were common centuries ago and most mechanical operations were powered either by windmills or waterwheels. With the present-day widespread use of electric gen-sets, the population do not sufficiently consider that their energy needs could be met by wind turbines. While the installation

of photovoltaic panels is growing on the domestic level, complementary wind turbines have yet to make a discernible entry into the energy mix within the domestic and commercial sector. Many of the street lights along the major roadways are being powered with hybrid solar/wind generators. The up-scaling of this technology to power domestic and commercial buildings is lagging notwithstanding that this form of renewable energy has the lowest projected development cost between all of the renewable energy technologies (see table 3-3 & 3-7). It was the general consensus of TWG and other attending stakeholders, that this delay could be reasoned by a lack of awareness and knowledge of the possibilities of wind energy generators and the available technical capacity locally. Since wind is variable and intermittent, installations considering wind power as the main power source would either have to be grid tied or have energy storage on site.

3.4.4 Proposed Measures for Overcoming Wind Energy Economic and Financial Barriers

Table 3-8 summarizes the main measures agreed by the TWG as being able to overcome the financial barriers identified.

Table 3-8: **Proposed Measures to Overcome Financial Barriers for Wind Energy**

Type	**Barrier**	**Proposed Measures**
Financial and Economic	Initial cost structure- Upfront costs on studies and preliminaries pre- generation	Development of a wind resource map for the country to allow interested parties to be able to access information of the wind energy potential in their location of interest without incurring this initial cost. In cases where the developer does incur the cost, development of a system of tax credit to be applied after project completion can be considered. This initiative should be undertaken by the Ministry of Energy and Ports, forming part of what should be a renewable energy potential mapping of the country. The department of Physical Planning should also be involved in order to ensure that correct representation of development zones is represented. Establishment of a revolving fund to provide financing or as surety to allow small businesses and households interested in installations to access financing to significantly address the upfront cost. Based on IRENA's projected cost US$0.053/kWh for wind energy and the current electricity price of US$0.36/kWh in Dominica, properly located wind turbines could deliver energy at seven times lower cost than the utility. (IRENA: Renewable Power Generation Costs in 2019 and DOMLEC rates) The savings foreseen from the lower electric bill can be directed to service the financing loaned. Reduction of import duties or possibly VAT on renewable energy generators (30%) will also address the issue of high upfront cost. The main resulting benefits are foreign exchange savings from reduced fossil fuel purchase and lower greenhouse gas emissions. On the larger commercial grid level, investments in the development of wind farms to provide power requires the undertaking of feasibility studies. The conduct and availability of these studies to include systems of management for operating in environments prone to annual tropical cyclones will provide for lowering the upfront cost of interested entrepreneurs. Other incentives such as import duty and income tax concession for an initial period will also address this issue.

Type	Barrier	Proposed Measures
		Lowering import tariffs on wind energy machinery, which currently stands at 30%. A comprehensive wind resource map estimating the wind resource of the island is needed. Sites with suspected commercial possibilities should be studied so a fair indication of the likely energy generating potential is understood. Possible turbulence should also be investigated as the island's topography is conducive to locations with good wind resources which can be negated by an unacceptable level of turbulence. The twelve months' sites investigation would require masses, stays, anemometers, wind vanes, and recorders all connected to a central network. This information can be correlated with the existing and previous wind measurement data from the airports. The projected costs for a comprehensive study of 20 sites on the island with wind information, analysis, and interpretation will be in the XCD200,000 to XCD300,000 range.

3.4.5 Proposed Measures for Overcoming Wind Energy Non-Financial Barriers

The east coast of Dominica is directly along the path with the north-east trade winds and possesses significant wind power resource (Winery 2004). Some other locations on island also have useful wind resource. The wind resource is estimated to be able to produce upwards of 30MW of power (Dominica Third National Communication to UNFCCC). This potential far exceeds the island's peak load requirements and the 35% non-baseload power the current grid can accommodate. Unless there is a corresponding interconnected grid with the neighbouring islands, the current grid connected capacity would have to be capped at about 5MW of wind and solar energy combined. Alternatively, the excess wind capacity could be used to baseload energy, like generating hydro energy from water pumped and stored in an elevated dam, or to produce hydrogen for power generation or marine transportation.

Since 2000, Guadeloupe, just 35km north of Dominica, has 42 megawatts of installed wind generators. (Guadeloupe Energie – Renewable energy 2018) Establishment of a collaboration arrangement with the authorities in Guadeloupe could be an ideal way to increase technical capacity of local personnel, who would be tasked to advance Dominica's wind energy generation development.

Table 3-9**: Proposed Measures for Overcoming Wind Energy Non-Financial Barriers**

Type	Barrier	Proposed Measures
Regulatory Policy and Action	Regulations governing the development and implementation of renewable energy especially for integration into the national grid	Review of regulatory framework to provide clear direction and equity for independent providers desirous of producing for the national grid. Renewable energy policy and action plan to establish criteria for selection of energy type for upscaling and new energy sources by energy providers. These guidelines must address

Type	Barrier	Proposed Measures
		affordability of generation technology, operation feasibility, greenhouse emissions and cost to consumers. Energy producer to be required to address these issues during the application for generation licence. This should be part of the routine work of the Independent Regulatory Commission (IRC), so no additional cost measures are foreseen.
Technical	Wind energy potential mapping	Project undertaken with appropriate personnel and equipment to map the wind energy potential of the island. In the first instance this undertaking can be carried out at several locations over a 12 months' period.
	Turbines vulnerability to high wind	Mount turbines on masts that can be lowered.
	Local technical capacity and knowledge in wind turbine installation and maintenance	Establishment of cooperation agreement with relevant authorities' operators of the many wind farms in the neighbouring island of Guadeloupe to assist in training local technicians will begin to address the knowledge gap in the short term. This could be a 20 trainees two-year program with collaboration between EU's INTEREG and Dominica's Ministry of Energy and Ports and the Dominica Association of Professional Engineers (DAPE). Support funding for this program could come from the INTEREG which is an EU funded program for cooperation between the EU and countries on its borders. The cost could be minimized to around XCD5000 per trainee if the program is conceived as a work study program for Dominica's trainees. Train a cadre of technicians and introduce and maintain renewable energy courses to include wind power at the local vocational institutions. The State college and UWI should be targeted as the primary delivery

Type	Barrier	Proposed Measures
		agency.
Awareness and Knowledge	Public awareness of the alternate energy possibilities and their potential	Concerted action to equip renewable energy advocates and schools to raise the renewable energy consciousness of the population by conducting public awareness campaigns – Renewable energy month; where basic instructions of the key elements of the different energy sources can be highlighted and demonstrated. This would greatly empower potential developers to reconsider alternative renewable energy options when energy supply is being considered.
	Public education efforts to sensitize the populace on the potential of wind energy as a viable option for the generation of electric power is inadequate.	Targeted promotion program on the benefits and possibilities of utilizing wind energy. The Energy Ministry should facilitate this action and also the creation of a wind energy map of the island.

3.5 Barrier analysis and enabling framework for photovoltaic solar energy

Of the four renewable energy sources considered in this TNA, solar energy is seeing the most public affinity, partly due to the widespread use of donated photovoltaic solar fixtures for emergency use during the months of power disruption after Hurricane Maria in 2017, and the increasing technical capability of many technicians. Anecdotal data pieced together since the passage of Hurricane Maria indicates that there is a widespread desire by residents to augment their energy supply with some solar energy as a safeguard against the next major power outage. Further, with much of the utility powered street lighting migrating to solar and the lighting of the main interconnecting roads with solar and wind powered LED fixtures, many residents are expressing a desire to include some level of solar at their homes. So far many of the systems are standalone and there must be better understanding of the pros and cons of standalone versus grid tied. Many residents' main concern is focused on having standby power in the event of power outages especially after storms in the hurricane season.

3.5.1 General Description for the Further Development of Photovoltaic Solar Energy

Energy from the sun can be transformed to electricity in photovoltaic (PV) cells and concentrating solar power (CSP), or to hot water in solar thermal units. Direct current electricity from photovoltaic cells can either be used as direct current electricity or inverted to alternating current electricity. The electricity generated can be used directly at the generating facility, or can be grid tied. Solar energy is limited to useful daylight hours therefore storage or other means are necessary if energy is needed in periods when the sun energy is not available. Because solar electricity varies with sunlight, it cannot be used as baseload, therefore, it must be coupled with a baseload system like hydro, geothermal, or

fossil fuel to provide reliable consistent electricity. Solar electric systems require a lot of space. Roof space can be used for homes and businesses, but utility solar generation would require large preferably flat or gently undulating fields to install panels or mirrors.

3.5.2 Economic and Financial Barriers to the Expansion of Photovoltaic Solar Energy

- Public awareness of the PV energy alternative beyond what currently obtains as per small lighting and other smaller appliances,
- Cost of financing,
- The current tariff system for producing and purchase of power (discourages uptake because of the significant difference in low selling price from the independent producer to the electric utility and high buy back price from the utility).

3.5.2.1 Cost of Photovoltaic Solar Energy

The cost of photovoltaic solar energy is assigned to the solar panels, the related control equipment, and the cost to install and connect. If the system is grid tied, then storage batteries can be omitted. Solar photovoltaic energy without batteries is currently the cheapest form of energy. However, since solar energy is not suitable for base load, its use either has to be complemented with a baseload source, or be supplemented with batteries or other storage means. Given the scarcity of flat land and more suitable alternatives like geothermal, hydro, and wind, large scale solar PV energy for the grid is far less attractive.

In Dominica, there also need to have a significant rebalancing of the price the electricity utility buys energy and the price energy is sold back to their customers. Various presentations have called for net metering to be used in the country to eliminate the price imbalance and to encourage solar and other renewable energy production by independent producers.

The projected photovoltaic solar energy production and levelized costs for solar has not been determined in Dominica. Since most solar equipment and technology used locally are imported from the US, cost associated to this jurisdiction are listed in following Table 3- 10.

Table 3-10**: Projected development and levelized costs for solar energy development in Dominica**

RE Type	**Projected Development Costs** /kW	**Projected Levelized Costs** /kWh
Photovoltaic Solar (residential & commercial standalone)	US$2436 per kW	US $0.08 per kilowatt-hour (kWh)

(US Energy Information Administration 2019) (IRENA 2019)

3.5.3 Non-Financial Barriers to the Expansion of Photovoltaic Solar Energy

The efficacy of solar photovoltaic systems was manifested strongly in the dark months after Hurricane Maria. There are however a number of impediments limiting the widespread utilization of photovoltaic solar namely:

1. The absence of policy or guidelines actively directing the incorporation of renewable energy and energy efficiency as a criterion in the energy generation process for the utility companies. Consideration of these are currently largely voluntary.

2. Building designs as it relates to the carbon footprint to include systems and structures to encourage energy efficiency and incorporation of renewable energy are totally dependent on the designers and owners' discretion.

3. The peak grid electricity consumption period is from dust to about 11pm, when solar energy generation is not possible. This makes it necessary to have an alternative backup energy source and or energy storage capacity. The absence of policy to direct the implementation of net metering, where excess power can be sent to the grid and withdrawn when required at a reasonable cost (without the avoided cost normally associated with fuel) is disadvantageous to the small independent power producers, thus lowering the attraction for the adoption of PV solar generation.

3.5.4 Proposed Measures for Overcoming Photovoltaic Solar Energy Barriers

Widespread use of photovoltaic solar energy after Hurricane Maria when most utility lines were down, enabled the local population to achieve a good introduction to photovoltaic solar energy usage. Out of this experience of prolonged power outage many people would like to have at least a standby supply available. However, as outlined in Table 3-11 various measures must be implemented to create a significant uptake in PV solar deployment.

Table 3-11: **Photovoltaic Solar Energy Proposed Measures**

Type	**Barrier**	**Proposed Measures**
Financial and Economic	Purchase and installation cost	Avail financing at advantageous rates for small businesses and household installations, understanding that the levelized cost of grid-tied net-metering solar energy is significantly cheaper than the current grid electricity.
Regulatory Policy and Action	Low incentive to encourage uptake	Ministry to encourage solar power by minimizing import duty and taxes on solar energy apparatus as an introductory feature for a period of 2 years.
	On-site renewable energy generation is largely voluntary	Add a low carbon requirement in the building code to encourage energy efficiency and on-site renewable energy generation in new and retrofit buildings.
	The price at which electricity is sold to the utility is significantly lower than the price it is bought from the utility.	Independent Regulatory Commission to regulate tariffs and measuring schemes between the electric utility and the independent small-scale producer to ensure greater equity and transparency of cost.
		Introduce net metering to operate between renewable energy producers and the electric utility.

Type	Barrier	Proposed Measures
Technical	Low technical capacity and knowledge in solar photovoltaic sizing, installation and upkeep	Train a cadre of technicians and introduce and maintain solar power courses at the educational and vocational institutions. This could be included as part of the Ministry of Education's education budget. Specific hands on training for 20 trainees at wind farms in Guadeloupe can be done through a cooperation agreement between Dominica and the EU's INTEREG. The cost could be minimized to around XCD5000 per trainee if the program is conceived as a work study program for Dominica's trainees.
Awareness and Knowledge	Public awareness of the price and emissions benefits of solar photovoltaic	Renewable energy advocates and schools must raise the renewable energy consciousness of the population. This approach is already being pursued by civil groups and NGOs like WAVE, Portsmouth Community Watch Foundation, and others. A national campaign through the NGOs and local authorities could be done for about XCD20,000 to finance promotional material, transportation, and some radio and social media postings.

3.5.5 Linkages of Energy Barriers

The barrier linkages between the three energy technologies are linked to various degrees. Firstly, two of the technologies, wind and residential and commercial standalone rooftop PV solar, are intermittent technologies which should be deployed with battery backup storage, or a baseload technology like hydro, or grid tied to avoid outages. Because of the limited availability of flat land on the island, residential and commercial standalone PV solar is the recommended solar technology. While on the east coast a combination of wind and solar PV could reduce the capacity of battery backup needed.

The barriers would all be significantly reduced or even eliminated on the education and awareness front if all the technologies were all grouped under the same heading and the elimination of these barriers were approached in unison. The offering could be for renewable energy and the result would benefit all the technologies thus reducing the need for three separate programs.

On the concessions front, all three technologies would benefit from a unified tariff reduction scheme to reduce upfront cost. The levelized cost and amortization period would however be different for all three technologies. Hydro would require the longest payback period because of its more elaborate preparation and construction, however, its levelized cost is projected to be the lowest in the long term.

Once financiers become familiar with one system, it would be a relatively small step to understand the concept for the other technologies. Levelized cost and non fossil fuel energy generation would become a standard concept within financing circles.

Since most rivers in Dominica flood a few times a year and are often just below flood stage, in suitable topographies, hydro systems could be designed with an adequate diversion dam, with sufficient medium term storage of a few months, to divert near flood stage and flood stage water into a diversion dam which would be fed through the penstock to the turbine thus maintaining a

guaranteed energy output throughout the year while averting flood damage downstream. This water storage could also be used for irrigation purposes in "*Karwem"* or the dry season.

3.6 Barrier analysis and enabling framework for energy efficiency technology

Most of the energy efficiency schemes advanced are relatively easily implemented and could yield significant GHG mitigation benefits. The cost, local availability and technical capacity of components to implement the schemes can all be relatively easily attained and in some instances be implemented within existing systems already implemented in homes and businesses.

The main barriers identified through consultation with the TWG and the TNA team limiting energy efficiency technologies are:

- Public awareness: Residents are generally inexperience and sometimes unaware of the benefits of energy efficiency. This is evidenced by the widespread implementation of more "exotic" energy in-efficient options compared to simpler less glamorous and often inexpensive solutions. An example of this is seen in the spending of over XCD3000 for the purchase and installation of an air conditioner unit. An energy inefficient home could spend EC$2000 to EC$6000 per annum for the electricity of air conditioning and fans operation. Building (new or renovated) with energy efficient features would negate these expenditures and payback could be in the zero to four years range. Energy efficient windows for instance would be the same price as the inefficient windows and savings would begin from day one.

- Institutional leadership: on issues such as appliance efficiency and building codes, regulatory departments should play a more direct role in advancing energy efficiency. The planning department should ensure that energy efficiency become a requirement within the building code, while an environmental levy, as currently applied to imported vehicles, can be extended to encourage more energy efficient appliances importation.

- Cost and access to financing: Technologies such as green roofs and ground source heat pumps, should be promoted via pilot demonstrations. Concessionary financing should be made available through national programs since this would ultimately result in money retained in the homeowner's or business's coffers thus enabling them to more easily meet their other commitments.

- Technical capacity: More designers and installation technicians of green roofs and ground source heat pumps needs to be trained. Training institutions, schools and other key government buildings can be outfitted with these technologies to demonstrate their effectiveness and to serve as training sites. Partnership arrangements and return visits to countries where these technologies have attained prominence are particularly encouraged.

The technologies prioritized for further consideration by the TWG included Automatic Light Controls: (Photocells, Light Level Sensors, Motion Detectors, Occupancy Sensors), Air-Conditioning: Ground Source Heat Pumps, Windows, and Green Roofs. See fig 3-12). Uptake of LED Lights and Energy Efficient Appliances to a lesser extent are already occurring via the need to reduce the relatively high monthly bills paid for electricity by many consumers. Minimizing Urban Heat Island Effect, while needing some awareness by town planners and the general public, will mostly happen because of the other mitigation actions outlined herein.

Table 3-12**: Barriers Facing Selected Energy Efficiency Technologies**

Technology	Regulatory	Awareness	Financial	Technical
LED Lights	1	1	1	1
Automatic Light Controls	1	4	2	1
Air-Conditioning: Ground Source Heat Pumps	3	5	4	4
Windows	1	5	1	1
Green Roofs	3	5	3	3
Energy Efficient Appliances	3	3	1	1
Minimizing Urban Heat Island Effect	4	5	3	4

Barrier Scoring: Highest Barrier=5 to Lowest Barrier = 1

3.6.1 LED Lights

LED lights penetration into regular use is already occurring. This is mainly due to notable energy savings and reduced availability of alternatives to incandescent and compact fluorescent light bulbs in stores. While 20W and 40W fluorescent tubes are still available, new installations and retrofits largely migrate to LED tubes.

3.6.2 Automatic Light Controls (Photocells, Light Level Sensors, Motion Detectors, Occupancy Sensors)

Automatic light controls are generally not widely applied locally. Street lights and some area lights are fitted with photocells, but most other buildings and areas rely on manual turn on and off. As a result, many light fixtures utilized in office blocks and unoccupied venues, that need to be turned on at night, stay on throughout the daylight hours, especially on weekends when there is no worker in attendance. Most new area-lights come with a motion detector option. However, this option is not always applied because of additional cost application. Greater effort and information awareness is needed to increase the use of this technology and provide education of its significant cost saving benefit.

Light level sensors and occupancy sensors are hardly ever installed locally. The critical barrier identified by the Team (Consultant & TWG) is awareness by end users and installers and the non-existence of regulations and guidelines requiring and inducing their consideration in design and installation.

3.6.3 Air-Conditioning: Ground Source Heat Pumps (GSHP)

Ground Source Heat Pumps, also referred to as Geo-Exchange, earth-coupled, geothermal, or water source heat pumps, are basically space heating or cooling systems which use heat exchangers, heat pumps, and coolant liquid to import or export heat from a location to or from the earth or nearby pond/water source.

The concept of ground source heat pumps is novel to Dominica, even among AC installers. Within this environment heat from buildings would be extracted and directed to approximately 6 feet below the earth surface where the temperature is approximately 65 degrees Fahrenheit (18 degrees Centigrade or Celsius). Pipes with coolant liquid are buried about 6 feet horizontally, 150 to 450 feet vertically, or is immersed in an adjacent/nearby body of water. A small pump consuming minimal power is used to circulate the coolant through the pipes and heat exchanger. This power can be sourced from the household power supply or from a dedicated renewable energy source.

Within the past 8 to 10 years, installation of inverter type AC units has been ongoing in Dominica. These units are up to 40% more energy efficient than what was previously utilized. Compared to inverter type units, ground source heat pump only uses a fraction of the energy. Barriers to and possible measures to the implementation of this technology include:

1. The level of awareness and technical capacity among consumers and installers of AC technology; The facilitation of a short training program in GSHP by the State College and Youth Skill Training Program similar to the modules developed and implemented for AC and refrigeration is recommended to raise awareness and also address the deficiency in capacity to design and install the technology. The training programs will also provide details of the associated benefits in operation cost savings and installation cost by designers, government, businesses, and home owners. The establishment of a pilot demonstration site within the training institution will also significantly raise awareness. The cost for installation of a unit in a 400 square feet room will be about XCD20000.

2. The technology is resource intensive in terms of land space and excavation cost for heat exchangers except in cases where an appropriate water body is within close proximity. This increases installation cost which most likely would require financing. A well design and installed ground source heat pump system will have an active life of over 25 years. The effective lifespan of the technology however increases the possibility of concluding negotiation of terms for finance payback that are very comfortable. GSHP technology can be particularly directed towards hotels who are significant consumers of air conditioning technology. Further, hotel plants in Dominica are often constructed in spacious areas which can relatively easily accommodate the heat diffusers of ground source heat pumps.

3.6.4 Windows

The Team concluded that the main barrier hindering the widespread use of more energy efficient casement and awning windows instead of the current slider and single or double hung windows is the absence of reliable information within the public domain generating a lack of institutional understanding and leadership that would encourage the use of the far superior energy efficient casement and awning windows in new and retrofit installations. Upfront installation and purchase cost is about the same for all the windows. Therefore, an understanding of the energy efficiency benefit and the associated comfort is assessed to be required to increase the installation of casement and awning windows thus lowering the use of fans and air conditioning. It is suggested that building designers should be primarily targeted to adopt this advocacy role. The building code, which is currently being updated should be utilized to provide the required technical information to empower designers to convince their clients to utilize more efficient technologies. The engagement of the architectural and engineering associations by the physical planning department is also recommended. The costs associated with these activities were assumed to be minimal as they formed part of the function of the planning department.

3.6.5 Green Roofs

Information on the application and benefits of green roofs are very limited in Dominica. This absence of information and inexperience with the technology was assessed to be a major barrier to its implementation. Many new concrete buildings built locally install concrete roofs as a climate adaptation to hurricanes. The heat and associated discomfort on the top floor of these buildings should be a strong inducement for the installation of green roofs. Once the utility of green roofs is understood, a persuasive argument can be presented that the additional investment required would be positive within three years or less payback period. The benefits accrued from energy savings for cooling is often sufficient to justify the cost. As in the case of the windows, the lead in raising

awareness should come from the Physical Planning Department engaging with the architectural and engineering associations.

3.6.6 Energy Efficient Appliances

The main barriers to more effective application of energy efficient appliances are ignorance of the cost benefit accrued and the absence of an institutional framework to guide implementation. Consideration for addressing this issue was focussed on the Electrical Division of the Ministry of Public Works, who has the responsibility to certify all electrical installation locally. Engagement between this unit and electrical designers is recommended as an effective way to raised awareness of the benefits of energy efficient fixtures within the building process as demand is wholly client driven. To address the general appliances utilized within the homes and businesses energy efficient standards should be required from appliance importers and enforced at the ports of entry. Generally, imported appliances that are manufactured for the North American and European markets conform to these countries' stringent energy efficiency standards. The problem occurs when importation is done from countries where these standards do not exist. A system of an environmental levy as applied for motor vehicles with particular characteristics is proposed to address this issue. All appliances below a particular efficiency rating will attract an additional levy based on estimate GHG emission targets. The value of the levy and the appliances that will be affected have not been clarified, but the proposed action will undoubtedly be effective in benefiting energy efficiency.

3.6.7 Minimizing Urban Heat Island Effect

Minimizing urban heat island effect can be achieved over time if various measures which mitigate it are consistently applied. Greening buildings, avoiding impervious surfaces to the best extent possible, maintaining and increasing trees and green cover, and lessening traffic congestion are good starting points. Once all are conscious of and militate against this phenomenon, urban heat island effect will be minimized.

Table 3-13**: Energy Efficiency Barriers and Proposed Measures**

Type	Technology	Barrier	Proposed Measures
Financial and Economic	LED Lights	Reduce attractiveness due to unavailability of Cost benefit information	Importers and the Electrical Division should actively undertake to advertise costs and benefits of the technology.
	Lighting Controls	Reduce attractiveness due to unavailability of Cost benefit information	Importers and the Electrical Division should inform their clients of the costs and benefits of the technology as part of the service offering. Ministry of Finance should reduce tariffs on these units for an introductory period to encourage their installation and the collection of data. Dominica State College Technical Division should be engaged by the Ministry of Public Works to collect data. Results obtained should be published. That ministry should allocate a grant of XCD20,000 for that task.

Type	Technology	Barrier	Proposed Measures
	Air Conditioning: Ground Source Heat Pumps	Reduce attractiveness due to unavailability of Cost benefit information	The state should provide part grant financing to establish pilot sites in different communities to encourage uptake. The Ministry of the Environment should encourage financial institutions to modify financial offerings and develop special programs for interested clients to incorporate efficiency features.
	Windows	No financial or economic barrier	
	Green Roofs	Cost benefit information	Building designers and the Planning Department should inform their clients of the costs and benefits of the technology. The Ministry of the Environment should encourage financial institutions to modify financial offerings and develop special programs for interested clients to incorporate efficiency features.
	Energy Efficient Appliances	Cost benefit information	Importers to include the cost savings and other benefits in their advertising
	Urban Heat Island Effect	No financial or economic barrier	
Regulatory Policy and Action	LED Lights	Energy efficiency is not a requirement for the importation of energy guzzling lights	Ministry of Finance should extend the environmental levy to include incandescent light bulbs
	Lighting controls	Energy efficiency is not a requirement for an installation certification.	The Electrical Division should require the installation of automatic lighting control devices as a requirement for the certification of new installations.
		Attractiveness of Automatic lighting controls - viewed as an unnecessary additional upfront cost.	Ministry of Finance should reduce import taxes on these controls for an introductory period to encourage their uptake.
	Air-Conditioning: Ground Source Heat Pumps	Concessions on Ground Source Heat Pumps	The Electrical Division should include Ground Source Heat Pumps as a requirement where it is applicable in the approval process of significant new buildings.
	Windows	No regulations on energy efficiency	The Planning Department should require energy efficient windows as part of building plans approval

Type	Technology	Barrier	Proposed Measures
	Green Roofs	No regulations on energy efficiency	The Planning Department should require green roofs on concrete roofs of new buildings as part of building plans approval.
	Energy Efficient Appliances	No regulations on energy efficiency	Ministry of Finance should extend the environmental levy to include appliances
	Urban Heat Island Effect	No regulations on minimizing it effect	Require Urban Heat Island Effect to be part of town planning and local authorities' supervision mandate.
Technical	LED Lights	No technical barrier	
	Lighting controls	Technical awareness of their energy saving merits.	The energy saving merits should be included in the education of electricians. Electrical supplies stores should also inform electricians and customers of the savings potential of lighting controls. A 20W fixture controlled by a photocell for darkness only turn-on, would save the user XCD26 per year
	Air-Conditioning: Ground Source Heat Pumps	Technical competence in design, installation and maintenance	Install demonstration installations and introduce Ground Source Heat Pumps skills development at the technical schools on the island. This training can be conducted by a Ground Source Heat Pump consultant for about XCD20,000 plus the cost to install one in a building with the owner bearing the cost of materials and installation.
	Windows	No technical barrier	
	Green Roofs	Technical competence to design, install and manage technology	Introduce green roof training at technical schools and work with architects, structural engineers, and builders to incorporate that feature in their buildings. This training can be conducted by a green roofs consultant for about XCD20,000 plus the cost to install two green roofs preferably one on a new and another on an existing building with the owners bearing the cost of materials and installation.
	Energy Efficient Appliances	No technical barrier	
	Urban Heat Island Effect	No technical barrier	

Type	Technology	Barrier	Proposed Measures
Awareness and Knowledge	LED Lights	Low public awareness and understanding of the financial saving and GHG emissions reduction	Importers and the Electrical Division should inform their clients of the costs and benefits of the technology understanding that the transition from filament or compact fluorescent light bulbs can save between 25% to 70% on consumption, which translates to about XCD0.4 to XCD1.2 per 40W bulb per month resulting in a payback within 4 months.
	Lighting controls	Low public awareness and understanding of the financial saving and GHG emissions reduction	Importers and the Electrical Division should inform their clients of the costs and benefits of the technology. They, with collaboration of environmental NGOs, should also have public awareness campaigns to enlighten consumers on the financial and greenhouse gas savings that can be accrued with these devices. This awareness campaign can be financed by the aforementioned parties for around XCD20,000 Understanding that the transition from filament or compact fluorescent light bulbs can save between 25% to 70% on consumption, which translate to about XCD0.4 to XCD1.2 per 40W bulb per month resulting in a payback for the controls within 18 months.
	Air-Conditioning: Ground Source Heat Pumps	Local inexperience with their utility and benefits	Launch an awareness campaign with public demonstration site. Collaboration with environmental NGOs to hold public awareness campaigns to enlighten consumers on the financial and greenhouse gas savings that can be accrued with Ground Source Heat Pumps. This awareness campaign can be financed by the Ministry of the Environment for around XCD20,000
	Windows	Low public awareness of their benefits	Launch an awareness campaign with public demonstration sites. Visits buildings using energy efficient windows should be sufficient to relays the energy efficiency benefits. The Ministry of the Environment should budget around XCD10,000 for this effort.
	Green Roofs	Local inexperience with their utility and benefits	Launch an awareness campaign with public demonstration site. This awareness campaign can be financed by the Ministry of the Environment for

Type	Technology	Barrier	Proposed Measures
			around XCD20,000
	Energy Efficient Appliances	Low public awareness and understanding of the financial saving and GHG emissions reduction	Launch an awareness campaign by importers and the Ministry of the Environment for around XCD10,000
	Urban Heat Island Effect	Low public awareness of their benefits	Launch an awareness campaign by the Ministry of the Environment for around XCD10,000

3.6.8 Cost of Implementing Energy Efficiency Measures

The cost to implement many of the energy efficiency measures is essentially minimal. Being aware that these measures exist and implementation of regulations requiring that they are installed in new and retrofit installations is necessary. For instance, in Dominica the cost to purchase and install an energy efficient window is the same as a non-efficient alternative. The same is true for lighting, appliances, and urban heat island effect. Automatic light controls will cost a few extra dollars if they are installed at the time of installation of the lighting system, but the cost would be recovered within a few months through electricity savings. Green Roofs and Ground Source Heat Pumps will require some expenditure, but they too would result in savings within one to four years of installation.

Table 3-14: **Energy Efficiency Costs**

Energy Efficiency	**Costs** (in XCD)
LED Lights	XCD 0
Automatic Light Controls	XCD150 to XCD200 per unit
Air-Conditioning: Ground Source Heat pumps	XCD13,500 to XCD24,300 - 600W
Windows	XCD0
Green Roofs	XCD15,000 to XCD30,000, with most paying around XCD22,000 for 1200 square feet
Energy Efficient Appliances	XCD50 to XCD300 per unit
Minimizing Urban Heat Island Effect	XCD0

Table 3-15: **Energy Efficiency Net Benefit of selected Technology** Automatic Light Controls

Technology	**Control Units per Site**	**Power per control unit** (W)	**Excess time on without control unit** (h)	**Consumption per year** (kWh)	**Cost of kWh of Energy** (XCD)	**Cost of Energy per year** (XCD)	**Payback Period**
Automatic Light Controls (Domestic)	1	1-unit x 10W = 10W	8h/day x 365 days/y = 2920h	29.2kWh	1.30/kWh	38	150/38=3.9 **4 years**
Automatic Light Controls (Business)	1	5- units x 30W = 150W	40h/week x 52w/y = 2080hrs	312kWh	1.30/kWh	406	200/406 = 1/2 **6 months**

It must be noted that a domestic unit would most likely have multiple units (light control) installed, which would reduce payback time correspondingly.

Table 3-16: **Energy Efficiency Net Benefit of selected Technology** Air-Conditioning: Ground Source Heat Pumps (Geothermal heat pumps) (GHPs))

Technology	**GHP units per site**	**running Power per GHP Unit**	**Power of** conventional **units being replaced** (kW)	conventional units consumption per year (kWh)	GH Pump Consumption per year (kWh)	**Cost of Energy** (XCD)	Difference in Cost of Energy per year (XCD)	Payback Period
Air-Conditioning : Ground Source Heat Pumps	1	660W	4 x 2.6kW = 10.4kW	4 x 2.6kW x 4h/d x 365 days = 15184kWh	1 x 660W x 4h/d x 365 days = 964kWh	1.30 per kWh	19739 – 1253 = 18,486	XCD24300 / XCD18486 = **16 months**

Table 3-17: **Energy Efficiency Net Benefit of selected Technology** Green Roofs

Technology	**Units/ Site**	**Cost of Green Roof Unit**	**Power of a/c units** (kW)	**Consumption per year** (kWh)	**Cost of Energy** (XCD/kWh)	**Cost of Energy per year** (XCD)	**Payback Period**
Green Roofs	1	$30,000	4 x 1.5kW = 6kW	4 x 1.5kW x 6h/d x 365days = 13140kWh	XCD1.30/kWh	XCD17082	21 months

3.6.9 Linkages of Energy Efficiency Measures

Energy Efficiency measures are all targeting the same outcome, namely: energy avoided is energy that do not have to be produced. So on the first level, a very effective energy efficiency scheme would reduce energy generation requirements, thus the energy generation systems could be downsized accordingly.

Energy efficiency would also generate less heat. An effective green roof would reduce or even eliminate the heat load of top floors thus correspondingly the air conditioning requirement on top floors would also be reduced for the same occupancy level. The same is true for energy efficient windows which maintained good ventilation thus reducing the need for artificial cooling if the ambient temperature is not exceptionally hot.

Lower lighting loads, whether derived from energy efficient lighting or lighting controls, would reduce the energy needs and to a lesser extent air conditioning.

Urban heat island effect raises the ambient temperature of the neighbourhood and, to the extent that it is lessened, would contribute to enhanced comfort levels and reduce or eliminate the need for artificial cooling.

Chapter 4. Transportation Sector

4.1 Barrier analysis and possible enabling framework for Transportation technology

Between 2005 and 2014 there was a net increase of 4543 vehicles on the roads in Dominica. Sixty-four percent (64%) or 2950 of these were sports utility vehicles (SUVs). Correspondingly, transportation greenhouse gas emissions increased from 46.8Gg to 71Gg during that period (INDC Sept 2015 page 10) Import duties and charges amount to approximately 140% of the internal combustion engine (ICE) vehicles' Cost, Insurance and Freight (CIF) amounts. Additionally, the environmental levy ranges from 1% of the total value on vehicles less than 5 years, to EC$3,000 on vehicles older than 5 years.

Currently, electric vehicles are virtually non-existent on the island. So too are charging stations and servicing garages and facilities. The uptake of electric vehicles will be significantly correlated to their financial attractiveness relative to fossil fuel vehicles and on the awareness of their benefits over what are currently used. Cost benefit analysis must also be pursued based on the foreign exchange retained because of the elimination of imported fossil fuel from the transportation loop and other ancillary benefits.

4.1.1 General Description of electric vehicles status quo and technologies

Battery electric vehicles (BEV) are vehicles whose power comes from an electric source like a battery, and the prime mover is an electric motor. This vehicle does not use the traditional fossil fuel internal combustion engine (ICE).

Electric vehicles themselves are very low GHG emitters. Their GHG emissions come mainly from the vehicle's manufacture and from the periodic replacement of the battery, whose current projected life is in the eight to twelve years range. However, the amount of operational GHGs they emit is a function of the source from which the battery is charged. If the charging station is powered by a non-renewable energy source, then the GHG emission is relatively high compared to if the battery is charged from a renewable energy source.

The power per pound of battery, a battery's energy density, is a critical element influencing the higher cost of electric vehicles. As batteries' energy density increase, there will be a corresponding drop in the price of electric vehicles. A battery with high energy density is inherently cheaper because it requires fewer raw materials and less weight to deliver the same range. The projected tipping point for price parity between electric vehicles and internal combustion engine (ICE) vehicles ranges from 2023 to 2025. Actually, price parity is already here for the higher-end vehicles.

Because electric vehicles still constitute a small percentage of the vehicles' market, their full production economies of scale have not yet been realized, yet according to Palmer et al (2017), a comparable sized electric vehicle powered by moderately priced electricity is cheaper to own and operate over a four-year period than a comparable combustion engine vehicle

4.1.2 Identification of barriers to deployment of electric buses and private vehicles

Low carbon transportation barriers extend across the board from a lack of financial accommodation and charging stations, to low public awareness of trends and benefits of low carbon transportation options. Dominica is well suited for a rapid transition to electric vehicles since almost every household has the possibility to self-generate solar energy, while others, especially on the east coast, can also generate wind energy, with possibilities for micro hydro in some communities. A holistic transition can allow many owners of electric vehicles to largely free themselves from the petrol pump or its public charging station replacement.

Changing of the status quo, should not solely focus on replacing petrol vehicles with electric vehicles. Serious consideration and effort should also be directed to simultaneously ushering in complementary transportation options like enhanced public transportation, carpooling and park-and-ride, and traffic control towards improved efficiency.

Currently there are only a couple of electric cars on island but no electric buses to encourage greater use of public transportation. This situation is mainly attributed to limited availability of validated information to make informed decision on feasibility, coupled with the indifference of auto dealerships to promote the virtues of electric vehicles, and the seemingly attractive competitive option of cheaper pre-owned vehicles mainly from Japan. The high price of grid electricity is also a disincentive for mass uptake of electric vehicles and must be addressed as an early step to ensure cheaper charging options.

For maximum benefit, the transition to electric vehicles should be accompanied by low per unit cost of public charging stations, and the installation of renewable energy units to charge these stations. Alternatively, electric vehicles owners can install personal renewable energy charging units on their premises for private at home charging. These actions have financial implications which would have to be considered in the transition. Though technical training of this new technology will be necessary, the universal familiarity with electric motors, electronics, and computers should ease the technical transition and flatten the learning curve.

Electric vehicles are categorized as zero-emission vehicles because they produce no direct exhaust or tailpipe emissions. Some of the benefits of electric vehicles are listed in Table 4-1.

Table 4-1**: Benefits of Electric Vehicles**

Benefits	**Electric Vehicles**
Fuel Economy	Most EVs achieve fuel economy ratings higher than 100 miles per gallon of gasoline equivalent (mpge) [5] The well-to-wheel efficiency of battery electric vehicles (BEV) is around 76%, compared to 30% for Fuel Cell Vehicles (FCV), 20% for diesel power train vehicles, and 16% for a gasoline power train vehicle. (Horváth & Partners, 2019) This translates to better than 50% lower fuel cost if all vehicles use fossil fuel at the base power source, and even better if the battery charging electricity for the EVs come from a renewable source.
Emissions Reductions	BEVs produce no tailpipe emissions. Life cycle emissions depend on the sources of electricity. Currently about a third of Dominica's grid electricity comes from hydro generation and two thirds from diesel generation. Projected BEVs' emissions can be reduced further if BEVs charging units are sourced from renewable energy at public charging stations or by private charging connections.
Fuel Cost Savings	BEVs run on electricity only. Electricity costs for a typical BEV range 6¢–11¢ (XCD) per mile.[6]
Fuelling Flexibility	Can charge at home, public charging stations, and some workplaces
Lower overall Cost	Cheaper to own and operate than similar priced fossil fuel vehicle over 4 years

[5] EVs are rated not in miles per gallon (mpg) but miles per gallon of gasoline equivalent (mpge). Similar to mpg, mpge represents the number of miles the vehicle can travel using a quantity of fuel (or, alternatively, electricity) with the same energy content as a gallon of gasoline.

[6] For conventional sedans, costs range about 27¢–41¢ (XCD) per mile

Benefits	Electric Vehicles
Reduced particle pollution from brake pads and other	Less particle pollution from brake pads, clutch plates, and other parts.
Reduced Maintenance	Less moving parts translates to lower maintenance.
Reduced noise	Much reduced engine noise

Sources: AFDC (afdc.energy.gov), FuelEconomy.gov.transportenvironment.org

4.1.2.1 Economic and Financial Barriers to Electric Vehicles

The main economic and financial barriers to electric vehicles uptake assessed by the TWG are:

• **Financial and Economic**: A serious impediment to the transition to electric vehicles was the import duties at over 140% of CIF cost which heavily skewed the purchase of vehicles towards cheaper preowned fossil fuel vehicles from Japan. Import duty on electric cars, SUVs, and coaster buses has now been slashed from over 140% to 20.75% for cars and SUVs, and to 34.4% for buses (coasters) with 21 or more seats. Import duty on electric mini-buses remains at 140% of CIF like its fossil fuel counterpart. Mini-buses are the main means of public transportation in Dominica. They carry over 95% of public passengers and are over 90% of the passenger buses in Dominica, Coasters mainly carry cruise ship tourists. The Ministry of Finance is being approached to consider correcting this omission as it would have significant negative impact on the transportation of islanders and on the greening of public transportation.

The current breakdown of mini-buses 'import duty which adds up to about 140% of Cost Insurance and Freight (CIF) is: Duty 40%, Excise Tax 28%, Customs Service Charge 4%, Environmental Levy 1% on vehicles less than 5 years old, and XCD$3000 on vehicles over 5 years, and 15% VAT. While the import duty of electric cars, SUVs, and coaster buses carry 0% Duty and VAT, Excise Tax 15% on cars and SUVs and 28% on coaster buses. Customs Service Charge and Environmental Levy remain at 4% and 1% respectively like for fossil fuel vehicles.

The leadership role of financial institutions in influencing the purchase of electric vehicles has been unattended thus far. Since electric vehicles are cheaper to operate over four years relative to fossil fuelled vehicles, and the transition to renewable energy powered electric vehicles would retain the fossil fuel foreign exchange to help fuel the local economy, financial institutions could be persuaded to undertake creative and special financing instruments to encourage the purchase of electric vehicle knowing that their loan repayments would be more assured. These institutions can be lobbied by the local authorities by developing policies to encourage the introduction of the technology, such as the introduction of pilots.

Financing will be needed for the establishment of charging facilities whether they are public charging stations or at home charging. Since the increased use of public transportation will be encouraged, financing will also be needed for the installation of rapid charging top-up facilities at the bus stations. Cost of finance for such new technologies is general high due to the inexperience with the technology locally and the higher risk so associated. However, the experience in other jurisdictions shows that financing cost should be reduced as servicing of loans granted for these technologies should not be problematic or delinquent as this is a direct replacement for fossil fuel and essentially the buses' chargers would be serving a captive clientele. Since the preference would be to charge from a

renewable source, be it photovoltaic solar, wind, or hydro, charging facilities will need finance to be established. The returns on this finance would increase as the uptake of electric vehicles accelerates.

The transition to electric vehicles will nullify the used parts market for derelict fossil fuel vehicles as the market for used or junk parts of these vehicles will decrease. The value of these derelict fossil fuel vehicles will be solely in their value on the scrap market. Therefore, there will be a need for finance to source equipment to compact these derelict vehicles to be shipped out to recycling iron mills in Trinidad or elsewhere. The projected estimated scrap value of vehicles will range from XCD3000 for a car to XCD7000 for a coaster bus. (Dominica Solid Waste Corporation 2021)

4.1.2.1.1 Cost of transitioning to Electric Vehicles

The cost of implementing barrier reduction must be juxtaposed against the economic, environmental and societal benefits of implementation. Though the upfront financial cost may be relatively high, studies in Europe and elsewhere have shown that over four years, an electric vehicle is cheaper to own and operate than a conventional fossil fuel vehicle. This is largely so because plug-in electric vehicles have the following cost advantages over petrol and diesel vehicles:

- The battery, motor, and associated electronics require little to no regular maintenance
- There are fewer fluids, such as engine oil, that require regular top-up;
- Brake wear is significantly reduced due to regenerative braking;
- There are far fewer moving parts relative to a fossil fuel engine;
- Fossil fuel is an imported commodity while most owners can self-generate renewable electricity or buy it at a much lower price than gasoline or diesel.

Operating costs for a typical electric vehicle range 6¢–11¢ (XCD) per mile, while a typical conventional petrol or diesel vehicle costs range about 27¢–41¢ (XCD) per mile. While owners can save significantly especially if they charge their vehicles from their own renewable energy generators, the change over from conventional vehicles to electric vehicles would require public charging stations. Current costs for these units are as follows:

Table 4-2**: Charging Equipment Costs**

Charging Equipment	**Costs** (in XCD)
Level 1 equipment [7]	$800 to $4,050
Level 2 equipment [8]	$1100 to $17,500
Direct-current (DC) fast charging equipment	$27,000 to $108,000

Policy action to encourage the importation of EV is currently being considered by the Government to address the unattractiveness of purchase of electric vehicles. The reduction of import duty and taxes from 140+% on SUVs, and cars to 20.75% and electric 20+ seater buses have also been reduced to 34.4 %. This has certainly make the purchasing of these electric vehicles much more attractive to the

[7] Level 1 charging is alternating current (AC) equipment which provides charging through a 120-volt (V) AC plug. Most, if not all, PEVs will come with a Level 1 cord set, so no additional charging equipment is required. 8 hours of charging at 120 V can replenish about 40 miles of electric range for a mid-size PEV

[8] Level 2 charging is alternating current (AC) equipment provides charging through 230 V or 208 V electrical services. Level 2 equipment can charge a typical PEV battery overnight.

average citizen. This inducement however omitted mini-buses (with less than 21 seats) which are the main means of public transportation for islanders. This omission is being drawn to the government's attention as mini-buses are a critical element in the island's public transportation sector.

4.1.2.2 Non-Financial Barriers to Electric Vehicles

Regulatory Policy and Action: The supporting infrastructure for introducing EV into Dominica in a meaningful way is absent. Guidelines and safety standards for charging ports, battery recycling and disposal facilities and also vehicle maintenance has not been decided. The determination of what is a road worthy EV, thus allowing approval of licensing by the Traffic Department of the Police also needs to be addressed. These limitations will require corrective action from the Ministry of Public Works and Digital Economy and the Ministry of National Security and Home Affairs.

Technical Limitations: Corresponding to the introduction of electric vehicles should be the installation of renewable energy charging stations so that the mitigation of greenhouse gas (GHG) emissions is not negated by the use of fossil fuel generated electricity from the central grid to power charging stations. The technical capacity limitation of the electrical and mechanical engineering programs taught at the college affects the quality of resource technicians available. This limitation also affects the quality of awareness campaign that can be generated if these are solely dependent on local resource.

The current battery life of electric vehicles is projected to be around 8 to 12 years. This would require an augmented environmentally friendly battery disposal scheme for expired and damaged batteries. This facility is not currently in existence locally.

There also need for machinery and scheme to dispose of derelict fossil fuel vehicles as their utility as spare parts would decline drastically.

Awareness and Knowledge: Electric vehicles are cheaper to own and operate over four years than a fossil fuel vehicle. This information is however not widely known or accepted locally. Two members of the TWG queried this information and believed this to be inaccurate if this comparison is being made with more fuel-efficient internal combustion vehicles. Research conducted by Sivak and Schoettle (2018), showed that on average, electric vehicles cost less than half to drive than their fossil fuel counterparts in the US. Further, the study concluded that the required fuel economy that gasoline vehicles would need to exceed for driving them to be less expensive than driving the basic electric vehicles is 57.6 mpg in the United States, with a maximum of 90.0 mpg in Washington and a minimum of 34.1 mpg in Hawaii.

The ensuing discussions with the TWG also presented the additional cost associated with the operation of fossil fuel vehicles that would not apply to EVs. Some of these included; fewer moving parts so less breakdown, no exhaust system, less need for cooling, less abrasive braking options, and no need to change oil, fan belts, air filters, timing belts, head gaskets, cylinder heads and spark plugs, injectors.

Recently, a local environmental NGO (WAVE and Portsmouth Community Watch Foundation) has been very active in engaging the public transportation sector in understanding the advantages and operation of electric vehicles. This effort is on-going and it seems to have enlighten many bus owners and drivers on the electric vehicles benefits and many have expressed an inclination to transit to electric vehicles if charging stations and other conditions are in place on their next bus purchase. No evidence of any documented local public awareness initiative encouraging the transition to electric vehicles and other similar mitigation technologies were found.

4.1.2.3 Proposed Financial and Economic Measures for Overcoming Electric Vehicles Barriers

One of the main financial barriers, namely electric vehicles are perceived to be too expensive, has been alleviated with a significant reduction in the 140+% import duty on vehicles. This rate has been cut by over 100% on cars, SUVs, and buses with more than 20 seats. The import duty still remains on mini-buses but representation is being made for a similar reduction in import duty. Strategic financing from the financial institutions still remains a limitation. Beyond these upfront obstacles, the vehicles become cheaper to maintain and operate than their conventional counterpart. A summary of measures to overcome the identified barriers are outlined in Table 4-3.

Table 4-3**: Proposed Financial and Economic Measures for Overcoming Electric Vehicles Barriers**

Type	Barrier	Proposed Measures
Financial and Economic	Import Tariffs on mini-buses at over 140% of Cost Insurance Freight charges	Provide importation tariff incentives based on a vehicle's carbon emissions. Include mini-buses in the import tax reduction program currently applied to electric cars, SUVs, and 20+seats coaster buses. Replacing the current duty with a Vehicle Emission Duty based on its greenhouse gas emissions would induce uptake.
	Purchasing cost relative to petrol vehicles	Strategic financing option that reduces initial payback and possible increase payback time. Payback can then be increased when cost benefit threshold is surpassed. Tie the annual vehicle licensing fee to its greenhouse gas emissions.
		Financing institutions, banks and credit unions, should provide lower interest rates and other inducements to make financing electric vehicles more attractive than financing fossil fuel vehicles.
	Cost of grid electricity	Incentivise and encourage renewable energy charging stations
	Public charging facilities	Government, financial institutions, and grant makers should provide funding and incentives for the erection of renewable energy charging stations.
		In this nascent transition to electric vehicles, Government policy should assist the uptake of electric vehicles by reducing the import charges on all electric vehicles, understanding that the foreign exchange savings on imported fossil fuel would boost the economy. The government could recover much of that lost revenue - caused by the reduction in electric vehicles import taxes - through taxes on other goods and also from the savings in retained foreign exchange caused by the elimination of fossil fuel

4.1.2.4 Proposed Non-Financial Measures to Overcome Electric Vehicles Barriers

Various official documents have advanced a pathway to significantly reduce vehicles carbon emissions. Table 4-4 lists the proposed measures for vehicles' carbon emissions.

Table 4-4**: Proposed non-financial measures to overcome electric vehicles barriers**

Type	Barrier	Proposed Measures
Regulatory Policy and Action	Regulations or action on outlined policy on low carbon vehicles Current regulatory framework does not mandate or incentivize to reduce emissions. Similar guidelines were developed and followed when transitioning to unleaded gasoline Selective tariff policy on electric vehicles	Implement policies and actions outlined in the Third National Communication and the Intended Nationally Determined Contributions. Action plan can be revisited to adopt a more realistic time frame. Draft and adopt vehicle regulations dealing with reduced carbon emission Provide significant importation tariff relief based on a vehicle's carbon emissions by replacing the import duties and taxes on electric vehicles with a Vehicle Emission Duty based on the vehicle's greenhouse gas emissions. Tie a vehicle's annual license fee to its greenhouse gas emissions and its intended use. Currently annual licensing fees are based on vehicle size and not on greenhouse gas emissions or intended use. Further reduction in importation duties on specific type of EVs (public transport) to incentivize uptake.
Technical	Charging EV vehicles currently will require charging stations be installed at strategic locations. These stations would largely depend on fossil fuels generated power. Adverse environmental impact caused by the accumulation of used batteries	Pilot project to introduce charging stations that are powered by renewable energy. Facilitate the training and know-how for the installation of public and private charging systems by engaging partner organisations or private sector partners. Augmented and improved the existing expired battery disposal scheme managed by Solid Waste Management Corporation. Augment the existing derelict vehicles disposal scheme.to accommodate the expected increase in fossil fuel units.
Awareness and Knowledge	The attractiveness of EVs to the general public is questionable due to the absence of quality information to guide decision making	Encourage the formation of greenhouse gas mitigation champions and other community-based advocates for transitioning to a low carbon economy (including EVs). The primary source of information and training for these groups should be education institutions and the Ministry of Environment engaging other international partners.

4.2 Barrier analysis and possible enabling framework for Enhanced Public Transportation

The GHG emission from transportation in 2014 was 71Gg CO_2e (Dominica Third National Communication to UNFCCC). These figures can be significantly reduced with increased public transportation.

The barriers to a greater uptake in public transportation are limited or non-existent off hours scheduling, limited remote routes service, and the absence of secure park-and-ride facilities. With some understanding, supported by institutional inducements and financial support, much improvement can be made in public transportation scheduling and reliability. For instance, financial support and other inducements can be used in an introductory period to encourage buses to ply certain routes or have later departures to serve clientele who would prefer a later departure. The buses should also be induced to ply less popular routes. This initial adjustment could grow into more people deferring to this service and ultimately easing the pressure to acquire a personal vehicle or to avoid using a personal vehicle for trips adequately serviced by public transportation. If buses would reliably ply more remote routes at convenient and off-hours periods, people would be more inclined to defer to public transportation particularly during routine trips. Further, it was the consensus of the TWG that many people will use park-and-ride if buses' schedules were more convenient and secure parking lots were available, especially when travelling to the commercial centres where parking is limited.

Linked to the uptake of public transportation is carpooling. Carpooling can be enhanced with more social interaction and institutional inducements to encourage its use. Privilege and/or concessionary parking is one such inducement that can encourage its expanded use. However, the TWG believed that support for carpooling should be secondary to enhanced public transportation inducements.

4.2.1 Economic and Financial Barriers to Enhanced Public Transportation

Currently minibuses ply the whole country at peak hours to get people to and from work and other major activities. However, out of peak hour, there is a sharp decline in the service. These vehicle owners, who are strictly private sector, are reluctant to expand the services outside of these hours given the limited persons seeking this service off-peak. It is unclear however, whether the reduced clientele off peak is due to the knowledge that the service is unavailable during this time or whether commuters genuinely did not require the service. The team was partial to the former situation especially in the out districts where commuters often come into the city during the peak hours to conduct business that often occur much later during the day. The introduction of bus service off peak within the Kalinago territory was thought to have evened out the peak hour crowd and is reportedly functioning very satisfactorily.

4.2.1.1 Cost of Implementation of Enhanced Public Transportation

The cost of implementing enhanced public transportation will mainly be expended on subsidies to buses to ply off hours and routes and to provide secure park-and-ride lots. Plying off hours and routes can be funded by government concessions with import duty relief on electric minibuses, and providing a grant to the operators to purchase renewable energy charging apparatus. In addition to encouraging the use of electric minibuses which are about 75% cheaper to operate, the government, whether national or local, could provide an introductory period subsidy to encourage uptake.

Park-and-Ride lots can either be provided by the national or interested local government, or private individuals could be encouraged and/or incentivized to provide park-and-ride lots to commuters for a fee. The bus operators or the commuters themselves could also partake in the service.

Table 4-5: **Enhanced Public Transportation Costs**

Enhanced Public Transportation	**Costs** (XCD)	**Comment**
Give subsidy to buses for plying off hours and routes	10,400	Initial subsidy is to help establish the route. The subsidy should be phased out as passengers increase, ultimately discontinued once break-even point is exceeded.
Install new and/or upgraded Park and-Ride lots	20,000 to 30,000	Depending on the site topography and pre-existing conditions

4.2.2 Non-Financial barriers to enhanced public transportation

There are insufficient covered bus stops and park-and-ride lots. Frequent rain discourages commuters from waiting for buses in off hours. For consumers who use private vehicles, safe park-and-ride lots would be helpful in encouraging them to use public transportation for routine trips.

4.2.3 Proposed measures for enhanced public transportation economic and financial barriers

Central and local governments issue grants to interested parties to build covered bus stops and park and-ride lots.

Table 4-6**: Enhanced public transportation economic and financial barriers and proposed measures**

Type	**Barrier**	**Proposed Measures**
Financial and Economic	Cost of operating off hours routes may be uneconomical initially	Provide financial inducements for buses to extend their hours or to add less populated areas to their bus routes. The inducements can be reduced or phased out as there is an increased utilization of the service towards viability.
	Cost implication for implementing and managing park-and-ride lots may make them unattractive to private investment especially in areas with limited government owned land space	Central and local governments should arrange to install park-and ride lots in all areas where there are sufficient commuters to make the installation economically feasible. This may need to include compulsory acquisition for public good as most of the acceptable areas are privately owned.

4.2.4 Proposed Non-Financial Measures for Enhanced Public Transportation

Official sheltered bus stops should be erected in the various locations where they are lacking. So too, park-and-ride lots should be laid in various communities. Correspondingly, a public awareness drive to enlighten commuters of the benefits of public transportation and encourage them to use the service should accompany this development.

Table 4-7**: Proposed non-financial measures for enhanced public transportation**

Type	**Barrier**	**Proposed Measures**
Regulatory Policy and Action	Official assignment of park-and-ride lots that are appropriately secured	Provide guidelines for the installation and operation of park-and-ride lots and designate the locations. Park and ride lots could be funded by the local village council who can charge a nominal fee to recover the cost of creating the lot. Parking lots would require use of a lot close to the village and preparing the lot with a tarrish surface. Cost for preparing a lot would be around XCD5000.
Technical	Scattered sparse population in some rural areas with a low critical mass and absence of bus stops.	Install bus stops or scheme to alert bus operators of a passenger pick-up in remote areas such as transport app
Awareness and Knowledge	Public awareness of the service	Publicize the service to potential commuters. This effort could be undertaken by the bus operators and the village council using flyers, posters, church announcements and word of mouth. The cost per village would be XCD200 or less.

US$1.00 is equivalent to XCD2.7169

Linkages of Transportation Barriers

The linkages between the transportation technologies, namely electric vehicles and enhanced public transportation, are all targeted at low carbon emissions and more efficient and convenient transportation.

The linkages of electric vehicles are also tied to renewable energy generation as the carbon emissions benefits would be significantly reduced if the energy to power electric vehicles are from fossil fuel sources. Renewable energy charging stations themselves would be good advertisement to renewable energy deployment in buildings, industry, and elsewhere.

There will also be some overlap in training as some of the principles of these technologies are derived from the same energy equations before they diverge to be more specific to their particular area. So core courses would serve all the technologies.

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