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Sustainable Land Management in the Commonwealth of Dominica: Strengthening Resilience of Agricultural Lands and Forests in Dominica.

WP #2 Identify and package a suite of effective SLM approaches and technologies in Agriculture suitable to the Dominican context in collaboration with relevant national institutions

January 2021

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List of acronyms and abbreviations

CS-FSS	Climate Smart Farmer Field School
CVI	Commonwealth Vulnerability Index
DEOSC	Dominica Essential Oils and Spices Cooperative
DEXIA	Dominica Export Import Agency
DoA	Division of Agriculture
DOWASCO	Dominica Water and Sewerage Company
DRM	Disaster Risk Management
DTU	Technical University of Denmark
EALCRP	Emergency Agricultural and Livelihood Climate Resilience Project
ECU	Environmental Coordinating Unit
FAO	Food and Agriculture Organization of the United Nations
FTCC	Food and Fertilizer Technology Centre of the Asian and Pacific Region
FWPD	Forestry Wildlife and Parks Division
GDP	Gross Domestic Product
GEF	Global Environment Facility
GOCD	Government of the Commonwealth of Dominica
HVNI	High Value Nature Index
IICA	Inter-American Institute for Cooperation on Agriculture
MoA	Ministry of Agriculture
MoERMKU	Ministry of the Environment Rural Modernization and Kalinago Upliftment
MCA	Multi Criteria Analysis
MTPNP	Morne Trois Pitons National Park
PISLM	Partnership Initiative for Sustainable Land Management
PSIP	Private Sector Investment Programme
SALT	Sloping Agricultural Land Technology
SLM	Sustainable Land Management
SOM	Soil Organic Matter
TSE	Tropical Storm Erika
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme

1 Introduction

Dominica is the largest of the Windward Islands and is one of the youngest islands in the Lesser Antilles. Its volcanic origins have created an island characterized by very rugged and steep terrain. The volcanic cone of Morne Diablotin (1,447 m), along with Morne aux Diables on the northern peninsula, dominates the topography of the northern half of the island, while a chain of mountains (including Morne Trois Pitons, Morne Micotrin, Morne Watt, Morne Anglais, and Morne Plat Pays) extends through the south of the island. The island's coastline is rocky with few beaches. Dominica's geographic location, topography and geology predispose the island to several natural hazards. Based on the Commonwealth Vulnerability Index (CVI), Dominica was ranked the 6th most vulnerable out of 111 countries assessed (Atkins, Mazzi, & Easter, 2000).

According to a climate change risk profile prepared for Dominica by CARIBSAVE (2012), the projected changes of most concern are rising ambient temperatures, changing rainfall patterns, more extreme events (i.e. floods and droughts) and increased likelihood of stronger hurricanes and storms.

The country has nine active volcanoes and experiences frequent seismic and geothermal activities, which, coupled with Dominica's terrain, facilitate topsoil movement and pose a threat to physical infrastructure. The major soil classification groups can be easily eroded due to their friable nature; thereby, increasing soil erosivity, especially on slopes left exposed (without adequate vegetative cover).

Dominica's climate is classified as humid tropical marine, characterized by little seasonal or diurnal variation and strong, steady trade winds. The island is among the wettest in the Caribbean, a factor which gives rise to its lush vegetation. Rainfall is higher in the interior which receives in excess of 8,000 mm annually, and drops off substantially to 2650 mm and 1760 mm on the northeast coast (Melville Hall) and the west coast (Canefield), respectively (Table 1). Fifty nine percent (59%) of the island area is covered by natural vegetation. There are five (5) major terrestrial ecosystems: mature tropical rainforest, montane thicket and cloud forest (elfin woodland), and littoral woodland along the windward coast, to which coastal swamp and dry scrub woodland is added in some documentation.

Dominica has a very long history of seasonal climatic threats that affect both terrestrial and coastal ecosystems (Barclay et al., 2019; Steiner, 2015). The most recent climatic events, Tropical Storm Erika and Hurricane Maria in 2015 and 2017, respectively, accounted for huge losses in all productive sectors of the Dominican economy. The combined damages and losses from Hurricane Maria were estimated at US$1.37 billion. This included US$55.27 million attributed to the agricultural sector. The major impacts included crop and livestock losses, damage to farm access roads, increased pest and disease-related problems, reduced land and labour productivity, threatened/lost livelihoods and food insecurity. These storms result in such impacts on the natural environment as land cover losses, soil erosion and land slippage, often not captured in post disaster assessments. However, these losses can be very significant with dire long-term impacts.

Table 1: Observed weather and climatic trends 1981 to 2010 (Douglas-Charles and Canefield Airports)

Normal Weather	Douglas-Charles- Melville Hall	Canefield
Climate Parameters	**Value**	**Value**
Normal annual rainfall	2652.7 mm or 104.45 in	1759.8 mm or 69.28 in
Average Daily Temp. (1990 – 2010)	26.6^{o}C or 81^{o}F	27.1^{o}C or 81^{o}F
Normal Relative Humidity	76% (30yrs.)	68% (30yrs.)
Average Maximum Temp. (1990 – 2010)	29.7^{o}C or 86^{o}F (21yrs.)	30.9^{o}C or 88^{o}F (21yrs.)
Average Minimum Temp. (1990 – 2010)	23.5^{o}C or 75^{o}F (21yrs.)	23.2^{o}C or 73^{o}F (21yrs.)
Wettest Month	November	September
Driest Month	February	March
Extreme Weather		
Maximum Temperature	34.3^{o}C or 93^{o}F (Aug 31st, 1996)	34.4^{o}C or 96^{o}F (Aug 7th 2005)
Minimum Temperature	16.9^{o}C or 63^{o}F (Dec 22nd, 1991)	18.0^{o}C or 64^{o}F (24/12/1991, 01/02/2009)
Highest Annual Rainfall	3731.8 mm or 152.3 in. (2004)	2458.5 mm or 96.79 in. (2011)
Highest Monthly Rainfall	912.0 mm or 37.2 in. (Nov 2004)	539.4 mm or 21.2 in. (Aug 2007)
Lowest Annual Rainfall	1950.3 mm or 79.6 in. (1994)	1266.1 mm or 49.8 in. (2000)
Lowest Monthly Rainfall	4.2 mm or 0.2 in. (Feb 2010)	0.4 mm or 0.02 in. (Feb 2010)

Source: Dominica Meteorology Service

1.1 Terms of reference

As part of the project "Strengthening Resilience of Agricultural Lands and Forests in The Commonwealth of Dominica", the consultant is expected to identify and package a suite of effective SLM approaches and technologies to include:

1. The review of existing SLM approaches and investigation of appropriate technologies
2. Engage stakeholders to identify and assess existing and/or available SLM approaches and technologies
3. Propose a package of SLM approaches and technologies for the context of agriculture in Dominica

1.2 Methodology

A multi-method research approach was used, which involved gathering secondary as well as primary data. There was a desk review of documentation on SLM-related projects implemented in Dominica, consultation with relevant staff of the Division of Agriculture (DoA) and the Forestry Wildlife and Parks Division (FWPD), CARDI, IICA, through individual interviews and focus group meetings. Several online SLM resources, like the World Overview of Conservation Approaches and Technologies (WOCAT, 2011), Food and Agriculture Organization (FAO) Soils Portal, scientific report and articles that discuss the implementation of Sloping Land Agricultural Technology (SALT) in the Philippines and in other parts of the world (Dalton, Smith, & Truong, 1996; Donjadee & Chinnarasri, 2012; Watson, 2000), the Food and Fertilizer Technology Center of the Asian and Pacific Region (FFTC) provided useful case studies on the implementation of approaches and technologies in conditions that mirror the Dominican context in many respects (FFTC, 2012).

As part of its climate change adaptation planning process, the Ministry of the Environment Rural Modernization and Kalinago Upliftment (MoERMKU 2020) recently prepared a technical needs assessment report with the support of a partnership between United Nations Environment Programme (UNEP) and Technical University of Denmark (DTU). Adaptive technology needs were selected from recommendations from a wide cross-section of stakeholders and then shortlisted by a technical working group (TWG) comprising of key stakeholders. Shortlisted technologies were further prioritized utilizing a modified multi-criteria analysis (MCA) approach to determine which technologies would move on to further analysis of potential implementation and enabling environment barriers. Soil loss / erosion and other land degradation issues related to agriculture in Dominica featured high on the list. The selected technologies and associated recommendations were validated during a focus group meeting with senior staff of the Division of Agriculture and factored into the recommended SLM technologies and approaches contained in this report. Furthermore, over 40 years of collective local experience gathered by the consultants in the design and implementation of SLM-related projects in Dominica and other Caribbean islands also form the basis for some of our recommendations.

Based on the comprehensive review undertaken, it is foreseen that the key characteristics of the island namely its landscape, topography, nature and properties of soils, history and culture of the people, land use and prevailing land degradation issues specifically within the geographic limits of the project (five parishes of St. David, St. Patrick, St. Paul, St. Joseph, and St. George): will significantly influence the technologies and approaches that are likely to be successful. Some of these are considered before a brief review of two SLM case studies and a package of recommended SLM approaches and technologies are proposed.

1.3 Agriculture in Dominica

Agriculture in Dominica is dominated by small farm cropping systems that are rainfed, and located predominantly on varying slopes. The average farm size is approximately two (2) acres. For over five previous decades and until 2014, the island had remained highly dependent on banana exports to the United Kingdom. Tree crops including coconuts, citrus, cocoa, avocado and other fruit trees were traditionally integrated on farms and contributed significantly, at different times, to export volumes and overall economic performance, measured as percentage of the Gross Domestic Product (GDP). Among several issues impacting the sector within the last two decades, pests and diseases have contributed to the demise of the citrus, banana and plantain subsectors. Frequent adverse climatic events have also contributed to retarding growth of the sector. Hurricane Maria virtually wiped-out Dominica's tree crops subsector. Efforts at revitalization of the agricultural sector is ongoing utilizing the Emergency Agricultural Livelihoods and Climate Resilience Project (EALCRP) as a launching pad. This project, funded by the World Bank, has supported the restoration of the sector post-hurricane Maria.
Contributions of traditional agro-processing operations like that of the Dominica Essential Oil and Spices Cooperative (DEOSC) have continued to show good growth prospects since being severely impacted by Tropical Storm Erika in 2015 and subsequently Hurricane Maria in 2017.

The realities of the Covid-19 pandemic and related lockdown have brought general wellness and nutrition into sharp focus. Efforts by the Division of Agriculture to encourage backyard gardening during that time have had positive impacts, attracting a number of new farmers to the sector. Overall, the sector continues to indicate much promise that it can significantly contribute to providing employment and supporting livelihoods especially within rural communities.

An important development within the sector over the past decade, is the involvement of Haitian migrant community, as productive farmers and major contributors to the agricultural labour force. They have also been able to link their production to market outlets. Increasingly, Haitian sellers, supplied primarily by Haitian farmers, occupy a growing share of the local public markets. Hucksters and exporters are also finding them more reliable and consistent in the production of various crops, particularly root crops.

Changes in the agriculture sector have brought about significant and notable changes in land use. The traditional largescale production of bananas and tree crops meant that on most of the cultivated lands minimum tillage was predominant. Replanting of fields would generally occur on an average of 2 to 4 years. Organic matter was also constantly supplied by the rapid cycling of leaves and a weekly supply of bunch stalks and pseudostems from harvesting. Contrast this with the current trend, where root crops like ginger, yam, sweet potato and to a lesser extent dasheen, which have become dominant crops, require much more intensive tillage operations. Emerging crops like pineapple and Irish potato also require considerable tillage. These are relatively short-term, with the tillage cycle repeated within 12 months. This is occurring on varying slopes and within the context of the CARIBSAVE climate change risk profile for Dominica: increase extreme climatic events that appears to be spot on. Questions about the sustainability of these types of land uses are relevant and should be appropriately addressed within the framework for agricultural development within the Commonwealth of Dominica.

2 Sustainable Land Management in Dominica

The United Nations defines sustainable land management (SLM) as the use of land resources including soils, water, animals and plants for the production of goods to meet changing human needs while simultaneously ensuring the long-term productive potential of these resources and maintenance of their environmental function. By this definition, the legacy of SLM in Dominica likely predates the arrival of Europeans to this part of the world. The Kalinago custom of shifting cultivation, using small plots that were allowed sufficient time for restoration before being reused, may have contributed to the quality and functionality of lands available to current inhabitants.

The rugged topography of the island limited the extent of exploitation of the land as occurred in several other islands with less challenging terrain. This may be one of the primary reasons that Dominica can lay claim to the title “Nature Island of the Caribbean”. Evidence suggests that many of the estates established during the colonial period installed various measures for soil and water management. Remnant sections of the contour stone terraces still exist on lands in the south, particularly Soufriere and Gallion. An informant confirmed that the traditional knowledge for constructing stone terraces still exists in the Gallion area. A large network of drains that existed on several large estates, like the Castle Bruce estate, remained until land subdivisions in the 70s. Unfortunately, the planning for these subdivisions did not include provisions for maintenance or improvement of existing soil and water management systems for supporting agricultural production in that area.

2.1 SLM approaches (past and present) used locally

There have been several attempts by the Division of Agriculture, through specific crop initiatives, like the Citrus & Coffee development program and the coconut rehabilitation project to support the design and installation of on-farm drainage. In fact, the Division of Agriculture maintained a mechanization unit equipped with backhoes up to 1998, with part of its mandate being the provision of mechanized land drainage services to farmers. The Dominica Banana Marketing Corporation introduced a similar program to support installation of drains on banana farms. Several farmer training initiatives included aspects of land suitability and criteria for site selection for agricultural development. Management options for reducing soil erosion were included as part of these trainings but generally the rate of adoption of these measures remained poor on the majority of farms. The banana industry, for example, placed more emphasis on addressing fruit quality issues and other market-related concerns rather than on productivity or soil conservation. The advent of farm certification and the Fairtrade production system saw some attention being placed on environmental management and stewardship responsibility on the part of farmers and the banana company. This included aspects of sustainable land management, like the development of annual environmental management plans, but without much visible change in on-farm practices.

More recently, Dominica has benefitted from technical and other assistance from various sources to support climate change adaptation and disaster risk mitigation. Several regional and international agencies have supported the government and other community-based groups and organizations to develop and implement sustainable land management initiatives. Following the passage of Hurricane Dean in 2007, the Government of the Commonwealth of Dominica (GOCD) requested support from the Food and Agriculture Organization (FAO) Technical Cooperation Project to enhance the resilience of Dominica's agriculture sector (including fisheries and forestry) to natural disasters. The project was implemented from June 2010 to December 2014 by the Ministry of Agriculture and Forestry and the Ministry of Environment, Natural Resources, Physical Planning and Fisheries, with the technical assistance of FAO. Among the outputs achieved were enhanced capacities of extension agents and farmers to promote best practices for disaster risk management (DRM) in crop production (soil and water management). A training manual on DRM addressing soil conservation and soil fertility improvement in banana and non-banana crop production systems was prepared.

Following tropical storm Erika, the Inter-American Institute for Cooperation on Agriculture (IICA) in collaboration with FAO (financing) supported the GOCD through a rapid response assistance facility to design and implement four on-farm demonstrations to address various SLM issues including, slope stabilization, soil conservation and drainage. Plots were installed at Cochrane, Warner, Kalinago Territory and Penville.

Under the Public Sector Investment Programme (PSIP) of the GOCD for the fiscal period 2020/2021, allocations were made to support completion of an improved hillside farming demonstration plot at Sylvania in the Central Region. Work started in the previous financial year and included the installation of vetiver strips and planting of tree crops. Plans are in place to include a gabion basket wall, drainage and check dams. Other planned activities include use of jute bags for slope stabilization and an agroforestry component. Sites in the West and East Regions are targeted for similar interventions during the current financial year. Overall, the activities are expected to demonstrate appropriate sustainable hillside farming techniques and soil conservation practices and improve uptake and adoption by farmers.

Supported with funding from the United Nations Development Program Global Environment Facility (UNDP-GEF), a project titled *Supporting Sustainable Ecosystems by Strengthening the Effectiveness of Dominica's Forest Area System*, was implemented in Dominica. It was designed to support the GOCD's efforts to better manage protected areas. The project focused primarily on the Morne Trois Pitons National Park (MTPNP) and was designed to address terrestrial biodiversity but included elements of sustainable land management such as, land degradation and climate change adaption since these themes both have significant impact on biodiversity. Trainings were conducted for farmers with lands in and around the buffer zone of the MTPNP, on environmentally friendly options for pest and disease management and composting techniques to meet crop nutrition requirements. The trainings were for a relatively short duration and held mostly on the southeast of the island. It is likely that implementation of this project was challenged by the passage of both Tropical Storm Erika (2015) and Hurricane Maria (2017). It was scheduled to start in July 2015 and end in July 2019.

A Sustainable Land Management Project was funded by the Global Environment Facility (GEF) and implemented by the United Nations Development Program (UNDP). The project was signed on 4th April 2006 with an expected closing date of December 30th 2009. The project's overall objective was to develop capacities for sustainable land management in appropriate government, civil society institutions and user groups, and mainstream sustainable land management considerations into government planning and strategy development. A mid-term review report indicated that several objectives were met, including capacity building at the Planning Division and the Ministry of Agriculture (MoA), noting that the MoA's extension staff gained better access to GIS maps that supported their work sufficiently to improve their output (Clarke, 2010). However, the implementation of activities related to mainstreaming SLM within the planning and strategic development functions of targeted government ministries were not realized as expected. The slow progress on the preparation and dissemination of appropriately targeted SLM knowledge packages was also highlighted. Included in the recommendations were suggestions for improving information sharing, collecting feedback from users and securing the commitment of the GOCD to support the project as initially agreed. The final outcomes of this project are not clear. The project was managed by the Environmental Coordinating Unit (ECU), whose current status or functionality is not certain and they could not be reached for an update.

3 Relevant SLM case studies

A review of both local and external reports on the implementation of relevant SLM approaches and technologies highlighted several success stories. Two relevant case studies are now considered.

3.1 Sloping Agricultural Land Technology (SALT) – Used by FAO in a post-Typhoon agriculture and livelihood restoration project in the Philippines.

Typhoon Haiyan devasted parts of the Philippines in 2013. Up till that time it was one of the most destructive typhoons to affect Philippines. The restoration project targeted severely affected locations dominated by upland coconut production (Borelli & Fernandez, 2017).

3.1.1 Description of the approach and technologies

As the name indicates, SALT offers SLM approaches and techniques appropriate for working lands with varies topographic relief. It is an ecologically-sound and proven technological package of soil conservation and food production measures which provides a setting for integrating short-term, annual and permanent crops. The crops are grown in alleys between contoured rows of nitrogen-fixing trees and shrubs like *Gliricidia sepium* (**Error! Reference source not found.**). A 10-step process for implementing SALT was outlined by the developer of the system (Watson, 2000).

Table 2: Summary of the 10-step process for implementing SALT

1	Make A-Frame	4	Plant N-fixing trees	7	Plant short-term crops	10	Build green terraces
2	Determine contour lines	5	Cultivate alternate strips	8	Trim N-fixing trees		
3	Cultivate contour lines	6	Plant permanent crops	9	Practice crop rotation		

3.1.1.1 The process:

The suitability of SALT was determined through consultations with government partners and community-based organizations and with the technical input of FAO.

The Climate-Smart Farmer Field School (CS-FFS) approach was used to initially train trainers from relevant government departments and selected farmers who were then responsible for training farmers. A demonstration site was established in each targeted municipality and used as the venue for conducting training sessions using the climate-smart farmer field school approach. Training initially focused on the basic SALT layout and concepts and then the establishment and maintenance of the system. FAO funded the first year of operations with input for the first year of operations along with support for production of short-term crops. Technical training packages to support upscaling and widespread adoption were developed through joint cooperation of FAO and local experts.

3.1.2 Results

The SALT approach enabled farmers to diversify their income streams and meet nutritional needs of their families by integrating vegetables and other cash crops in a system that complemented their main crops (e.g., coconut and corn).

Over 100 SALT sites were established in the Typhoon-affected regions, which benefitted more than 2 200 households and 74 community-based organizations that rely on coconut-based farming systems for their livelihood.

Many of the farmers working with community-based organizations in the project are now practicing the technology on their own personal plots.

SALT sites are located in the farmers' own communities, allowing women to participate more fully in farming activities and earn additional income.

Local government units help sustain the project by providing technical assistance and reinforcing the SALT design and concept by coaching and mentoring farmers.

Community-based groups were encouraged to invest their own financial resources to convert several other sites into demonstration plots that replicated the CS-FFS programme.

The modules and training material used by some agricultural technicians in the CS-FFS have combined FAO and technical inputs from the local government departments and experts to form a partnership in knowledge sharing. Local experts also participated as resource speakers.

Collaboration with the different levels of government, especially the local government units, contributed greatly to the sustainability of the SALT activity. Government partners have been involved and consulted at every level of the process. This ensured greater sustainability of field practices and knowledge transfer, effective relationships with government and beneficiaries, and 'ownership' of the SALT sites by both the community-based organizations and the local government units.

Crop diversification helps in soil conservation and nutrient preservation, and the use of leguminous crops and perennial trees stabilizes and enriches the soil.

Promotion of crop rotation and crop diversification helps reduce infestations of pests and diseases.

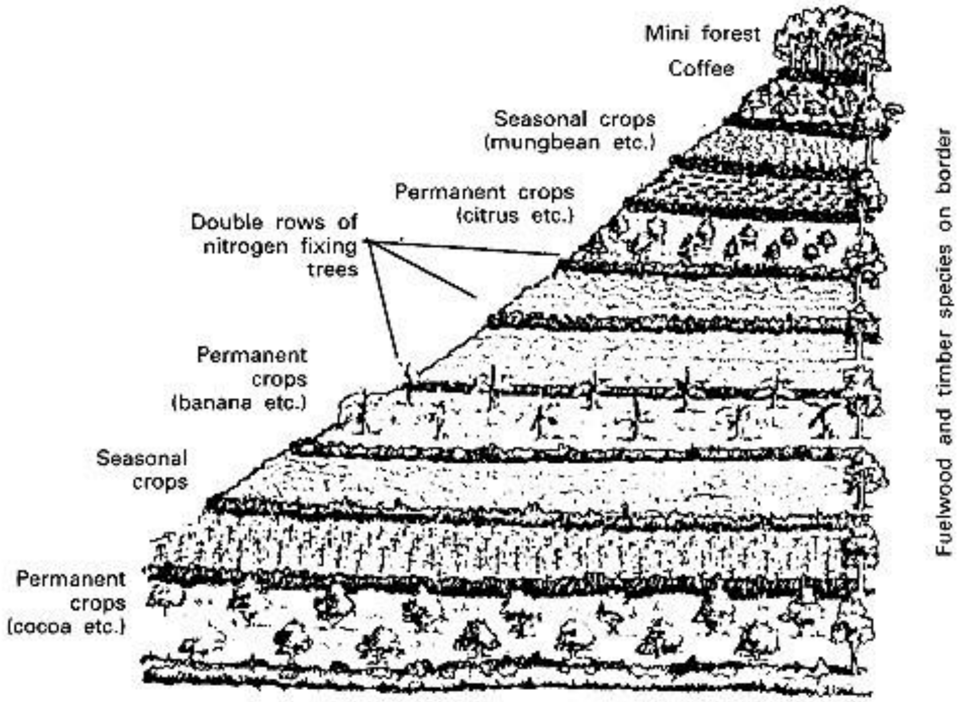


Figure 1:Conceptual representation of a typical sloping agriculture technology farm

Source: Laquihon (1987) in (Watson, 2000)

Figure 2: FAO established SALT site in typhoon affected area of the Philippines that allowed coconut-based farming communities to provide alternative livelihood sources by integrating short-tern and annual crops with coconuts. Source (FAO)

3.2 Assessment of vulnerability and adaptation needs of small holder farmers in Dominica

In August 2015 Tropical Storm Erika (TSE) unleashed over ten inches of rainfall in a six-hour period resulting in extensive damage to the agriculture sector. Damages to farms, on-farm infrastructure and farm access roads were estimated at US$ 24.6 million. The GOCD was supported by IICA and FAO to assess the vulnerability of smallholder crop farmers and to provide support to adaptation efforts that would make their farming systems more resilient to climatic events.

3.2.1 Process

The Ministry staff initially selected a community that had experienced significant land slippage and subsidence during TSE, the Cochrane Village. A team comprising senior Division of Agriculture staff, consultants, IICA representative and leading farmers from the area, visited several affected areas of the community and jointly selected a farm for the implementation of SLM technologies. The consultants then had the task to develop a slop stabilization plan for the area that would serve as a demonstration site to highlight best practice.

Site description

Location	Top of the Cochrane Village at the intersection of the Springfield access road
GPS coordinates	15.34123 , 61.36039
Plot size:	1.17 acres
Altitude	473m (1,553 ft)
Average slope	20^o
Soil description	Free draining allophanoid latosolics, very good soil texture.
Site history	Vegetables root crops
Current use:	Vegetables and root crops
Vulnerabilities:	Runoff from the roads, soil erosion, mass soil movement (subsidence and land slips)
Soil conservation measures:	Shallow drains
Climate change risks:	Intense rains causing landslides, drought

3.2.1.1 Recommendations:

The consultants recommended a package of interventions that would help limit soil erosion and stabilize the area to reduce or prevent mass soil movement. The technologies employed included agroforestry and other measures to reduce soil erosion, stabilize the affected slope. Some of these are shown in figures 3 to 5 below.

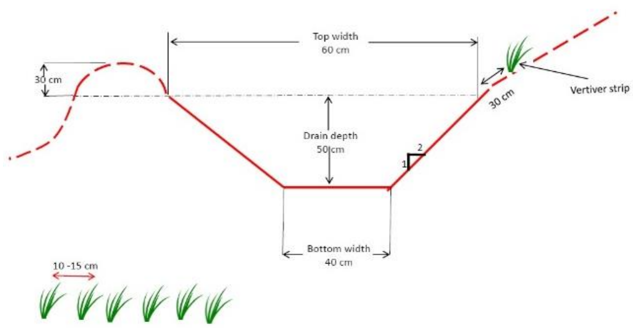


Figure 3: Trapezoidal shaped storm and field drains contour drains, with vetiver strips

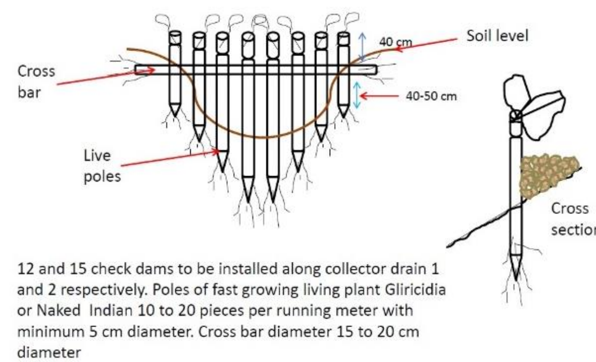
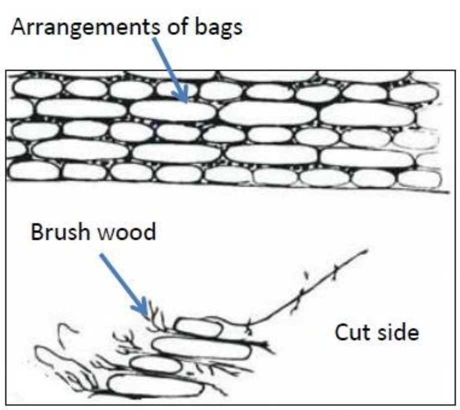


Figure 4 Check dams installed along the main collector drain to reduce the velocity of drainage water



Schematic of soft gabion retaining wall

- Cut and remove debris at the base/toe of the slide (approx. 6ft). Compact and level with 4 inches of sub-base material.
- Fill empty bags with sand/rubble and place them with their open ends directed towards the cut slope side by side
- Push soil from the cut slope on the bags and cover bags fully.
- Place a layer of freshly cut fast growing brush wood (Eg. Gliricidia sp.) with their but ends directed towards the cut slope.
- Cover the brushwood with another layer of soil
- Place another layer of filled bags length-wise over the brush layer by giving a step ½ ft. over the first layer
- Place a layer of soil over the bags and give brush wood treatment as above
- Repeat the process until the required height is of the wall is achieved

Figure 5 Soft gabion wall installed at the toe of the landslide to prevent further slippage.

The soft gabion wall technology was adapted from experiences with low cost slope stabilization techniques in Pakistan and trialed here for the first time in Dominica (Shah, 2008).

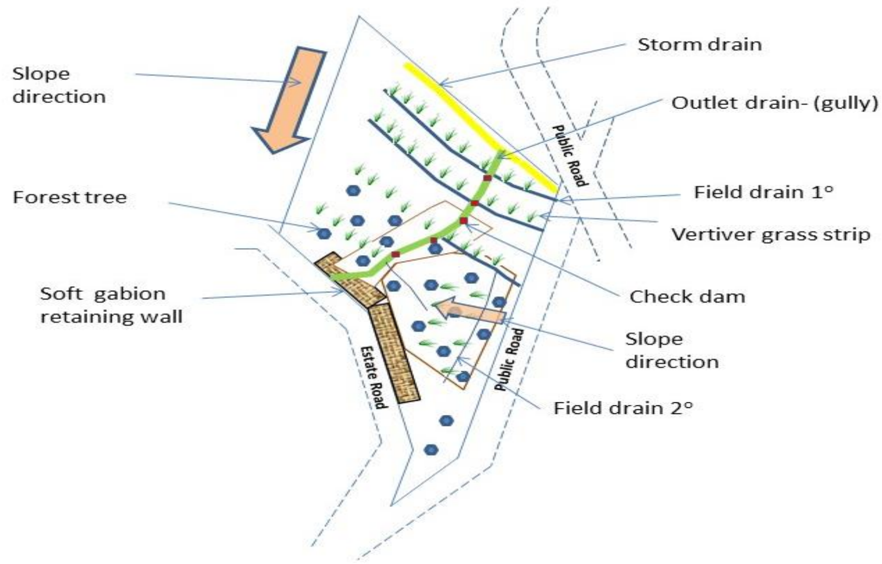


Figure 6 Slope stabilization demonstration plot design - Cochrane

3.2.2 Results

The design was successfully installed by a contractor and supervised by the consultants.

The technology continues to function well and stood the test of Hurricane Maria in 2017 and all subsequent rainfall events since it's installation with no sign of failure.

The adaption spill off anticipated has not materialized

The expected continued involvement of the farmers and extension staff of the Division of Agriculture was not realized.

4 A package of SLM approaches for Dominica

In his most recent national budget address, the Prime Minister of Dominica, Honorable Roosevelt Skerrit, outlined a national objective for agriculture that essentially incorporates a SLM approach. He noted that, "The objective of this Government is to continue to implement policies which will result in a sustainable agriculture system, that will guarantee food security, rural livelihoods, economic development and growth." The achievement of this objective rest with the adoption and implementation of location-specific SLM practice on a national scale.

Sustainable land management practice is two dimensional and consist of:

SLM technology - described as a physical practice that controls land degradation and or enhances productivity, consisting of one or more measures and,

SLM approaches - ways and means used to implement one or more SLM technologies. It describes technical and material support, involvement, and roles of different stakeholders. An Approach can refer to a project/ programme or to activities initiated by land users themselves (WOCAT, 2011).

A consideration of SLM approaches for Dominica should begin with an appreciation for the physical environment and a recognition of existing and potential threats to land resources. McConaghy (1970) noted that Dominica's rugged mountainous terrain made it imperative that due consideration is given to landscape features and inherent soil characteristics for the successful management of land resources in the country. On that basis, it is also prudent to consider the prevailing pressures that may be contributing to land degradation. An attempt was made earlier to describe the physical environment and also provide a snap shot of past and ongoing SLM approaches implemented in Dominica. The disjointed approach of individual agencies and Government departments going it alone has not yielded the desired results. There are numerous examples in different parts of the world where SLM approaches were successfully implemented to the benefit and well-being of persons. An approach that seems to work is that of SLM mainstreaming.

4.1 SLM Mainstreaming

SLM mainstreaming is defined as a process which aims to integrate SLM principles and objectives in development policies, plans, programmes and expenditure and evaluate their linkages with institutional and civil society actions, leading to a comprehensive national response to the problem of land degradation. Such an approach fits well with the nature island image that Dominica has projected for itself. It is also in keeping with the country's motto 'Apres Bondyé C'est La Terre' 'After God is the land'. There are proven strategies to achieve SLM mainstreaming and this could be a critical step to achieving some of the stated goals and objectives for national development. Such an approach is likely to bring life to the recently developed national land use policy and national land use plan for Dominica. The designation of an officially recognized SLM champion within the Ministry of Blue and Green Economy, Agriculture and National Food Security is likely to support the mainstreaming agenda. Another critical policy approach is to incentivize SLM adoption at the level of the farm, community-based organization and at the level of the extension support staff. Such SLM incentives should be embedded in any support programmes that are designed to support agricultural development in Dominica. Other actions directed at addressing specific environmental stresses will be required. The following approaches are now considered.

4.2 Soil erosion and land slippage/subsidence

A combination of steep slopes and high rainfall which Dominica is well-known for is a recipe for aggravated soil erosion. Poor farming practices that involve high tillage and exposure of the soil surface compounds this situation. The technical packages especially for the dominant crops that involve relatively high tillage must be revisited. Extension staff and farmers must be trained to assess land conditions and be supported in their decision making about where to locate different crops based on land suitability and potential risks of soil loss and degradation. Support should also be readily available for the design of storm drains and the installation of vetiver strips along contours. Apart from building capacity among farmers and extension personnel, the adoption of these approaches should be strategically incentivized to increase uptake of technology. Approved Incentives should not breed dependency as this will be to the detriment of sustainability.

Slopes along riparian areas that are cleared for farming are highly susceptible to slippage. Enforcement of legislation to maintain the integrity of buffer zones in riparian areas and reduce land slippage risks must be an integral component of this approach.

Figure 8 Severe soil erosion observed at the top of the Crayfish River watershed, Kalinago Territory

Figure 7 Subsidence observed on a farm at Bataka in the Kalinago Territory (Photo Credit Burton, A.,2020)

4.3 Soil organic matter

Soil organic matter (SOM) content influences several important soil characteristics and the ecosystem services they provide. These include water holding capacity, nutrient cycling and release for plant uptake, buffering pH changes, improving soil texture and workability and sequestration of carbon. The SOM content of soil is therefore a very important parameter that is indicative of soil health and its productive capacity. Unfortunately, SOM is not often measured or considered within the limited diagnostic capabilities available locally. However, farmers will generally, have a good idea, from physical appearance, of a soil that has a high SOM content. This is usually associated with newly cleared land or lands that were left fallow for extended periods. Approaches that build SOM and soil health generally, must be vigorously pursued. Several past attempts at introducing composting have seen limited success. While this effort should continue other options for maintaining and increasing SOM should be pursued. These include the integration of trees, and cover crops that can add organic matter consistently to soils. This could be a carefully planned strategy of sequential planting where a leguminous cover crop that can tolerate shade is integrated with short or long-term crops.

4.4 Mitigate land degradation and restore degraded land

Soil erosion is the major cause of land degradation in Dominica. Among other contributing factors are inappropriate farming practices, poor land use choices, road construction, poor drainage and invasive plants like lemon grass (*Cymbopogon citratus*) and African Tuliptree (*Spathodea campanulata*). An approach to land restoration that addresses the core issues must be developed. Demonstration plots showing how restoration can be achieved are effective ways to give hope and confidence to farmers and land owners that restoration is possible. Pilot plots to demonstrate how different types of land degradation issues could be successfully addressed and restored would be the primary approach. This should be supported by the development of appropriate knowledge packages in different media formats that are made available to the general public. Capacity building targeted at personnel from ministries and departments responsible for agriculture, physical planning and public works and housing should form part of this approach.

Figure 10 Restoration of degraded land at Tarou using a jute mesh and vetiver strips

Figure 9 Land preparation for root crops involving clearing and tillage on slopes (Photo Credit Burton, A., 2020)

4.5 Soil fertility management

While there are only five major soil types in Dominica, knowledge about their general characteristics and strategies for management is very limited. Sadly, this limitation exists among agriculture professionals who provide support to farmers. This is partly because most of the information is not readily accessible or in formats that are not readily assimilated without some basic (or above basic) knowledge of soil science. Nonetheless a concerted effort must be made to make this information more user friendly. This will support the use of this data for decision making on the part of farmers and extension staff but also on the part of the authorities and agribusiness entities that import and make fertilizers and soil ameliorants available to farmers. For example, the protosols and young soils can usually provide adequate plant nutrients but water shortage is usually the most critical factor limiting crop-growth in the dry season. The allophanoid soils have high moisture-holding capacity, good structure and structural stability and provide an excellent medium for crop growth, though they are often very deficient in certain plant nutrients, especially phosphate and sometimes sulphate and also in calcium and magnesium. The allophanes have a cation sorption capacity (ability of soil particles to hold essential nutrients) that is pH dependent. At low pH values sorption is low and nutrient cations K and NH_4 are readily leached from these acid soils. Such information can inform decisions about fertility management and help farmers make better choices that could positively impact production cost and productivity. Management of SOM is also critical to soil fertility management on Dominica soils.

4.6 Improve crop productivity

Several techniques that have been tried and proven are available for improving crop productivity. Support should be given to revisit the technical packages available for various crops to ensure that appropriate techniques, suitable for local conditions are included. Demonstration and use of the farmer field school approach can be helpful to build capacity of farmers and their workers. Crop productivity improvements are measured on a per area basis and needs accurate measurements of both area and the weight of produce. Record keeping is therefore essential to keeping track of productivity targets as being informed when adjustments may be necessary. Several of the other approaches will redound to improved crop productivity once implemented consistently well.

4.7 Wet and dry season strategies

Seasonal variations in moisture patterns can have varied effects on crop production depending on soil type and geographic location. Coastal areas like certain parts of Warner with smectite dominant clays will usually find that crop production may be impossible without irrigation. Rainwater harvesting options can be considered for areas where irrigation from other water sources is not feasible. Other techniques to conserve moisture can also be employed. If one considers that production is possible in countries and zones that don't receive a fraction of the rainfall that our driest areas receive in a year, then surely there is more that can be done to reduce negative impact on production from a relatively short dry period. This calls for a better understanding of our environment and to learn how to better manage these periods that usually occur around the same time each year. Likewise, a wet season strategy must also be in place to deal with the problems of the wet season when excess water, elevated water tables and erosion and loss of applied nutrients can be problematic. Strategies like sub-surface placement of fertilizers can reduce runoff losses. Clearing drains and pruning tree crops can be helpful to reduce humidity and reduce wind damage. Strategies may be both crop and location-specific.

4.8 Protect vulnerable lands and limit land use conversion

Dominica has remained among the least densely populated countries in the Caribbean due mainly to its high net migration rate. Since Dominican's generally pride themselves in owning land, whether they reside abroad or not, the pressures for land for housing and other types of development will increase. This threat must be planned for and carefully managed. The forested lands and its rich biodiversity makes Dominica truly the Nature Isle. The natural spaces from north to south include protected forest but also significant portions of forest that are privately owned. Some areas like the west coast near the Mero village, for example, are habitats for rare and endangered plant species like the Buccaneer palm (*Pseudophoenix sargentii*). Over 20,600 ha, representing 27% of the total land area of Dominica is designated as protected areas or proposed to be designated. Development objectives with the potential to diminish the high nature value of these spaces must be carefully considered and where possible restrict use or find alternative development pathways that are compatible with the environment. The conflict between nature and man's development is always present. However, where carefully thought-out plans and systems are in place, adverse impacts can be minimized. A part of this approach will be to use systems like the High Nature Value Index (HNVI) to evaluate and decide on available options where nature-development conflicts may arise.

Table 3: Designated and proposed protected areas in Dominica

Designation type/Name of Protected Areas	Status	Year of designation	Area (ha)	IUCN Category
International (World Heritage Site)				
Morne Trois Pitons National Park		1997	6875	N/A
National				
Forest Reserve				
Central	Designated	1952	410	VI
Northern	Designated	1977	8814	VI
Marine Reserve				
Soufriere/Scott's Head	Designated	1998	700 (Marine)	V
Cabrits	Designated	1998	421 (Marine)	II
National Park				
Cabrits	Designated	1987	531	II
Morne Trois Pitons	Designated	1975	6875	II
Morne Diablotin	Designated	2000	3450	II
Protected Forest				
Stewart Hall Water Catchment	Designated	1975	318	VI
Total Area (Designated)			**20,398**	
Other				
Indian River	Proposed	1995	79	Not reported
Soufriere Sulphur Spring	Proposed	1995	102	Not reported
Syndicate Parrot Reserve	Proposed	1989	83	Not reported
Total Area (Proposed)			**264**	
Total Area Designated and Proposed			**20662**	

The International Union for Conservation of Nature (IUCN) protected area categories includes:

- Strict nature reserve — Category Ia.
- Wilderness area — Category Ib.
- National park — Category II.
- Natural monument and Natural feature — Category III.
- Habitat management area and Species management area — Category IV.
- Protected landscape and Protected seascape — Category V.
- Category VI – protected area with sustainable use of natural resources

4.9 Soil pollution

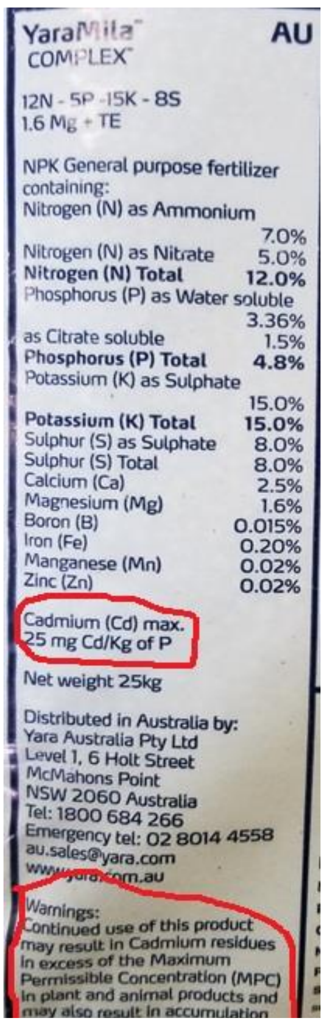


Figure 11 Photo of a fertilizer bag offered for sale in Dominica showing Cd content and warning

On the occasion of World Soils Day, in December 2018, FAO highlighted and gave central focus to the issue of soil pollution. In an official statement the FAO noted that "urgent action is needed to address soil pollution and contain the multiple threats it poses to global food safety and food scarcity"(FAO 2018). Soil pollution is defined as the presence of toxic chemicals (pollutants and contaminants) in soil in high enough concentrations to pose a risk to human health and or the ecosystem. In the case of naturally occurring contaminants, even when their levels are not high enough to pose a risk, soil pollution is still said to occur if the levels of the contaminants in soil exceed the levels that should be naturally present. There's a tendency to feel that we are safe in Dominica to soil pollution threats. However, with limited diagnostic capability we are still uncertain about this reality. Heavy metals like cadmium (Cd) are known carcinogens, and that occur naturally in Dominica's soils. Volcanic soils generally are thought to have naturally relatively high Cd levels (Cadmium Working Group, 2011; Ramtahal et al., 2016). The pollution from agricultural practices like phosphate fertilizer applications used heavily on root crops are also of concern (Roberts, 2014). The quality of rock phosphate used for fertilizer blends and subsequent management of soils where fertilizers are used like additions of organic matter and maintaining good nutrient balances can help to reduce bioaccumulation by crop plants. Figure 10 shows that local systems are not sufficiently sensitized and informed about the potential harm that can come through this source or pollution. There are regional examples, like in Jamaica where root crops were found to contain high levels of contaminants, enough to pose health risks (Tomlinson, 2013).

The potential risk of soil pollution from applied pesticides is also a major cause of concern. The example of the soil pollution from the pesticide, Chlordecone, used on banana plantations in neighbouring French islands and the links to an alarming rate of prostate cancer has been widely reported (BBC, 2019). There must be a voice to raise the alarm of this potential threat to Dominica and to influence policy that will prevent potentially harmful products from being used while supporting the introduction and development or sustainable and environmentally friendly alternatives.

5 Conclusion

Sustainable land management is not a panacea. It will not solve all the problems faced and neither is it a quick fix. However, it offers an opportunity to address perennial problems through logical approaches that have been tried and proven. Living in the Nature Island of the Caribbean, Dominicans pride themselves on the natural beauty of their homeland. The region has grown to expect that produce from Dominica is natural and wholesome. Dominica has also remained reliant on the productive capacity of its natural resources, especially its rich volcanic soil. The evidence indicates several shifts in the social and economic landscape of farming and use of natural spaces in Dominica. The increasing number of farmers who don't own land and are without cultural ties to the island, as with the growing number of Haitian immigrant farmers is already having implications on land use. With the main driver being quick returns, shorter-term crops are preferred and in many cases lands that are steep with high risk for erosion and slippage are used. Since these short-term crops require high tillage the soil is made loose and repeatedly used. This is not the only problem of land degradation to address. There are many others as was highlighted earlier. The agencies with responsibility for land management do not have a framework for collaboration, and this must be prioritized as a very important objective. Led by appropriate policy directives from the GOCD, the Ministry of Agriculture, Ministry of Environment, Divisions of Forestry and Planning, Lands and Surveys, Public Works and entities like Dominica Water and Sewerage Company (DOWASCO), need to have a common agenda on natural resources management for the Commonwealth of Dominica.

The two cases studies highlighted were effective in addressing land degradation problems in the locations where the various SLM approaches and technologies were implemented. However, the case from the Philippines succeeded in reaching a lot more farmers and community-based groups were involved to the extent that they took ownership of the process. The realized benefits of SALT to reduce soil loss, enhance soil productivity and simultaneously diversify livelihood sources of small farmers is very desirable. It is highly recommended that stakeholders (particularly DoA staff) pursue a detailed review of previous SLM activities undertaken in Dominica using the WOCAT questionnaires on SLM Approaches and Technologies as a guide. Such a review process will indicate where the shortcomings were on previous SLM projects and what must me done to ensure that greater success is achieved in the future. The Barrier analysis report from the Technology needs assessment currently being finalized will also be an important resource to determine the shortfall in previous programs implemented locally. The time taken to review and learn from past mistakes and to assess successful examples implemented elsewhere should be an extremely beneficial exercise. This is a likely pathway to sustainable gains.

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