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PROJECT COMPONENT/ACTIVITY:	**OUTPUT 2.1.4: DEGRADED WATERSHEDS IN AT LEAST 8 VILLAGES REHABILITATED WITH NATIVE VEGETATION BASED ON SITE SPECIFIC REHABILITATION PLANS DEVELOPED IN COLLABORATION WITH LOCAL COMMUNITIES** **OUTPUT 2.1.5: INCREASED PUBLIC UNDERSTANDING AND AWARENESS OF LD ISSUES AND ASSOCIATED SLM OPTIONS, AND INCREASED SUPPORT FOR LAND REGULATIONS**
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QUAYANERI WATERSHED MANAGEMENT PLAN (2023- 2028)

This report was prepared by EcoApp Inc.

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VALIDITY PERIOD FOR PLAN

This plan is valid for a period of five years from August 2023 to September 2028

PREPARATION, REVIEW AND APPROVAL OF PLAN

This plan was prepared by EcoApp Inc in partial fulfillment of the consultancy- Strengthening the uptake of Sustainable Land Management (SLM) in the Commonwealth of Dominica for the PISLM.

UPDATING OF THE PLAN

This plan may be revised during the period it is effective if there are substantial changes in activities occurring in the watershed or new data is generated that sheds further light on ecosystem functioning. In either case, the implementing authority of the plan must approve all revisions of the plan and endorse any changes to it.

APPROVAL

The plan was approved by key stakeholders.

ACKNOWLEDGEMENTS

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ACRONYMS

BMP	Best management practice
QR	Quayaneri River
QW	Quayaneri Watershed
QWMP	Quayaneri Watershed Management Plan
QWMC	Quayaneri Watershed Management Council
CARPHA	Caribbean Public Health Agency
CREAD	Climate Resilience Executing Agency for Dominica
DBMC	Dominica Banana Marketing Corporation
DOWASCO	Dominica Water and Sewerage Company
EBA	Ecosystem based Adaptation
FD	Forestry Division
GEF	Global Environment Facility
GoCD	Government of the Commonwealth of Dominica
GSPS	Growth Social Protection Strategy
IBA	Important Bird Area
LFA	Logical framework analysis
LID	Low Impact Development
MGD	Millions of gallons per day
MST	Microbial source tracking
MOA	Ministry of Agriculture
NBSAP	National Biodiversity Strategies and Action Plans
NRDS	National Resilience Development Strategy
PISLM	Partnership Initiative for Sustainable Land Management
SALT	Sloping Agricultural Land Technology
SDG	Sustainable Development Goal
SGD	St Georges Declaration
SLM	Sustainable Land Management
SPACC	Specific Programme for Adaptation to Climate Change
SPCR	Strategic Program on Climate Resilience
TDML	Total Daily Maximum Load
UNESCO	United Nations Education, Scientific, and Cultural Organization
WHO	World health organization

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EXECUTIVE SUMMARY

The headwater region of the Quayaneri Watershed (QW) is part of the Morne Trois Piton National Park (MTPNP), a World Heritage Site that is internationally recognized for its rich biodiversity and unparalleled high nature value landscape features. The multiplicity and range of benefits of this watershed system to Dominica is priceless, yet its integrity and function is threatened due to unsustainable human activities and repeated impacts from severe storm events. Owing to intense farming activities, topography, and high rainfall conditions, the Quayaneri Watershed (QW) remains vulnerable to further degradation of its hydrologic functions. The loss of critical ecosystems services and functions could diminish its outstanding universal value and threaten its World Heritage status. This will also have implications for conservation within the QW and those whose livelihoods depend on ecosystem services it provides. Unless urgent landscape-level action is taken, it is expected that the watershed system will lose its ability to bounce back, and spiral downwards to levels of decline that may be extremely prohibitive to restore.

The QW is the source of potable water for the La Plaine community and several nearby hamlets. Recognizing the importance of this watershed system and cognizant of prevailing threats, the Government of Dominica, supported by the Partnership Initiative for Sustainable Land Management through the consultancy under the GEF-financed project "*Sustainable Land Management (SLM) in the Commonwealth of Dominica"* identified the Watershed as a case study and pilot for the implementation of sustainable land management approaches in watershed restoration. Consequently, a watershed management plan was developed to better guide, control and mitigate against the natural and human stresses on the system. The plan is aimed at sustaining and restoring critical ecosystem functions and services for greater resilience and is a blueprint to guide groups, farmers, state agencies to work collaboratively for the protection of watershed systems in Dominica. The plan also seeks to integrate existing plans for MTPNP buffer area management, which was developed under a previous programme, the Global Environment Facility (GEF)-funded Special Programme for Adaptation to Climate Change (SPACC).

The Quayaneri Watershed is part of the Quayaneri-Morne Jaune complex draining an area of about 1376 hectares. The watershed also falls under Quayaneri sub-basin encompassing a section of the La Plaine community. The watershed has a high stream density, steep topography and farming is prevalent in the mid to lower regions of the system. There is growth in the number of unplanned housing and tourism facilities dedicated to stayover visitors in the area. The watershed ecosystem is diverse, with several primitive, endemic and native plants, animal and bird species contributing to its rich biodiversity.

The plan is designed to guide management interventions to minimize the potential threats that could compromise the ecological function and productivity of the system. The core problems in the watershed include but not limited to:

- indiscriminate use of agrochemicals and inorganic fertilizers and potential pollution of surface and groundwater
- cultivation of short-term crops on steep hillsides without proper soil and water conservation measures
- deforestation in the upper watershed regions

- removal of riparian buffers and cultivation up to the riverbank, especially in the mid and lower sections of the watershed
- change in land ownership and land uses with several expats owning land within the buffer zone of the Morne Trois Piton National Park (MTPNP) which forms part of the watersheds headwater region.
- altered hydrologic flows and deteriorating quality of surface water (elevated enterococci counts), especially in the lower watershed region.
- Uncontrolled disposal of untreated solid and liquid waste from livestock operations in or near riparian areas with serious concerns for surface water pollution
- poor farming practices that result in increased risk from landslides and erosion
- The discontinuation of national farm certification schemes (GlobalGap and Fairtrade) coupled with a transition to short-term root crops (using high tillage) has contributed to the overall decline in SLM.
- weak enforcement and compliance to laws regarding forestry and watershed management
- lack of awareness of sustainable land and watershed management
- not enough local champions for watershed protection in the community

The plan embraces participatory approaches for planning, implementation, and evaluation. It characterizes the present watershed conditions and identifies problems, objectives, and strategies in partnership with stakeholders. Implementation of the plan involves various expertise and skills including technical, project management, monitoring and evaluation, and communication. A Watershed Management Council is recommended to coordinate aspects of the plan's implementation. Notwithstanding, it is strongly recommended to:

- Establish a cost sharing mechanism and set up a co-management scheme to enable the implementation of the WMP.
- Stabilize the most vulnerable riparian zones with fast growing tree species and where favourable, cultivate economic species, grass barriers and introduce other bioengineering interventions to retard the rate of overland transport of sediment into the watercourse. A minimum buffer width of 50 m should be encouraged for best results.
- Establish a volunteer water quality monitoring program for continuous and cost-effective monitoring of the BR and at minimum, annual reporting of results to gauge whether interventions are effective.
- Pursue a long-term financing arrangement to support monitoring and implementation of key activities. This should also involve the recruitment and engagement of a designated Watershed Coordinator (WC) to assist the La Plaine Watershed Management Council (LWMC)
- Promote sustainable land management (SLM) approaches and technologies including sloping agricultural land technology (SALT) and low impact development (LID) practices to minimize erosion and pollutant runoff. In addition, along the main corridors, buffer protection should be enforced with adequate tree cover.
- Develop and promote education and awareness programs throughout the life of the plan to modify behaviours and attitudes towards ecosystem/watershed management.

Public education is regarded as critical to long term success of watershed management in general. Opportunities should be explored to target women, marginalized groups and youth.

- Undertake additional studies to link and quantify the impact of climate change on watershed hydrology and the extent to which farming practices induce watershed degradation. A crop suitability study should also be considered to determine the most viable crops and farming systems that can be practiced within the prevailing constraints of the watershed. Ultimately, this will reduce the vulnerabilities of downstream communities and ecosystems.
- Implement the Dominica National Land Use Policy and Plan as a pilot in the Quayaneri Watershed (QW). This will create a unique opportunity to test the adequacy of the implementation instruments as the system is representative of other watershed systems in Dominica, particularly those on the southeast and east of the island.
- Promote and ensure adherence to guidelines requiring Environmental Impact Assessments (EIA) for infrastructural developments in this ecologically sensitive area is prioritized. Ongoing and planned investments in tourism plants and aqua culture are of particular concern. These establishments will place greater demands on water resources and possibly spur additional similar investments in the watershed.
- Facilitate community participation in forest restoration with a focus on establishment of riparian buffers, MTPNP buffer management, plant propagation and establishment of native forest species and agroforestry farming systems

2. BACKGROUND

1.1 Context

Watershed ecosystems are among Dominica's most prized assets, yet many systems continue to be degraded as a result of natural disturbances and human actions. Dominica is highly vulnerable to weather and climate related disasters which adversely impact its forest and watershed systems. The loss of critical natural resources and ecosystem services is likely to have profound implications for human quality of life. The general trends for climate change in the region are worsening extreme weather events coupled with human stressors which makes predictive impact modeling extremely difficult. As a result, proactive mitigatory measures to diminish risks cannot be undertaken with a high degree of specificity, unless urgent landscape-level action is taken. It is expected that many watershed systems in Dominica will become less resilient and lose their innate ability to recover from disturbances. Ultimately, this means that more and more resources will need to be diverted from productive sectors to remedy ecosystem degradation at increasingly higher costs.

Dominica has made considerable efforts to pursue a sustainable development agenda and have ratified several international treaties and conventions including the Rotterdam Convention, Stockholm Convention, the United Nations Convention to Combat Desertification, the Convention on Biodiversity, and United Nations Framework Convention on Climate Change (UNFCCC), all of which aim to promote responsible environmental management and biodiversity conservation. As a signatory to the St George's Declaration (SGD) of Principles for Environmental Sustainability in the OECS, it embraces an environmental policy framework and action plan to conserve its vital resource base. Some of these broad commitments are reflected in national strategies. For example, Dominica's National Resilience Development Strategy (NRDS) is a broad national framework for strengthening institutions, resource management capabilities, and national disaster response systems. Specially, objective two of the NRDS "Enhancing the resilience of ecosystems and sustainable use of natural resources (Forestry, Marine, Water resources)" provide the roadmap to pursuing the development of watershed management programs for the protection of forest ecosystems and water resources.

The NRDS provides an opportunity to mainstream sustainable development goals (SDG) in national and sub-national development planning frameworks. With particular reference to SDG Goal #15 (Protection, restoration, and promotion of sustainable use of terrestrial ecosystems and combat desertification and halting biodiversity loss), a foundation exists within the national agenda to pursue land use management plans. In addition, Dominica's Strategic Program on Climate Resilience (SPCR) establishes a framework on how to address climate and disaster risk management. Also enshrined in Dominica's Growth and Social Protection Strategy (GSPS) is the willingness to integrate green principles into national economic management and planning and connect environmental preservation and management into a coherent strategy for achieving higher levels of sustained economic growth. The recent successive impacts of Tropical Storm Erika and Hurricane Maria have elevated the urgency with which climate change adaptation objectives must be factored into national development plans.

It is within this abbreviated context that watershed management becomes relevant, highlighting the need to pursue more coordinated approaches to conservation. Dominica NRDS emphasizes

that conservation, sustainable use of natural resources, and the preservation of biodiversity, is an essential prerequisite for the island to strengthen its adaptive capacities and to create sustainable livelihood opportunities for resource-dependent communities. This pilot watershed management plan for Batali will help refine approaches for integrated watershed management and planning.

1.2 Rationale

In the context of climate change and the continued anthropogenic disturbances within the Quayaneri Watershed (QW), there is urgent need to develop and implement a watershed management plan (WMP) to better guide, control and mitigate against the natural and human stresses on the system. There is recognition that the watershed and its resources are critically important to sustaining an adequate supply of freshwater to meet agricultural and domestic needs for the communities of La Plaine. The link between watershed health, ecosystem function and the social and economic wellbeing of the communities are driving the need for sustainable resource management at all levels. This has been particularly heightened following the devastating impacts of Hurricane Maria on watershed resources in Dominica. The rivers, streams and embayment waters which form part of the watershed system are productive environments that cradle biological diversity indispensable for the "ecosystem services" which supports fisheries, tourism, and agriculture.

The watershed management plan for Quayaneri, La Plaine is aimed at sustaining and restoring ecosystem functions and services for greater resilience. It is a recognition of the need to develop a watershed-based approach to the issues confronting the watershed. The plan will provide a blueprint to help groups, farmers, and state agencies work across the divides to better protect and restore water resource conditions throughout the watershed. It will also complement other sustainable land management initiatives presently ongoing in the area.

1.3 Purpose of the Quayaneri Watershed Management Plan (QWMP)

The watershed ecosystems within the upper and mid sections of the Quayaneri Watershed remain fragile and vulnerable to further degradation. Many threats remain which can further destabilize the watershed system. Thus, a proactive WMP for the area will serve to deter any imminent threats to the system. The specific purpose of the QWMP is to

- Provide strategic direction for ensuring conservation and protection of ecosystems and biodiversity within the watershed.
- Support sustainable local livelihoods linked to conservation and protection of the watershed.

2 Description of the Quayaneri Watershed

2.1 Physical description

The QW is part of the Quayaneri-Morne Jaune Complex draining an area of about 1376 hectares. The Quayaneri sub-basin is fed by the Taberi River in the lower section of the watershed (Figure 1). The upper watershed (above 150 m) is characterized by steep hills with regenerating forest and a farming-modified landscape sparsely populated with mixed cropped farms and succession forest. The mid-watershed (above 70 and less than 150 m) is used mostly for crop agriculture and is comprised of steep and gently sloping land. Plantains, bananas and root crops dominate. Cinnamon, cocoa and other fruit trees are also produced in that area. In

the lower region is relatively flat and is increasingly occupied by tourism-related establishments, including several guests houses and other small rustic accommodation for tourists. A mixture of crop and livestock farms also occupy the lower Watershed.

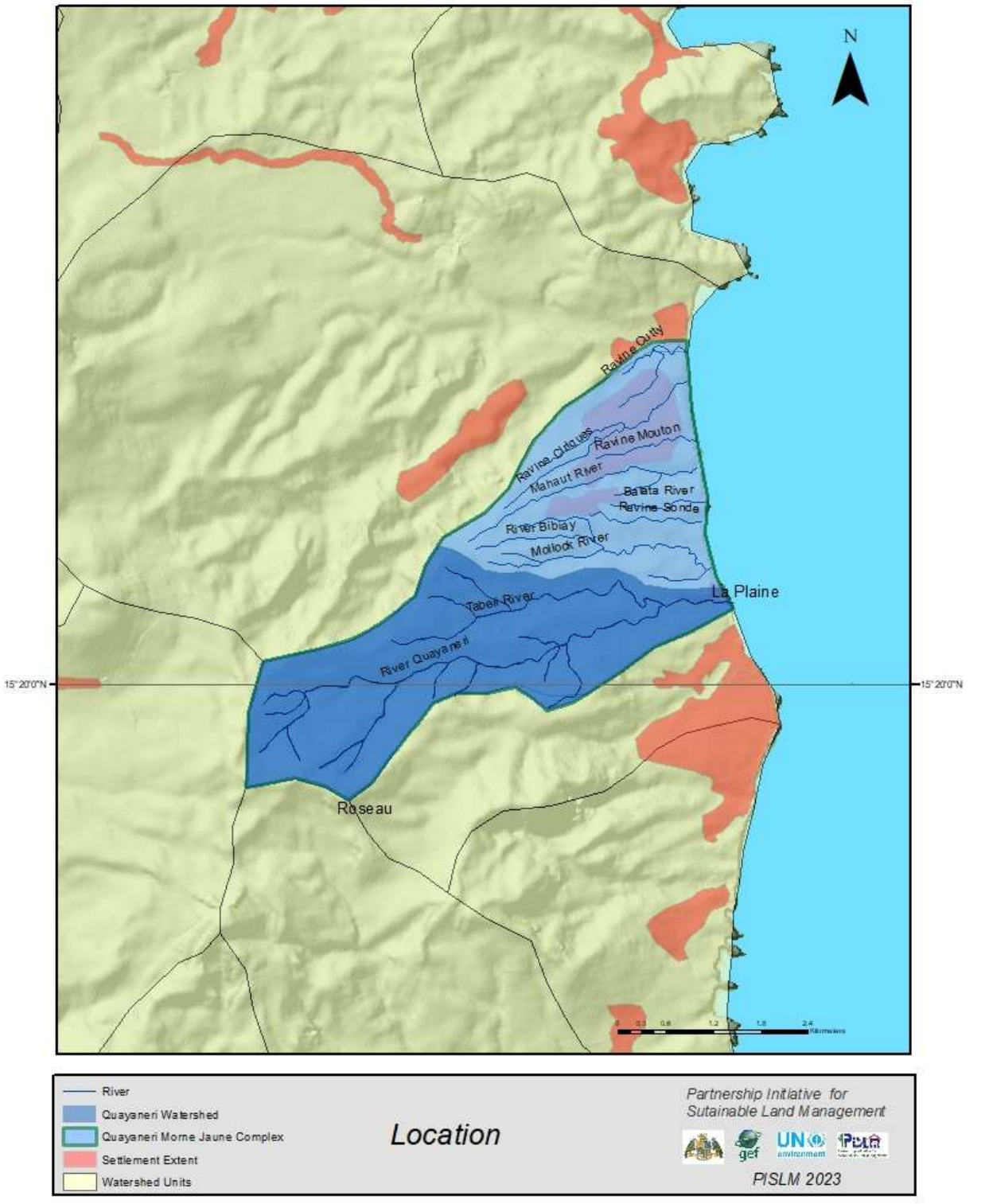

Figure 1: Quayaneri Watershed Extents

2.1.1 The watershed drainage system

The Quayaneri Watershed has a characteristic dendritic stream network where several tributaries converge into the main Quayaneri River (Figure 2). This is an indication that throughout the watershed, sub-surface rocks are composed of homogeneous materials, and which have similar resistance to weathering so there is no apparent control over the direction of the tributaries. The watershed is fed by the Taberi River which joins the Quayaneri River in the lower WS region. The WS also consists of a complex of smaller streams originating from several mountainous peaks most of which have seasonal surface flows.

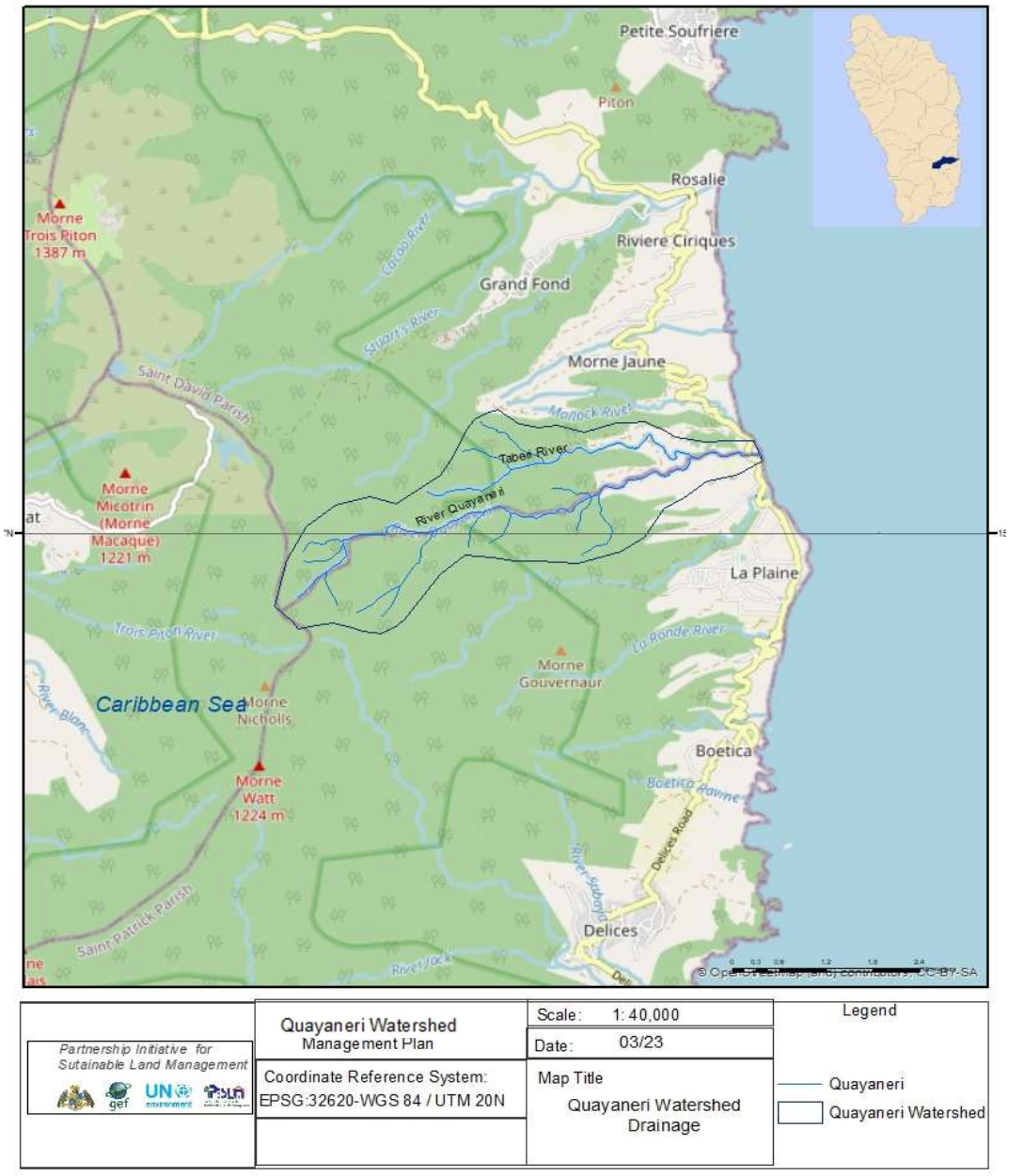

Figure 2: Drainage pattern of Quayaneri Watershed

Like most other watershed systems in Dominica, the watershed length and slope determine the transit time for flow through the watershed and has implications for emergency response for the downstream communities during significant rainfall events. An average watershed length of

7 km (based on GIS analysis) was estimated for the system and was measured as the distance along the main channel from the watershed outlet to the basin divide.

2.1.2 Watershed Slope

Slope is variable throughout the QW (Figure 3). The upper and mid watershed regions are dominated by slopes greater than 20°. The gently sloping land available (under 15°) is concentrated in the lower region. On the young soils. This area has been used extensively for crop farming. In recent years there has been an increase in cattle and small ruminant production in that area.

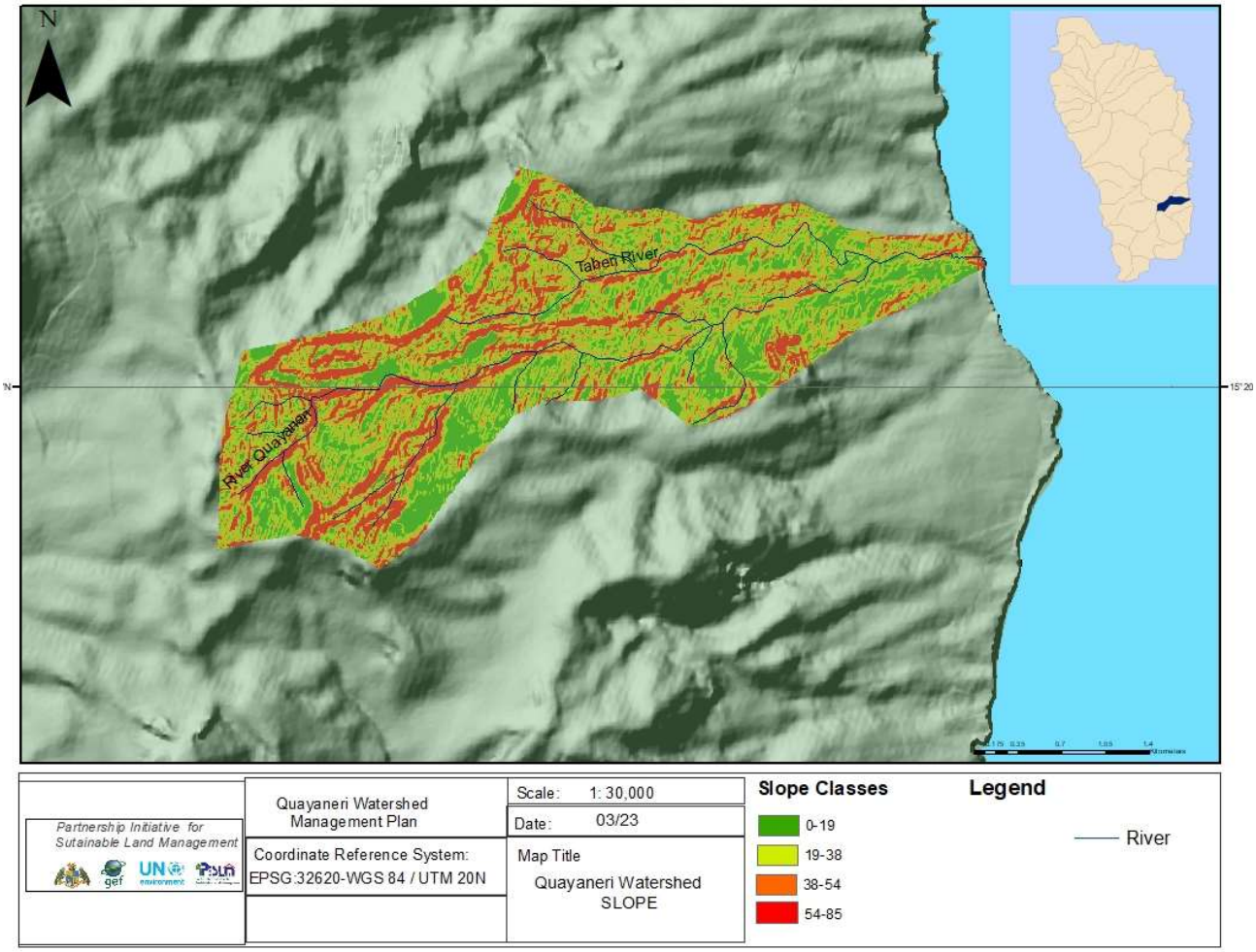

Figure 3: Slope characterization of the Quayaneri Watershed

The average slope of the watershed, rainfall intensity and duration, vegetation cover, and soil saturation significantly influences the transition time and the volume of runoff that is transported into the watercourse. This attribute gives rise to the watershed hydrographic network. Other factors including geology, climate, and environment also contribute to the formation and orientation of the hydrographic network. The hydrographic network is one of the most defining characteristics of any watershed.

2.2 Seasonal climate (rainfall)

The area has a seasonal climate which is typically hot and wet depending on elevation. . Most of Dominica's rainfall is terrain enhanced. Orographic precipitation is attributed to a combination of steady trade wind and simple mountain geometry. The highest elevations can receive 7000 mm of rainfall annually, but rain pulses are brief and average drying ratio is small (< 1%)[1].

Rainfall is variable throughout the year and is lowest for regions near the coast. Average rainfall computed for the 12-year period (1999-2010) for La Plaine based on data from a collection site at Delices used by the FWPD is 3248 mm (See Figure 4). Monthly average rainfall over this period is 270.6 mm. The driest month (least rainfall) is March with an average of 42.8 mm while the wettest (highest rainfall) over the same period is October averaging 479 mm. In the reporting period, annual recorded rainfall for the area exceeded 4000 mm only in 2004. Because of relatively high rainfall in uppermost regions, surface flows continue for nearly all the major streams in watersheds even though there are noticeable volume changes in the peak dry season.

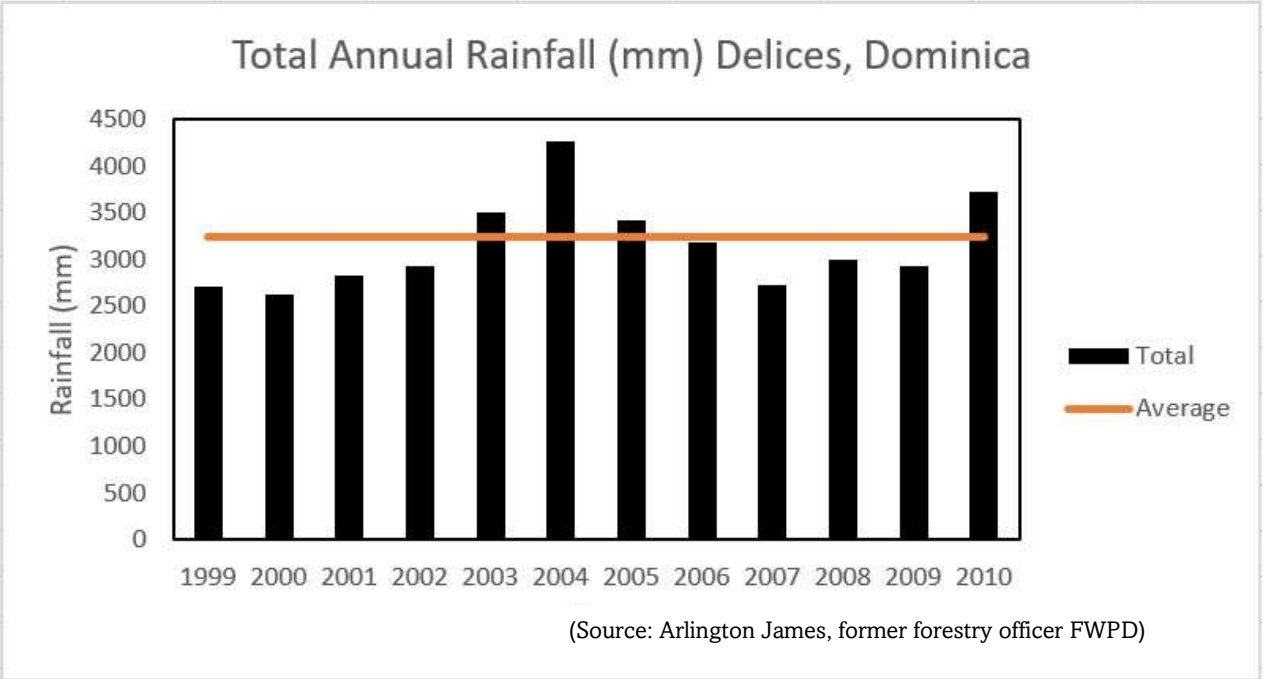

Figure 4: Total Annual rainfall for La Plaine based on a 12-year average for Delices FWPD data. Orange line shows the running average for the period. Reliable rainfall data for that location is only available for 1999 to 2010

The upper regions of the Quayaneri-Morne Jaune Complex fall within the MTNP however, in recent decades there has been reducing flow regimes in the watershed. There are apparently no acute concerns about the quality and reliability of the supply (anecdotal evidence). Climatic change and variation and related forest cover loss, deforestation and or change in land use, especially in the upper watershed are considered among the main drivers precipitating decline of this essential ecosystem services. More research needs to be conducted using historic rainfall

[1] Smith, R.B., Schafer, P., Kirshbaum, D.J., and Regina, E. 2009. Orographic precipitation in the Tropics: Experiments in Dominica. Journal of Atmospheric Sciences Vol 66. Is..6. DOI: https://doi.org/10.1175/2008JAS2920.1

data to determine whether the overall rainfall for the area has in fact been declining in the last 100+years. In the case of land use patterns, there is evidence of forest clearing for the cultivation of cannabis, illegal harvesting of forest trees, hurricane impact as well as other unsustainable agricultural practices in and around the upper reaches of the watershed. This may be contributing to observed changes in watershed hydrologic responses, whereby peak flows following rainfall events tend to be greater for lower intensity rainfall. No long-term systematic monitoring of flows at the Quayaneri River has ever been undertaken.

2.2.1 Temperature

Figure 5 shows the annual mean temperature recorded at the nearest official meteorological on the northeast coast. The estimated 30- year mean temperature for La Plaine is 26.6 ^{0}C. The mean minimum temperature 23.5 ^{0}C. The estimated mean maximum temperature is 29.7 ^{0}C.

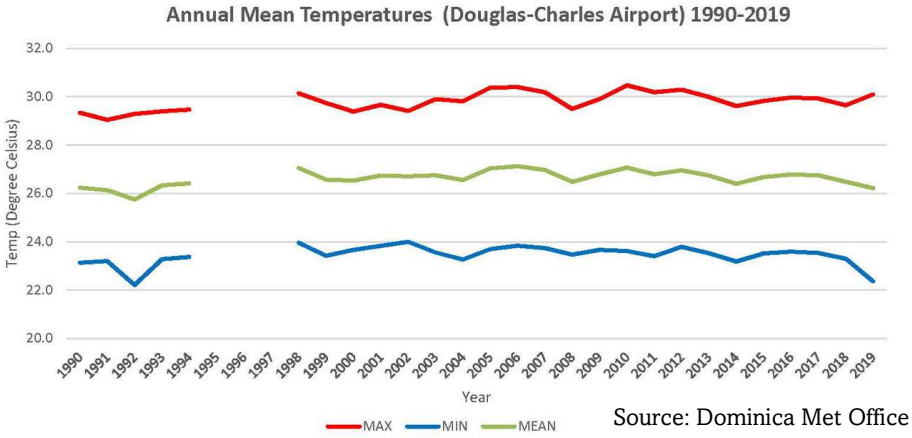

Figure 5: Mean Annual temperature for Douglas-Charles Airport based on a 30-year average for Marigot, Dominica

Climate change variability will likely alter the hydrology of the watershed with higher rainfall increasing surface soil loss and pollutant discharges. Unsustainable human practices that diminish the quality of ecosystem health will also likely enhance erosion with lower and short intense rainfall. On the contrary, higher temperatures are likely to increase demand for water to meet agriculture, tourism, and domestic needs. It is likely that new water-use conflicts may emerge. Higher temperatures may also affect hydrology by its influence on evapotranspiration (a significant part of the water budget). This could significantly alter the hydrological cycle within the locality and cause water deficits. As a result of the noticeable trends in both rainfall and temperature, it is imperative that the watershed health be restored to better cushion the impacts of variable weather events.

2.3 Watershed Hydrology

The watershed has a moderate stream density (1376 ha/15) i.e., for every 92 ha on average, there is at least one stream. These are either seasonal or perennial streams. A physical stream assessment of the main water course was conducted in the lower, mid, and upper watershed (See Figure 6) using the United States Department of Agriculture Stream Visual Assessment

Protocol (SVAP)[2] to ascertain the general health and stability of the watercourse. The SVAP method is regarded as the first step of a four-part assessment protocol to assess ecosystem health associated with streams. This first level assessment provides information on the basic health of the stream, specifically associated with the physical conditions within the assessment area. The results of these assessments are useful in deciding whether further ecological assessments are necessary and to inform stream restoration planning. Overall assessment scores are summarized in Table 1 and fall into four distinct categories namely Optimal (16-20), Sub-Optimal (11-15), Marginal (6-10) and Poor (≤ 5). The general ecological parameters and stability of the water course in the upper reaches is assessed to be marginal to poor. On the contrary, the lower and mid watercourse is deemed optimal and sub-optimal respectively. As per the result of hydrologic assessment, the watershed health and the stability of streams appear to be threatened from the impacts of unsustainable agriculture practices, loss of forest cover and the effects of natural disasters. The loss of riparian vegetation due to agricultural is a major issue affecting the stability of the water course and influx of sediment from the surrounding hillsides

[2] https://efotg.sc.egov.usda.gov/references/public/OK/NWCC_99-1_Stream_Visual_Assessment_Protocol.pdf

Table 1: Stream Assessment Scoring Card for the Quayaneri River

Assessment Element	Watercourse sections Stream Assessment Scoring		
	lower	mid	upper
Sediment deposition in pool	15	18	20
Channel flow status[1]	18	20	19
Water clarity	18	20	20
Channel Alteration	19	20	12
Channel Sinuosity	19	17	5
Bank Stability -Left bank	17	16	18
Bank Stability-right bank	16	19	18
Riparian vegetative Zone width -left bank	2	4	7
Riparian vegetative zone width-right bank	2	11	9
Observed aquatic life in stream	5	5	9
Presence of coarse wood debris (count)	1	3	5
Channel width at station (m)	9	5	5
Wetted width of channel (m)	9	5	5
% wetted width	100	100	100
Right bank slope Steep (S), Moderate (M), Flat (F)	S	S	M
Left bank slope Steep (S), Moderate (M), Flat (F)	M	M	S

Results Key: Excellent | Good | Borderline | Very Poor

2.3.1 Stream flow and water quality

Fifteen tributaries and two main rivers drain the entire Quayaneri water catchment. Stream flow data for the area is scanty but a one-off measurement was taken in the dry season (30/04/2021) during the watershed catchment study in the upper, mid and lower sections of the main river (See Figure 7). Table 2 gives the summary of the flow for each section of the river.

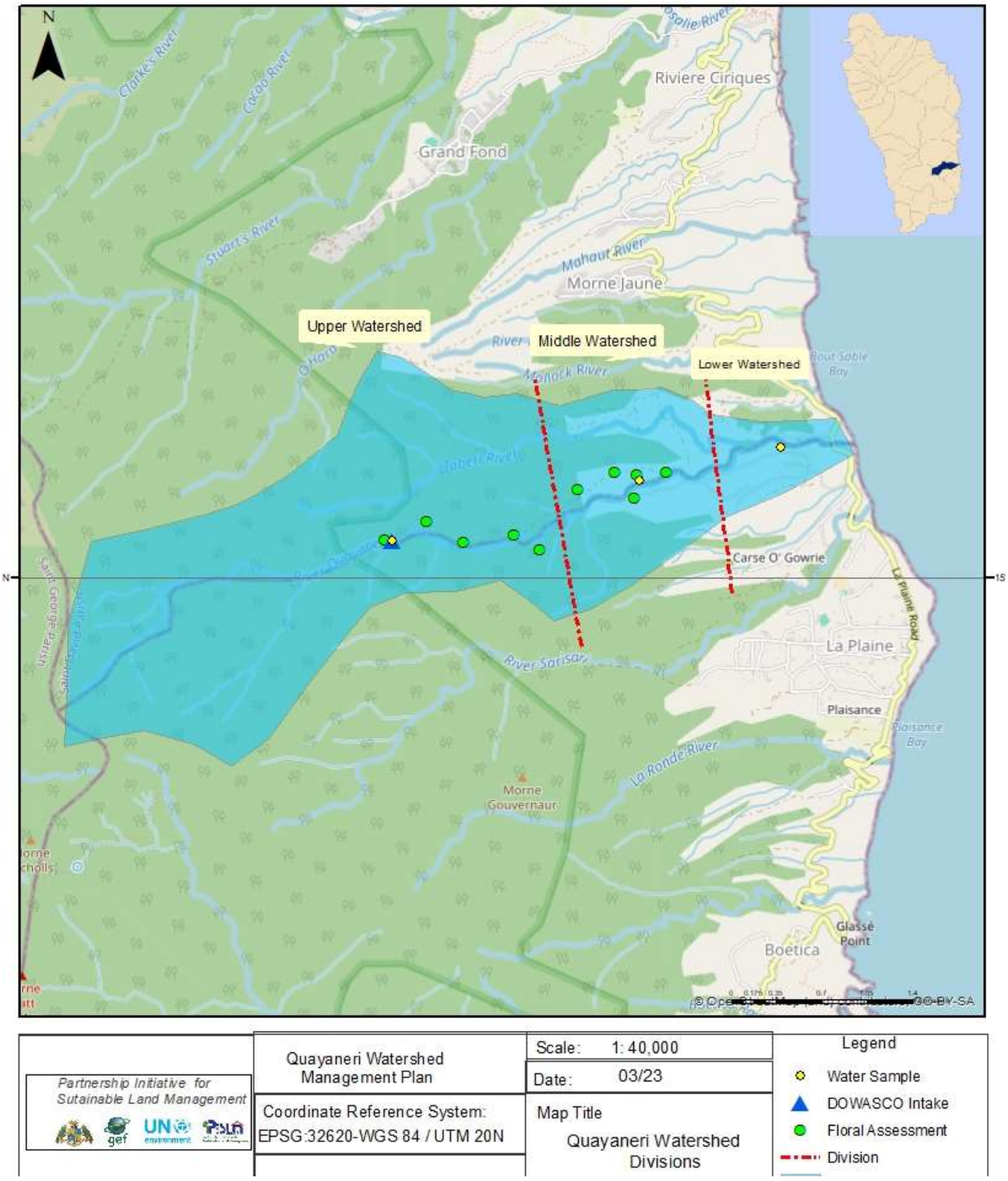

Figure 6: Sampled locations in the QW.

Three water quality monitoring stations and measurement of stream flow are highlighted with 10 sample plots to characterize the vegetation of the area. Agricultural activities dominate the lower watershed precluding vegetation sampling.

Table 2 Summary streamflow measurement for sections of the Quayaneri River (Streamflow measurement conducted 16/08/2021)

Location	M^3/S	GPD
Upper watershed	0.18	3,420,960
Mid watershed	0.225	4,276,200
Lower Watershed	0.275	5,226,467

The flowrate is highest in the lower watershed region where the two rivers converge and exceeds 5.2 m GPD. In the upper watershed flow is 0.18 M^3/S and gradually increased to 0.225 M^3 in the mid watershed as more tributaries converge. No significant rainfall preceded this measurement. During the peak dry season (March- May) flow can decrease up to 30% or more of the wet season measurement based on flow data from DOWASCO for some major rivers. The QR is classified as a Class B river owing to dry season discharge of less than 8 mgd.

Table 3 summarizes the microbiological and pesticidal analysis for water samples taken at two sample sites along the main QR (Qa_Lo_01 and Qa_Mi_02). Please refer to Figure 7 for sample locations. Due to time constraints and processing costs, sampling in the uppermost region of the watershed was not possible to allow same-day transfer of samples to Saint Lucia. Samples were processed by the CARPHA- Environmental Health and Sustainable Development Department Laboratory in Saint Lucia.

Table 3: Water quality parameters for Quayaneri River (Sampled on 08/02/2023[a] and 16/08/2021[b])

Test/Parameter	Sample ID	Method	Result
Chemical Analysis[a]			**mg/L = ppm**
Phosphate	Qa_Lo_01	-	0.08
Nitrate	Qa_Lo_01	-	3.0
Microbiological[b]			**CFU/100 mL**
E. coli count	Qa_Lo_01	EPA1103.1	11
Enterococci	Qa_Lo_01_DUP	EPA1103.1	8
E. coli count	Qa_Lo_01_DUP	CEHILSM-4	45
Enterococci	Qa_Lo_01	CEHILSM-4	**39**
Pesticidal Analysis[a]			**mg/L**
Diquat	Qa_Mi_01	EPA549.1	<0.002
Paraquat	Qa_Mi_01	EPA549.1	<0.002
Diazinon	Qa_Mi_01	EPA3510C/8270D	<0.02
Malathion	Qa_Mi_01	EPA3510C/8270D	<0.02
Dimethoate	Qa_Mi_01	EPA3510C/8270D	<0.06

The Caribbean Public Health Agency recommends the following limits and ranges for surface waters: E.coli (126 CFU/100 mL); Enterococci (35 CFU/100 mL). Based on these recommended limits, Enterococci levels in the lower watershed are high. Note that this is a single sampling effort and does not show a trend.

Nitrates in river water often range from 0.01-3.0 mg/L. Natural levels of nitrate in freshwater streams are usually less than 1 mg/L. Concentrations over 10 mg/L can have an effect on aquatic life. CARPHA recommends 5 mg/L as the maximum nitrate concentration allowed for drinking water.

Results of water quality analysis for the lower section of the Quayaneri River show a concentration of 3 mg/L. The dominant activities upstream include crop and livestock farming which could be potential point sources for elevated nitrate levels in the water. While below the maximum limit the results are indicative of ongoing impacts of human activities on water quality.

On the other hand phosphate levels were recorded as 0.08 mg/L. This is well below CARPHA's recommendation of 1 mg/L for phosphate concentrations in drinking water. Phosphates do not pose health risks to humans except when they persist at high concentrations (well above allowable limits). Typically, background concentrations for phosphates in surface flows are approximately 10 ug/L. Concentrations higher than 0.05 mg/L could be an indication of human impacts. High levels of both nitrates and phosphates can contribute to eutrophication of fresh water and adjoining marine ecosystems.

Enterococci levels detected in samples retrieved in the low sections of the QR is 39 CFU/100 mL This is above the (35 CFU/100 mL) recommended by CARPHA for surface waters. Enterococci have widely been used as indicators of human feacal contamination in surface waters[3].but their presence in animal feaces[4], soil[5] and on plants[6] makes them less reliable. It is likely that elevated levels of enterococci in the low watershed regions is from a single or combined source, possibly: farm sewage, from the nearby paddocks and piggery.

Research has shown that runoff generated by storm events around intensively farmed areas can also contain extremely high concentrations of enterococci. When a surface water is known to contain concentrations of enterococci that exceed regulatory standards, actions must be taken to reduce their concentrations. Microbial source tracking (MST) has become an increasingly popular tool for identifying sources of enterococcal contamination in water[7]. Upon entering surface water, enterococci concentrations may vary due to dispersion and advection, which are controlled by concentration gradients and fluid velocities, respectively. In addition, sedimentation/deposition, resuspension, particle interactions, and light and dark inactivation

[3] Boehm A. B., and Sassoubre L.M., 2014. Enterococci as indicators of environmental fecal contamination. In Gilmore MS, et al. (ed), Enterococci: From Commensals to Leading Causes of Drug Resistant Infection. (Online.) Massachusetts Eye and Ear Infirmary, Boston, MA. https://www.ncbi.nlm.nih.gov/books/NBK190421/.

[4] Layton B.A., Walters S.P., Lam L.H and Boehm A.B. 2010. Enterococcus species distribution among human and animal hosts using multiplex PCR. J Appl Microbiol:109(2):539–574.

[5] Goto D.K., Yan, T. 2011. Effects of land uses on fecal indicator bacteria in the water and soil of a tropical watershed. Microbes Environ: 26(3):254–260

[6] Imamura G.J., Thompson R.S., Boehm A.B. and Jay J.A. 2011. Beach wrack is a reservoir for feacal indicator bacteria along the California coast. FEMS Microbiol Ecol: 77(1):40–49

[7] Boehm A. B., and Sassoubre L.M., 2014. Enterococci as indicators of environmental fecal contamination. In Gilmore MS, et al. (ed), Enterococci: From Commensals to Leading Causes of Drug Resistant Infection. (Online.) Massachusetts Eye and Ear Infirmary, Boston, MA. https://www.ncbi.nlm.nih.gov/books/NBK190421/

due to environmental stresses can also affect concentration. Therefore, continuous sampling and monitoring is key to ensuring safety of surface waters.

The sample was retrieved within an actively farmed area, downstream of the animal husbandry sites and near to eco-tourism establishment. Riparian buffers are significantly depleted within the area allowing unimpeded runoff from farms and an adjacent road into the water course. It should be noted that prior to the sampling event, no significant rainfall was recorded for the area. Given proximity to farms and upstream animal husbandry practices and absence of vegetated buffers, groundwater infiltration is a probable cause of enterococci entry in the watercourse. Significant rainfall events are expected to increase the presence of these microbes in the water column

Results of pesticidal analysis for the targeted groups were within the acceptable limits. It is important to note that pesticides constitute one of the major sources of environmental hazards to humans and animals as they concentrate in the food chain. These results should not be interpreted to mean that water quality is good as no samples were collected after storm events or during the rainy season when their transport is more likely.

2.3.2 Sediment load

Sediment load (SL) or sediment transport is the movement of organic and inorganic particles by water. In general, the greater the flow, the more sediment that can be transported. Sediment movement in streams and rivers take several forms. Suspended sediment is the finer particles which are held in suspension by the eddy currents in the flowing stream, and which only settle out when the stream velocity decreases, such as when the streambed becomes flatter, or the stream discharges into a pond or lake. Larger solid particles are rolled along the streambed and called the bedload.

The relative quantities moved in suspension and as bedload vary greatly from one watershed to the next. At one extreme, during high rainfall events, sediments originating from eroded fine-grained soil, such as allophanoid clays, may remain almost entirely in suspension during transport. This is typical of the characteristic chocolate brown colour of rivers during and after high rainfall events. On the other hand, a fast-flowing clear mountain stream may have negligible amounts of suspended matter and almost all the movement of gravel, pebbles and stones are restricted to the on the streambed.

Sediment transport and their subsequent deposition can overburden aquatic habitats and decrease the amount of available sunlight penetrating the water column. The net effect of this is that it limits photosynthesis and production of algae and macrophytes and affects the functions and biodiversity of benthic ecosystems.

The tendency for sediment transport and loading in the Quayaneri embayment is high during high intense rainfall given the inherent vulnerability and active hillside farming within the watershed. When this occurs, the embayment ecosystems critical to sustaining fisheries and tourism are smothered adversely affecting coral reef systems. The decline in coastal pelagic

fisheries in Dominica is widely attributed to high sediment loading rates from terrigenous sources and longshore drift of sediment laden waters from quarry activities.

Sediment transport is a good indication of how a watershed responds to various interventions. In order to a establish baseline as part of long-term monitoring strategy for the QW, basal and storm-induced sediment load was estimated by the total suspended solid (TSS) method. Unfortunately, a prolonged dry season during the study period precluded storm-induced measurements. **Basal-flow suspended sediment load calculated for the QR on 14/02/2023 was 59 mg/s or 5.1 kg/d.** There was no measurable rainfall for several weeks prior to this measurement and net sediment transport was expected to be low. It is however difficult to gauge whether this value is within a normal range of variability for this system given the general lack of sediment transport studies and data for Dominica. More dry and wet season measurements will need to be made over time to determine average seasonal loads. In one study conducted in two small watersheds in St. Lucia which are of comparable size, under contrasting land management regimes showed that the soil losses from an intensively cultivated agricultural watershed were 20-times higher in magnitude than that of a forested watersheds both for peak rainfall event and for total duration of analysis. This was due to higher surface runoff rates and exposure of soil to direct raindrop impact within cultivated areas (Cox et al. 2006).

2.4 Soils

There are three main soil types within the watershed as indicated in Figure 7.

2.4.1 Allophanoid Latosolics

Allophanoid Latosolics are the dominant soils in the watershed. They are highly permeable, low bulk density and at least 40% of matrix-clay size. According to Lang (1967) Allophanoid soils are normally exceptionally stable even on very steep slopes and mass movements are limited except when the slope is undercut by a stream. This soil type develops best in areas which receive a tremendous amount of rain usually greater than 3,750 mm and where the dry season is limited, and leaching is intense and constant[8].

2.4.2 Young Soils

Yong soils occur mostly in the lower regions of the watershed and long the main flood plains of the QR up to the mid watershed regions. . They are unstable, shallow and consist of compact parent material at their base. As a result, drainage is moderately rapid and lateral.

2.4.3 The Skeletals

Skeletals are less common and exist in a small pocket at the highest elevation on the northern flanks of the Taberi River where the parent material is subjected to continuous weathering. This soil is very shallow, prone to erosion and can support little, if any, agricultural activities. They are quite low in fertility with little topsoil development.

[8] Caribbean Handbook on Risk Information Management http://www.charim.net/datamanagement/36

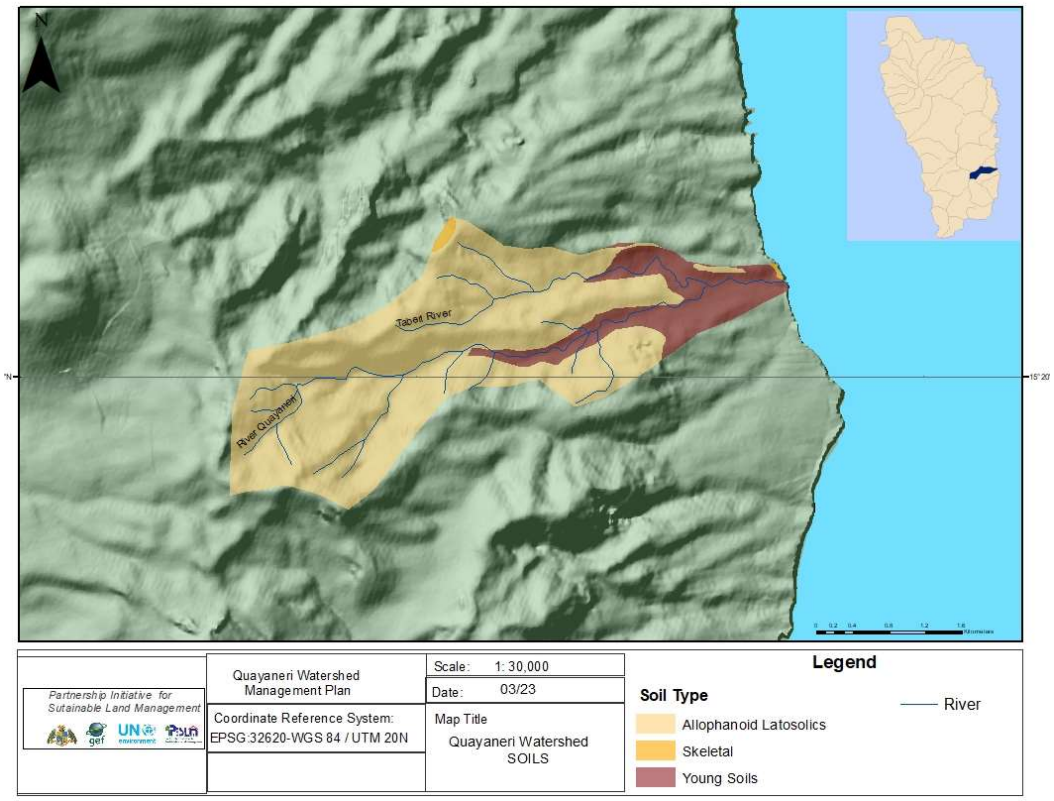

Figure 7 Soil types within the Quayaneri Watershed

2.4.4 Land capability based on soil type and relevant land characteristics

Land capability refers to the ability of an area to sustainably support a given land use without adverse degradation effects to the land and related ecosystems. Agricultural land capability systems in the Caribbean are primarily based on slope, erosion hazard, rainfall and soil type and fertility. In the case of the Quayaneri WS the authors have adapted a simple methodology based on Lang (1967) to assess land capability and make broad recommendations to guide land use management. In Table 4 below, modified from Cox 2005, the dominant soil types within the watershed were characterized as stable and fragile. As indicated earlier the allophanoid latosolics are inherently more stable and display greater resistance to erosion. The young soils on slopes in the lower and parts of the mid watershed region are most fragile and present the highest erosion risks within the watershed. Skeletals confined to a single area is also prone to erosion.

Table 4: Land capability classes and recommended management regimes

<table>
<tr><th></th><th>Stable</th><th>Fragile</th></tr>
<tr><td rowspan="2">Slope classes</td><td>Erosion hazard classes
• Nil
• None
• Low to very Low</td><td>Erosion hazard classes:
• High or moderately high
• High if cultivated
• Very high</td></tr>
<tr><td colspan="2">Soil type</td></tr>
<tr><td rowspan="2">Allophanoid Latosolics (BL3, BL6, BL7)*</td><td>Young soils (IB)*</td></tr>
<tr><td>Skeletal (Skel)*</td></tr>
<tr><td>0° – 5°</td><td rowspan="4">A1 Intensive agriculture
Annual crops or animal husbandry; soil conservation measures where required; tree crops optional</td><td>C1 Intensive agriculture
Annual crops or animal husbandry; soil conservation measures where required; tree crops optional</td></tr>
<tr><td>5° – 10</td><td>C2 Agroforestry/forestry
Tree crops with dense crown cover intercropped with annual crops; tree orchard, natural or plantation forest</td></tr>
<tr><td>10° – 15°</td><td rowspan="4">C3 Production/ protection forestry
Timber plantations, tree crops, forest enrichment, non-mechanized selective harvesting where permissible, forest recreation</td></tr>
<tr><td>15° - 20°</td></tr>
<tr><td>20° - 25°</td><td rowspan="2">A2 Agriculture/Ag-forestry
Agricultural crops on shallow sloping areas, alley cropping; On steeper-annual crops and tree crops</td></tr>
<tr><td>25° - 30°</td></tr>
<tr><td>>30°</td><td>A3 Production/protection forestry
Timber plantation, tree crops, forest enrichment, non-mechanized selective harvesting where permissible, forest recreation</td></tr>
</table>

(After Lang (1967) ***See Appendix C section 8.3**

2.5 Floristic Diversity and land cover

The vegetation cover in the mid and lower regions of the QW has been significantly influenced by human activity. These areas were once the site of huge banana plantations where most of the original vegetation were cleared to establish banana farms and access roads. The lower region of the watershed is actively farmed at present with bananas, plantains and other aroids (Figure 9) and is an estimated area of 192 hectares or 14.6% of total watershed area. The dominant vegetation in the mid to upper regions are the secondary rainforest which 37% (492 hectares) of the watershed by land area. This expanse of vegetation is discontinuous with huge fallow areas and new clearings for cultivation. Montane forests exist at the highest elevation where rainfall is most intense, and soils are characteristically shallower. Montane Forest comprise 13% of the watershed or 175 hectares. On the northern flanks of the lower watershed

is a small patch of semi evergreen forest which is estimated to cover just over 1% (14 hectares) of the watered land surface area.

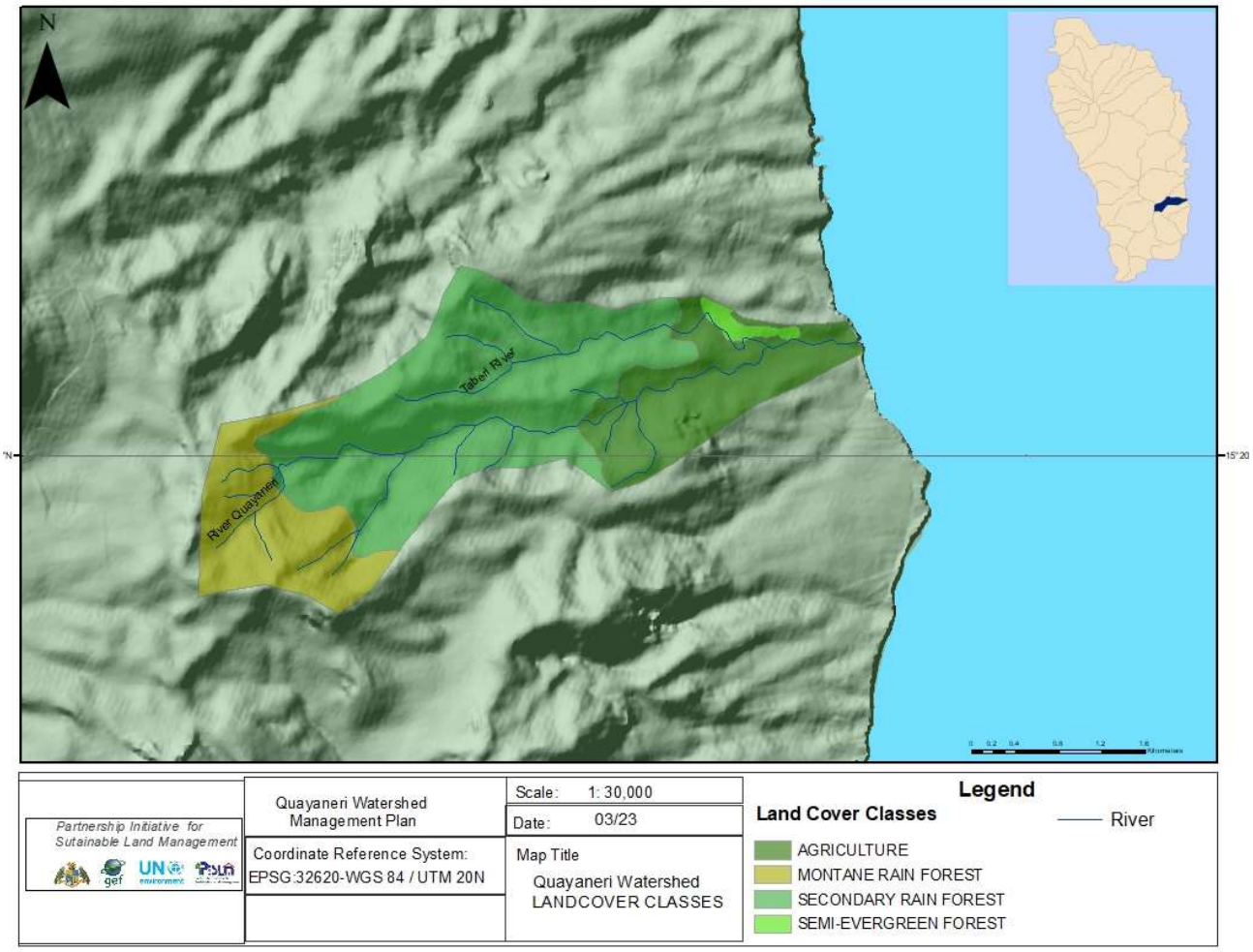

Figure 9: Land use cover map of the QW

The forest is however one of the largest natural resource assets for the community critical to water and biodiversity conservation. It is also driving local investments into ecotourism investments. Good management practices and effective planning aimed at restoring key watershed processes and species diversity are paramount to the full recovery of the system. It is therefore critical to gauge how the system has been recovering following the devastating impacts of Hurricane Maria nearly 8 years ago. Accordingly, EcoApp Inc. conducted a baseline assessment of mid to upper regions of the watershed in April 2021 to determine species diversity and evenness. The lower watershed region was not included in the faunal survey because much of the vegetation has been lost due to crop establishment. The Shannon Diversity Index (sometimes called the Shannon-Wiener Index), H, and the Shannon Equitability, $E_{H,}$ was calculated from the faunal survey completed for the watershed. High *H* values denotes a high species diversity for a particular community of plants and vice versa. Values for evenness range from 0 to 1 with higher values indicating more evenness in terms of species distribution. The result of this analysis is summarized in Table 5.

From the data, the upper watershed has a higher species diversity compared to the mid regions. This was wildly anticipated because much of the upper watershed region is part of the MTPNP where forest use is restricted. Human activities including clearing of lands for crop establishment in the upper mid regions of the watershed is encroaching on the MTPNP boundary line and is presently one of the major issues affecting forest management there. This is compounded by the fact that most of the land in this transition zone is still under private ownership and being sold to private developers. On the contrary, the mid watershed has been impacted by farming and deforestation and has a comparatively lower species evenness. Forest management for Quayaneri should take these indices into account when planning enrichment planting programs for the area.

Table 5: Summary of values re Shannon Diversity Index and Evenness for surveyed vegetation QW

Watershed Section	Value
Upper H	2.20
Upper E_H	0.81
Middle H	1.39
Middle E_H	0.63

2.6 Faunal Diversity

Surveys of the MTPNP[9], which includes a section of the QW, indicate at least 13 species of mammals, 50 birds, 12 reptiles and amphibians and 12 crustaceans. Apart from seven species of bats and the introduced black-eared opossum *Didelphys marsupialis* and agouti *Dasyprocta* spp (Figure 8). There are no terrestrial mammals beside feral cats, pigs and two species of rat. Birds include the locally iconic imperial amazon parrot, *Amazona imperialis* and red-necked amazon parrot, *A. arausiaca*, both once common but now threatened. Boa *Boa constrictor nebulosa* which grows to 3.6m in length is common in the Park. There are no poisonous snakes. Three species of lizards, including the endemic *Anolis oculatus*, exist in the Park along with several species of freshwater shrimps and crabs. The island's two native species of tree frogs, including the endemic *Eleutherodactylus amplinympha*, also occur in the Park. There is a wide variety of moths and 55 species of butterflies.

Figure 8 Agouti Dasyprocta spp

2.7 Birds

Bird diversity and association to a forest is indicative of how complex the forest community structure might be. Forested areas have a mix of different vegetation types including the tall

[9] Environmental Coordinating Unit (2000). *The Commonwealth of Dominica's First National Report on the Implementation of the United Nations Convention to Combat Desertification (UNCCD).* Ministry of Agriculture, Planning and Environment, Roseau, Dominica. 34 pp

trees that make up the forest canopy as well as layers of shrubs and other understory plants. These plants provide food sources, breeding and nesting habitats, and protection from predators. The type, density and structure of plant life in a forest will influence the bird species that live there. Different species thrive under different conditions, with some preferring dense, mixed underbrush and others preferring a more open habitat.

Dominica's has four important bird areas (IBAs) which are international priority sites for bird conservation. Three of these areas are in the south of the island, close to and within the MTPNP covering an area of 106 km² (including marine areas) and about 13% of the islands' land area[10]. The QW is associated with the largest IBA and therefore it is important for bird conservation. IBA designations are established on the basis of 25 key bird species associated with an area. Of these 25 species, at least three globally threatened birds, all 19 restricted-range species, and six congregatory seabirds are found there[11]. It is well known that the Forest Reserves were established to preserve the endangered Imperial Amazon (*Amazona imperialis)* and the vulnerable, Red-necked Amazon (*Amazona arausiaca)*. The majority of the island's *A. imperialis* and the A. *arausiaca* is reported to either live in or frequent the area.

A total of 176 species of birds have been recorded for Dominica, of which about 66% are Neotropical migrants and 34% are resident species. Twenty-nine species of birds were recorded during a bird survey of the watershed according EcoApp Inc. Figure 11 shows percent recorded per region of the watershed. Highest bird counts were recorded in the UML regions. Despite the seemingly relative intactness of the upper watershed regions, only 7% of the total counts were found there. Table 6 presents bird counts per watershed sub-section while Table 7 collectively shows the main species associated with the general watershed.

Table 6: Bird counts per watershed region

Watershed region	Watershed section ID	Bird Count	%
Lower only	L	4	14
Lower & Mid	L&M	7	24
Mid only	M	5	17
Upper Only	U	2	7
Upper Mid and Lower	UML	11	38
Total		29	

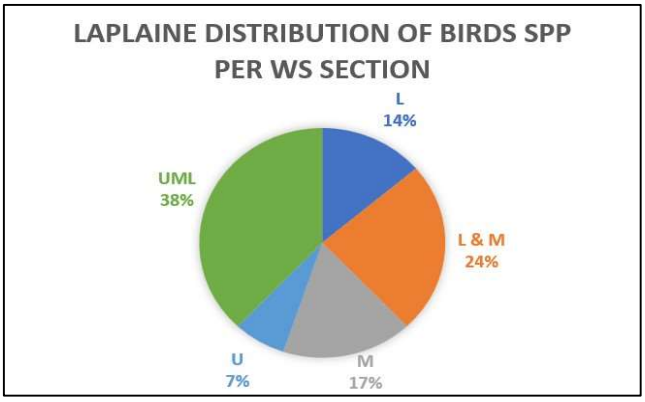

Figure 9 Distribution of birds throughout the

In spite of the conservation legislation and protective measures in place, biodiversity is under pressure in Dominica. Habitat is being lost due to agricultural expansion, housing development and proliferation of other activities including marijuana cultivation) in the island's interior and areas used by the parrots (Durand and Jno. Baptiste 2000). The study also concluded that the harvest of mature gommier trees (*Dacryodes excelsa*) which are slashed for illegal gum

[10,11]Durand and Jno.Baptiste 2000. The wildlife of Dominica. Forestry Wildlife and Parks (Ministry of Agriculture and the Environment (http://datazone.birdlife.org/userfiles/file/IBAs/CaribCntryPDFs/dominica.pdf)

harvesting, is a major threat to these endangered species. This is one of the key tree species used by both parrots for food and nesting. In addition, natural disasters (e.g., tropical storms and hurricanes are also a significant threat to habitat. Hurricanes are particularly worrying to the parrot populations, their nesting trees, and foraging areas, especially considering that with climate change more frequent and intense storms are anticipated. This is likely to delay or prevent forest recovery to previous conditions. Hurricane David devastated Dominica in 1979, nearly extirpating *A. imperialis*, and reducing *A. arausiaca* to a fragment of its former range[12]. The recent impact of Hurricane Maria (2017) also had major consequences for both species of parrots.

Table 7: List of bird species associated with the QW

No	Common Name of Bird	Scientific Name	Status
1	Antillean Crested Hummingbird	Orthorlynius cristatus	Caribbean endemic
2	Antillean Euphonia	Euphonia musica	Caribbean endemic
3	Bananaquit	Coereba flaveola	
4	Black-faced Grassquit	Tiaris bicolor	
5	Black-whiskered Vireo	Vireo altiloquus	
6	Blue-headed Hummingbird	Cyanophaia bicolor	Caribbean endemic
7	Broad-winged Hawk	Buteo platypterus	
8	Brown Trembler	Cinclocerthia ruficauda	
9	Carib Grackle	Quiscalus lugubris	
10	Caribbean Elaennia	Elaenia martinica	Caribbean endemic
11	Common Ground Dove	Columbina Passerina	
12	Gray Kingbird	Tyrannus dominicensis	
13	Green Heron	Butorides virescens	
14	Green-throated Carib	Eulampis holosericeus	Caribbean endemic
15	House Wren	Troglodytes aedon	
16	Lesser Antillean Bullfinch	Loxigilla noctis	Caribbean endemic
17	Lesser Antillean Flycatcher	Myiarchus oberi	Caribbean endemic
18	Little Blue Heron	Egretta caerulea	
19	Mangrove Cuckoo	Coccyzus minor	

[12] Durand and Jno.Baptiste 2000. The wildlife of Dominica. Forestry Wildlife and Parks (Ministry of Agriculture and the Environment (http://datazone.birdlife.org/userfiles/file/IBAs/CaribCntryPDFs/dominica.pdf)

No	Common Name of Bird	Scientific Name	Status
20	Plumbeous Warbler	Setophaga plumbea	Caribbean endemic
21	Purple-throated Carib	Eulampis jugularis	Caribbean endemic
22	Red-necked Parrot	Amazona arausica	Dominican endemic
23	Ringed Kingfisher	Megaceryle torquata	
24	Scaly-breasted Thrasher	Allenia fusca	
25	Scaly-naped Pigeon	Patagioenas squamosa	Caribbean endemic
26	Smooth-billed Ani	Crotophaga ani	
27	Spotted Sandpiper	Actitis macularius	Neotropical migrant
28	Yellow-crowned Night Heron	Nyctanassa violicea	
29	Zenaida Dove	Zenaida aurita	

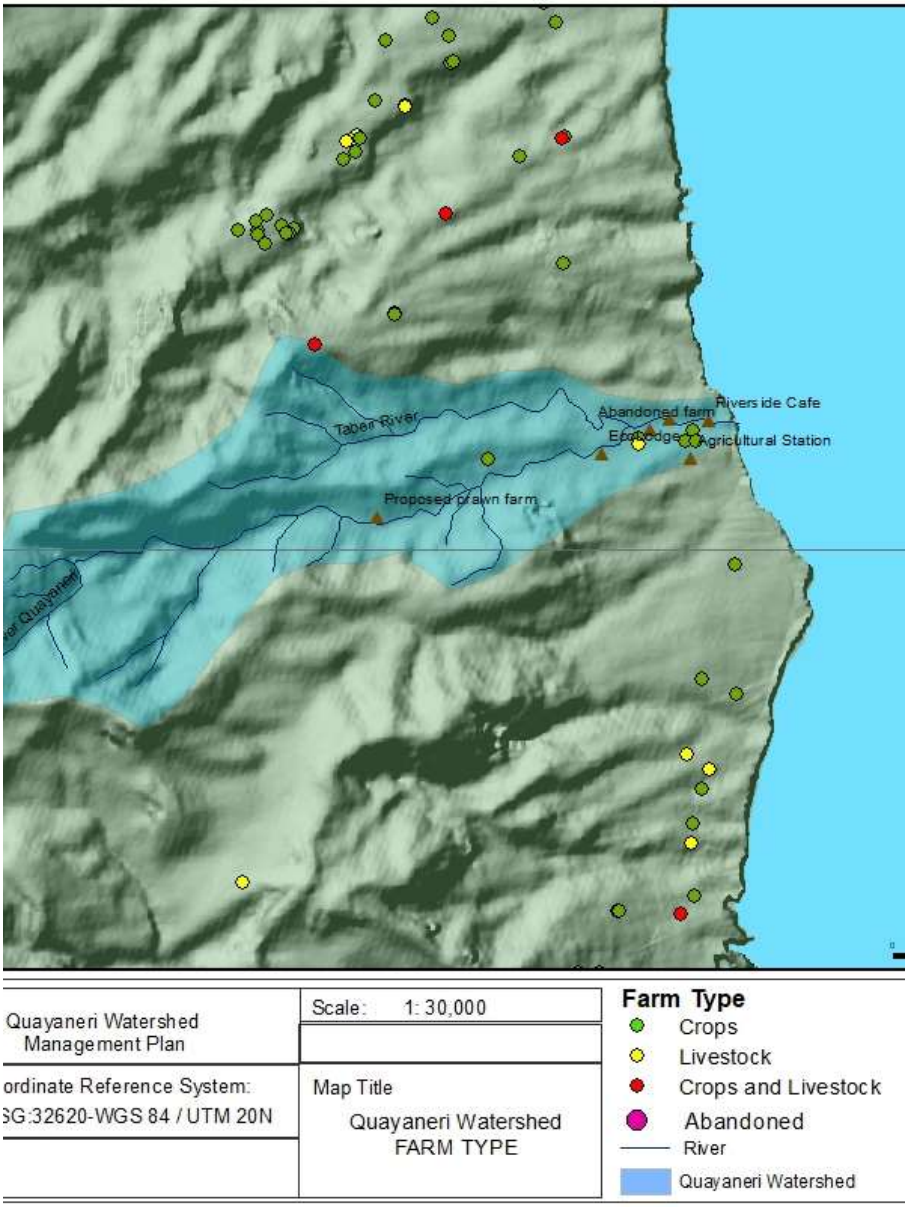

Figure 10: Location of major farms and tourism establishments in the QW

2.8 Agriculture and land use

Like any other agriculture dependent community in Dominica, open-field production is mostly practiced. Without exception, agricultural production in Dominica and in this watershed is characterized by clear felling of forests, high use of agricultural inputs including inorganic fertilizers and agro-pesticides[13]. Along many parts of the main river, farming occurs right up to the edge of the riverbank where the original riparian vegetation has either been removed or depleted. This practice continues to destabilize the watercourse and promote soil loss. The

[13] Rainy, W., et al., 1987. Dominica (West Indies) Banana Industry Rehabilitation: A Pesticide. Assessment Island Resources Foundation (IRF), St. Thomas, VI. http://www.oas.org/reia/iwcam/pdf/dominica/report.pdf

lower and mid sections of the watershed are the most actively farmed regions. Up until a few years ago, these areas were generally large estates concentrating on banana production but smaller holdings are now more common with a mix of other crops being established. Evidence of human impact on the landscape is most evident in the mid watershed regions where abandon farms give huge grass land-like formations.
The lower watershed region is generally undulating and more conducive to mechanized agriculture. There is an agricultural station nearby which provides planting material and technical assistance to farmers. The area was also well noted as the site of a controversial piggery and a source of effluent discharge into the river. A major paddock development for goat and cattle rearing has been established in areas where farms have been abandoned. In the lower section of the upper watershed, a site had been cleared for a proposed prawn-farming development, was observed during the field survey.

The eco-tourism potential of the area has been on the rise. There is concern amongst farmers that some of the prime lands within this watershed are being sold to foreigners for development. At present, there is the Citrus Creek Plantation Hotel and 'La Kabann Cé Tèt Canal Ecolodge' which takes advantage of the unique biodiversity of the area. The potential for promoting the area for birdwatching, hiking and recreational river use remains largely untapped.

Given the topographical features and entrenched subsistence farming culture, the agricultural sector and notably, farming within the QW, suffered high damages and losses following the passage of Hurricane Maria. This severely affected the livelihoods of the farming community. An estimated 80–100 percent of root crops, vegetables, bananas, and plantains and 90 percent of tree crops were damaged nationally including damages to farm buildings, equipment and losses in livestock totaling an estimated US$179.6 million[14].

Presently, agricultural land-use is estimated as 192 hectares or 14.6% of total watershed area where more than 140 farmers operate on a full-time basis. On the surrounding hillsides, annuals including root crops such as dasheens (*Colocasia esculenta*), tannia (*Xanthosoma sagittifolium)*, ginger (*Zingiber officinal*), yams (Dioscorea spp), and sweet potatoes *(Ipomoea batatas)* are mostly cultivated. These crops require significant soil disturbance which increases the potential for erosion and soil loss. Bananas and plantains are mostly grown in the flatter areas. Farm locations within the watershed are depicted in Figure 10.

2.9 Socio-economic Status

The village of La Plaine (15°17′N 61°15′W) is located on the eastern side of the island of Dominica in the Parish of St Patrick with a population of 1,128 (Table 8). It is the second-largest population settlement in Saint Patrick's Parish. Most of the settlement is to the south of the watershed boundary line and small pockets also exist along the outskirts of its northernmost flanks. There are 562 dwelling units with an average of 2.5 persons per household according to the Dominica Census Report 2011[15].

[14] Dominica Emergency Agriculture Livelihoods and Climate Resilience Project, https://agriculture.gov.dm/images/documents/basic_project_data.pdf

[15] https://stats.gov.dm/wp-content/uploads/2019/06/Population_and_Housing_Census_2011.pdf

Table 8: Non-Institutional population, households, and dwelling units by geographic area 2011 for La Plaine

Communities	Non-Institutional Population	No. of households	No. of persons per household	No. of dwelling units
La Plaine	1128	482	2.5	562

Source: 2011 National Census

Houses are clustered mostly in the largest expanse of flat land in this area. Figure 11 shows major population settlement in La Plaine.

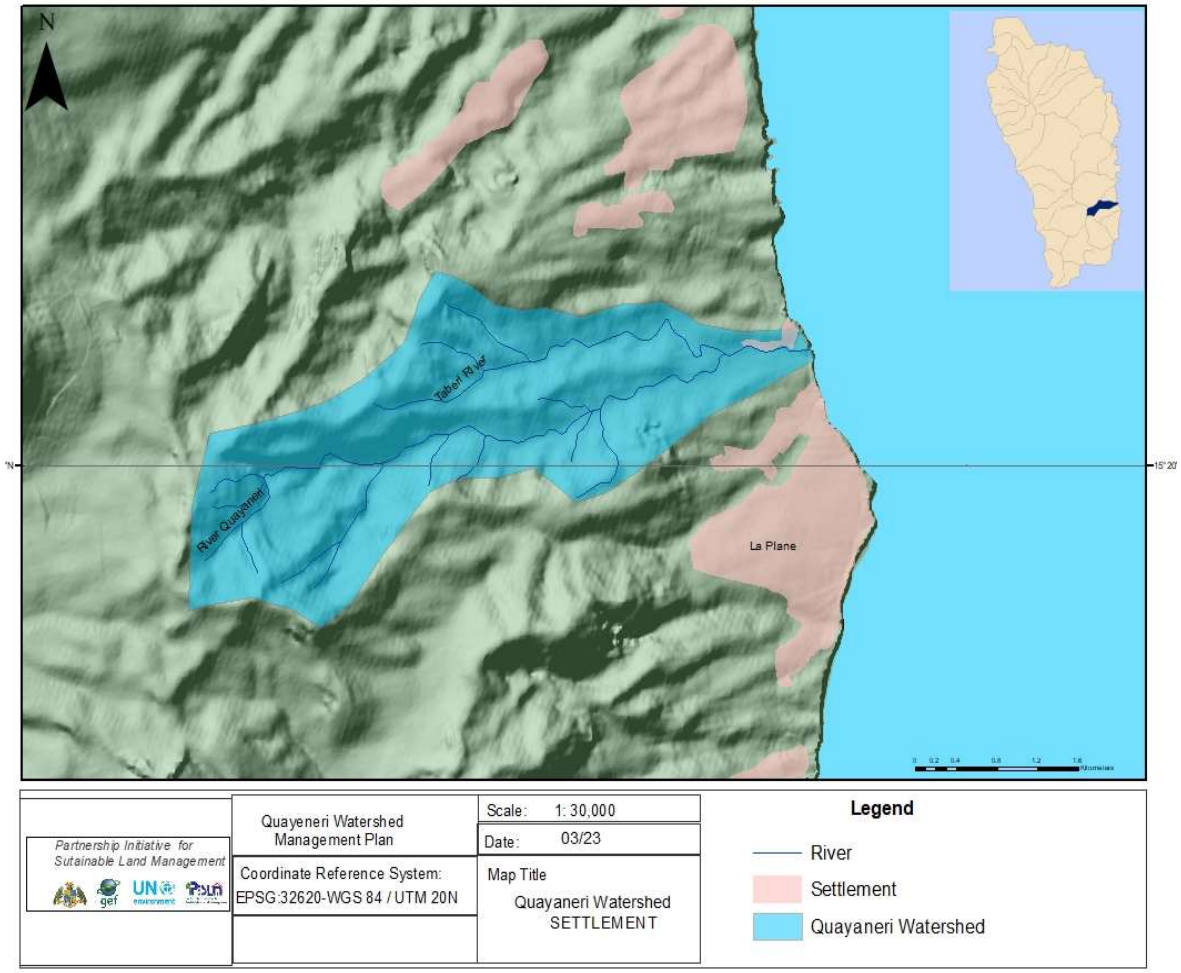

Figure 11: Settlement within the QW

St Patrick, like Joseph and St David, are among the poorest parishes in Dominica. According to a Poverty Assessment Report[16], poverty levels are at least 10% higher than the national average

[16] Kairi Consultants Limiteed 2008/2009. Country Poverty Assessment-Dominica Volume 1 Main Report. Submitted to the Caribbean Development Bank in collaboration with the national assessment team of Dominica. Accessed on 6/16/2023: https://prais.unccd.int/sites/default/files/2018-08/Dominica%20CPA%202009%20Main%20Report%20Final.pdf

in these communities. The east coast inclusive of La Plaine is heavily engaged and reliant on primary activity, namely agriculture and fishing. It is possible that for certain specific reasons, La Plaine might have suffered from rural population drift in the last couple decades as the banana industry went into decline. This situation contributed in part to loss of household income and sustainable employment. Non-Banana crop cultivation has increased but not on the scale as for bananas. Small eco-tourism establishments have not been sufficient to address unemployment problems but are regarded as one area where growth can accelerate. The development of a viable agro-tourism enterprise in the area will ultimately depend on conserving the natural environment and biodiversity.

2.10 Use of water resources

The Water and Sewerage Act, Chap. 43:04 of the revised laws of Dominica states the Government's water policy. The Act generally speaks to the orderly and coordinated development, use and conservation of Dominica's water resources. It also makes the DOWASCO responsible for the supply of water to all residents of the country. The demand for water can be categorized as potable and non-potable. The potable demand consists of the domestic, commercial and industrial demand whilst the non-potable is inclusive of agricultural, laundering, hydro-electrical, religious and baptismal, recreational to include swimming, boating, and commercial ecotourism activities.

Water is abstracted for community use in the upper sections of the Quayaneri River where a weir has been constructed and is fed to the communities through a line which forms the main artery of the supply network. The undulating terrain offers the benefit of water being gravity fed throughout the network without need for the use of pumps. The upper section of the QR has the capacity to supply 3.4 mgd and under the present stream classification system for the supply of potable water, it is considered a class B Stream. Nationally, DOWASCO's main potable water infrastructure is located on the largest rivers including Indian, Picard, Layou, Roseau, Blenheim, Hampstead, Clyde, Pagua, Castle Bruce and Rosalie rivers all of which have average annual flows in the order of 10mgd[17] and typically supply multiple communities.

The Quayaneri supply system is generally more than adequate to satisfy the demands of the Community of La Plaine and its surrounding hamlets. Water demand for rural household was estimated at 45 gallons per head per day[18]. However, it is not uncommon that during the dry season, intermittent shortages can be experienced. This is associated with the observation that in some streams dry weather could drop to as low as 30% of their average wet weather flows. The period from January to June is considered to be the drier half of the year although this distinction is less pronounced in some years through the interior and the east coast than along the west coast. In the months of April and May the occurrence of hot, dry spells tend to be more persistent and more intense. During these dry spells water consumption increases due to increased watering of lawns and backyard gardens, as well as longer and more frequent bathing. The effect of this increased consumption is compounded by a reduction in stream flows. Good

[17,18] http://www.oas.org/reia/iwcam/pdf/dominica/report.pdf

watershed management ensures the community water security is safeguarded and should form part of strategic planning for the sustainable development of the community.

Given the local geology of the area and the absence of agriculture above the main abstraction point, water quality has been known to be of a high standard thus requiring minimal treatment. The only form of treatment used within the network is chlorination and water quality test results are generally within the limits of the World Health Organization (WHO) standards.

3 Summary of Key Issues within the Quayaneri Watershed

3.1 Introduction

The QW transitions from relatively well-preserved forests in the upper watershed regions to an agricultural modified landscape in the lower watershed. Deforestation is evident throughout the mid and lower watershed regions. The removal of riparian buffers along much of the watercourse increases the risk of streambank collapse and soil loss. The poorly developed Skeletals are prone to erosion and the modification of the flow channel. The combination of slopes, varied topography and often alternating dry and wet spells in this area requires a combination of biological and structural soil and water conservation measures to provide a protective vegetation cover and to minimize the downward transport of soil. The maintenance of good vegetative cover and reintroduction of native species in areas where disturbance is most acute, must be considered as part of any restoration effort for this watershed system. Without these measures, the watershed's health is likely to get worse because of the severity and frequency of extreme weather events and the recovery lag times for certain species. This chapter presents a summary of the main issues relating to this watershed.

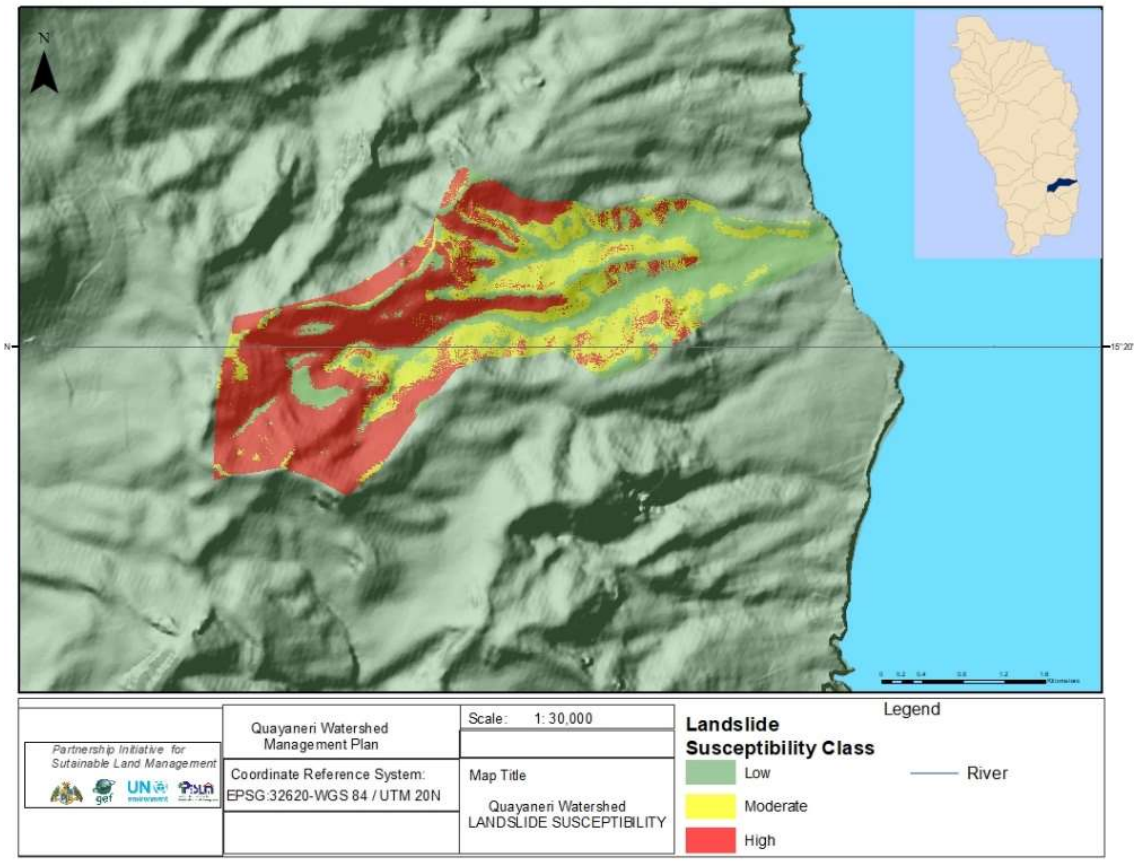

Figure 12: Landslide susceptibility within the QW

3.2 Landslide vulnerability of the Quayaneri Watershed

Dominica's landscape is primarily of volcanic deposits that form rugged peaks with slopes greater than 40 degrees. The island is undoubtedly the only water surplus country in the Eastern Caribbean, receiving more than 8000 mm annual rainfall at highest elevations[19]. There are three dominant soil types present in this watershed namely: Allophanoid Latosolics, Young Soils and Skeletals. They differ primarily based on the types and quantities of clay minerals they contain, characteristics that are highly influenced by climatic factors and time.

Slope, soil type and climate play a large role in the occurrence of landslides in Dominica. A landside is essentially the movement of soil, rocks or debris down a slope. On steep slopes in the upper watershed, landslides can be triggered by high intensity rainfall during tropical storms and hurricanes but can also be caused by human activities such as deforestation and poorly designed road construction[20]. Figure 12 shows the upper and steeper areas of this watershed

[19] Williams, A. N. (2020). Deluge: Dominica's Water Surplus, The Caribbean Water Crisis and The Global Water Challenge. ACT Press.

[20] DeGraff, J. V., Bryce, R., Jibson, R. W., Mora, S., & Rogers, C. T. (1989). Landslides: their extent and significance in the Caribbean. Landslides: Extent and economic significance, 68.

have a higher vulnerability to landslide formations. The risk is moderate to low in the mid and low watershed region respectively.

The landslide susceptibility map of the QW (Figure 12) shows areas in the watershed where landslides occur or are likely to occur. The likelihood is indicated either qualitatively (as high, moderate, low, and not susceptible) or quantitatively (e.g., as the density in number of landslides per square kilometer, or area affected per square km). Landslide susceptibility takes into consideration where slides have occurred in the past and where they may occur in the future given present vulnerabilities.

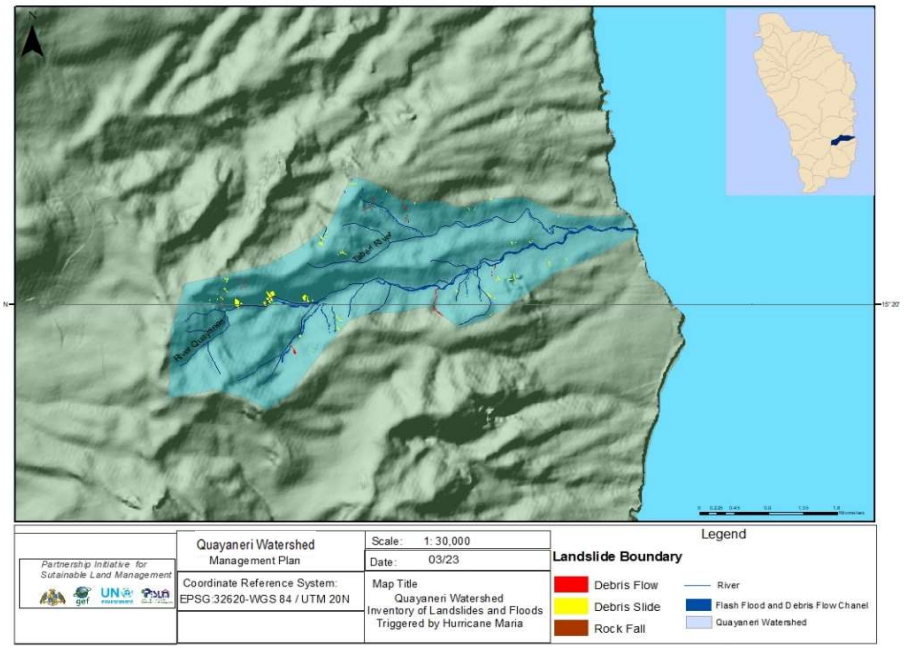

Figure 13: Landslides in the QW attributed to Hurricane Maria

The risk for landslide development within the QW is moderate to low. Most of the slides occurred in the upper watershed regions where the slope and rainfall is steeper and higher, respectively. Soil type seems to play a less critical role in the formation of the slides in this watershed. At present, some landslide-prone areas are actively farmed.

An important but less studied effect is the attritional impact of hazards such as landslides and slope instability which increase year-to-year costs of creating or sustaining infrastructure and make recovery from intensive events harder[21]. The effects on farm productivity needs to be studied as well. Figure 13 illustrates areas in the watershed impacted by slides during the passage of Hurricane Maria in 2017. Thirteen (13) debris flows (fast moving mudslides often referred to as mudflows, or debris avalanche) occurred in areas of the mid to upper watershed of in small pockets in the along the steepest slopes. Debris slides (mass of unconsolidated and incoherent soil and rock fragments that slide or roll rapidly down a steep slope) occurred throughout the watershed, but high densities were noted for the upper watershed. Several of the of the 67 landslides impacting the area occurred within the vicinity of active farming areas. More studies are required to determine the root causes of landslides. Rockfalls were less common in this watershed.

Hurricane Maria exposed the impacts of poor land use management that had remained hidden in the hinterlands for several decades. The unprotected and unstable slopes left behind from deforestation within the mountainous interior has accelerated soil erosion and accumulation of

[21]Barclay, J., Wilkinson, E., White, C. S., Shelton, C., Forster, J., Few, R., Honychurch, L. (2019). Historical Trajectories of Disaster Risk in Dominica. International Journal of Disaster Risk Science, 10(2), 149–165. https://doi.org/10.1007/s13753-019- 0215-z

soil and other debris in rivers and streams. This will elevate the risk of flash floods in the foreseeable future. With these conditions in the upper catchments, it is expected that debris flows will be triggered with rainfall thresholds that are substantially lower than storm events. Prolonged low intensity rainfall during the rainy season is also capable of producing debris slides particularly within areas where the young soils are dominant.

3.3 Unsustainable Land Use

3.3.1 Deforestation

Deforestation is the leading cause of soil loss and uncontrolled erosive surface runoff within the watershed. When new areas are cleared for cultivation, percolation and ground water recharging processes are altered. If the cleared areas are exhaustively farmed, without adequate ground cover or other measures to restore soil health, fertility will rapidly decline in the exposed ground. Figure 17 shows patches of cleared forested hillsides where recovery rates are slow. Gradually, farming and the clearing of forest continues to encroach close to the boundaries of the protected forest of the MTPNP. Deforestation is the major cause of habitat fragmentation and loss. The practices of slash and burn agriculture is also detrimental, as forest fires destroys both mature and regenerating seedlings and saplings. Figure 18 highlights the effect of fire in the lower section of the watershed. It is estimated that approximately 20-30% (anecdotal information) of the forest cover in the watershed have either been removed or altered.

Figure 14: Deforestation along riparian area in QW for establishment of a prawn farm.

Figure 15: Effects of fire on tree loss in the watershed

There evidence is clear that farming practices continue in and around the upper catchment areas without riparian buffer systems in place. Part of the problem stems from private land ownership rights and the lack of control in areas close to the boundaries of the MTPNP. Vegetation removal in this area depletes the forest buffers and increases the risk of soil erosion and water pollution. Farming in these areas may also have an effect of the local hydrology which may either increase the risk of landslides or diminish the water retention capacity of the system.

The QW is well noted for the cultivation of bananas but since the decline of the banana industry a mix of vegetables and short-term root crops such as ginger, dasheen and yams are being cultivated. The cultivation of these crops involves intense soil disturbance during planting and harvest which normally coincides with the onset of the rainy season. Often farmers do not practice soil conservation as this increase their production costs. Hillside cultivation contributes to soil and nutrient loss. The application of agrochemicals under

Figure 16: Farming in the riparian zone up to the edge of the riverbank

3.4 Shifts to cultivation of short-term crop without adequate soil conservation measures

In recent years the mix of crops dominating the farming landscape has changed significantly. There is now a shift from tree crops and banana cultivation to the production of high value short-term crops like ginger, yams and vegetables (Figure 20). These crops require high tillage and weed control. They do not provide long-term or adequate soil cover or comparable organic matter returns. Land tenure arrangements have shifted in equal proportions, moving from farmer owned to a dominance of rent and lease arrangements. This stifles investments in long-term crops and measures including the establishment of proper drainage systems.

Figure 17: Soil preparation for root crops in the upper region of the QW

3.5 Water supply and quality

Water is the major transport agent (for soil and contaminants) connecting the upper with the lower watershed regions. Good water quality and consistency of supply is a major function of the watershed system however, human actions have largely elevated the risk for contamination of rivers and streams in most watershed systems. Notably for the QW, the indiscriminate use of agrochemicals and chemical fertilizers is a cause for concern. In addition, a piggery and paddock system for cattle and goat rearing close to the main river can introduce effluents into the waterway and impair its quality. The eco-tourism establishments in the lower watershed are highly dependent on good water quality. It is also important to note that the water supply for the community was relocated to a site further up river due irreparable damages to the intake, heavy sedimentation and morphological changes of the river- channel and -bed following Tropical Storm Erika and Hurricane Maria. This is a pattern observed in several other watersheds and is likely to recur with future hydrometeorological events. Dredging and similar interventions that alter channel morphology can also have detrimental effects on aquatic biodiversity, introduce silt and resuspend contaminants into the water column (Figure 21). The net effects are the elevation of riverbed downstream of where these disturbances occur, increased risk of flooding, and subsurface flows during the dryer periods.

Figure 18: Unsustainable and ill-advised alteration of the river channel morphology in the lower section of the OW

3.6 Weak monitoring and enforcement

There is no regulated zoning or land use management plan for the QW. Crop selection, farm location, and road access are all left to the choice of the individual farmers and landowners. Although the Forest Act Chapter 60:01 of the laws of the Commonwealth of Dominica makes provision for protection of lands above water intakes, little monitoring and reporting means activities go unchecked. Extension services are provided to farmers by the Ministry of Blue and Green Economy, Agriculture and National Food Security but the role of extension staff is mostly confined to crop production and pest control. The Forestry Division Eastern Range staff oversees activities in the area but there is a lack of manpower to cover this vast area. One of the key problems flagged during the community consultation stage is that there is no clear authority to report to when questionable activities in the watershed are observed.

3.7 Lack of awareness on sustainable watershed management

Concern for watershed protection is growing, however, the awareness levels in the community are not nearly enough. There is no organized forum for getting the public sensitized to address critical watershed management issues.

3.8 Not enough local champions for watershed protection in the community

Watershed governance is about ensuring that local voices and concerns shape decision-making at the highest level. The presence of a community-based group would create an opportunity to bring critical issues to the forefront and ensure that a more holistic and process-oriented approach is adopted. Participatory approaches value communication, perspective sharing, peer-to-peer learning, negotiation, and the development of adaptive plans that are accepted by diverse stakeholders in the community[22]. Unfortunately, no organized voices or community groups have been able to echo concerns to the relevant authority. For watershed management plans to be effective, local champions are needed. When done right, watershed governance can help resolve complex resource management problems and conflicts which otherwise would be daunting.

4 Policies, Rules, Regulations, and Institutional Framework for Watershed Management

4.1 Introduction

The institutional base of natural resource management in Dominica dates to the late 1940's with the establishment of a Forestry Department in 1949. Over time, this institutional base has widened to include a host of mainly government ministries and departments, which have specific responsibilities for management of different aspects of the island ecosystem.

The protection and management of forest and water resources, river basins, and watersheds is crucial for long-term ecological resilience and national adaptation to climate change. The value of these critical resources is enshrined in *Forest Act chap 60:01* and in various Statutory Rules and Orders pertaining to water and sewerage management, physical planning, and fisheries management of the laws of the Commonwealth of Dominica. These legislations combined with Dominica's ratification of several international agreements for the conservation of biological diversity and combating desertification, is a demonstration of the Government's willingness to preserve the islands' watersheds and forestry resources to preserve the health of its people. Together these Acts and Statutory Rules largely set the framework for watershed management and planning at local and national levels.

Since the 1975 declaration of the Stewart Hall Catchment Area (Protected Forest) Order under Sections 4 and 5 of the Forest Act Chapter 60:01, a model for water catchment management in Dominica has evolved. The declaration summarily highlights what is and what's not permissible within the watershed catchment designation and outlined the role that DOWASCO and the Forestry, Wildlife and Parks Division (FWPD) must play to preserve the integrity of the catchments.

According to section 2 of the Water and Sewerage Statutory Rules and Order No.13 of 1995, water catchment includes any area designated as a "protected forest" having areal extents depending on classification of streams.

[22] Berkes, F. 2017. Environmental governance for the Anthropocene? Social-ecological systems, resilience, and collaborative learning. *Sustainability*, *9*, 1232

CLASS A STREAM

All rivers, lakes, streams having an average dry season streamflow of more than 8 million gallons per day and producing or capable of producing portable water for domestic use or export

CATCHMENT AREAL EXTENT

All land upstream of the intake and within 50 metres of each side of any class A stream forms part of the water catchment

RESTRICTION IN WATER CATCHMENT

(a) agricultural activity requiring the use of agro-chemical inputs.
(b) camping.
(c) chainsaw harvesting.
(d) mechanized logging
(e) road construction

CLASS B STREAM

All watercourses carrying permanent running water at the average dry season flow rate of 1 to 8 million gallons per day;

CATCHMENT AREAL EXTENT

All land one 100 metres from the outer boundary of the 50 metres for class A stream forms a filter strip
All land within 20 metres of each side of any class B or C stream forms part of the water catchment

RESTRICTION IN WATER CATCHMENT

Selected logging maybe permitted providing
Harvesting is restricted to over mature or sickly stems
Harvesting occurs in dry season conditions
Not more than19% canopy is removed
Lumber produced in situ
Trees not felled into water catchment

CLASS C STREAM

All watercourses carrying water at the average dry season flow rate of less than one million gallons per day.

CATACHMENT AREAL EXTENT

All land 50 metres from the outer boundary of the 20 metres area of any class B stream forms a filter strip

All land within 20 metres of each side of any class B or C stream forms part of the water catchment

RESTRICTION IN WATER CATCHMENT

Harvesting of timber may be carried within strip on the following condition
- all skid trails are restored by filling or flat-blading in dry season conditions
- harvesting takes place in dry season conditions
- skidding is carried out in an uphill direction
- skid trails do not cross any class B stream

In line with the above Orders, ***Statutory Rules and Order 11 of 1995*** makes the declaration that all water catchments are declared to be protected forests. Accordingly, any person who in any protected forest -

(a) applies or stores pesticides
(b) builds any hut or other living place or livestock enclosure
(c) burns, cuts, fells, removes, takes or works any forest produce.
(d) captures, hunts or kills any bird, fish or wild animal unless he is the holder of a license or permitted to do so
(e) carries out any planting other than reforestation on slopes over 20^0
(f) constructs or re-opens any road or saw-pit
(g) grazes livestock or allows livestock to trespass
(h) leaves therein any material, object or substance likely to cause a fire.
(i) sets fire to any grass or undergrowth or assists in lighting any fire or leaves unattended a fire which he has lit or caused by his negligence, before the fire has been thoroughly extinguished
(j) squats or resides
(k) washes in any river or stream any equipment used for applying pesticides
(I) washes in any river or stream containers which contain or have contained pesticides,

commits an offence and is liable on conviction to a fine of 1500 dollars and six months imprisonment.

4.2 Role of key institutions in leveraging watershed management

4.2.1 DOWASCO

DOWASCO is responsible for supplying potable water to Dominican households and business establishments. The company was enacted by an Act of Parliament to manage water and sanitation on the island. DOWASCO's water supply system network is quite complex, divided into 43 water catchment areas, fed by 38 intakes and produces approximately 32,277 m^3 of water daily to approximately 25,000 households (National Resilience Development Strategy 2030 of Dominica).

Resilience building in the water sector goes beyond the sector itself to include both land-use and forest management. The demarcating and protecting of water catchment areas to avoiding encroachment through farming and forest harvesting must be maximized to safeguard water resources. Since the bulk of pipe borne water is drawn from rivers and streams, DOWASCO must constantly monitor and restore degraded forest areas especially the buffer regions of the catchment. DOWASCO can best achieve this by collaborating with the FWPD to promote landscape restoration using appropriate native species. Collaborative plans are also needed between DOWASCO and Ministry of Agriculture to improve soil conservation within watersheds. This is particularly urgent in the QW, where intensive farming increases surface erosion and river turbidity.

4.2.2 Forestry, Wildlife and Parks Division.

The Forestry, Wildlife and Parks Division is primarily responsible for enforcing several pieces of legislation and their accompanying regulations as they pertain to the protection and management of Dominica's (terrestrial) natural resources. These include the Forestry and Wildlife Act (Chap. 60:02 of the Revised Laws of Dominica) and Regulations, the Forests Act (Chap. 60:01) and Regulations, and the National Parks and Protected Areas Act (Chap. 42:02) and Regulations. The FWPD is also legally mandated to carry out some law enforcement functions under the Water and Sewage Act as these pertain to the protection of water catchments in forest reserves and elsewhere. They are therefore an integral player in watershed management and planning in Dominica. The FWPD continues to play a very important role in coordinating national reforestation efforts and the enforcement of forestry, wildlife, and national parks legislation. These responsibilities require public awareness, capacity, and skills development as well as mobilization of community groups to build strong partnerships for resource management. Serious limitations including attrition of trained and experienced staff and insufficient budgetary provisions are among the main factors inhibiting the FWPD from fulfilling these obligations. However, there are several emerging opportunities for grant funding, project support and funded capacity building programs to address forest restoration, climate change adaptation and various land degradation issues that the Division can capitalize on. Several multilateral conventions and protocols and various national action plans afford opportunities for networking and building critical partnerships that can add tremendous value to the work of the FWPD.

4.2.3 The Fisheries Division of the Ministry of Blue and Green Economy, Agriculture and National Food Security

The Fisheries Division is one of the major institutions governing the affairs of the marine space. Given the interconnectedness of BW with the embayment waters, good watershed management is indispensable for the health of the embayment and preservation of fisheries livelihood. Therefore, there is need for synergies and development of joint programs between the Divisions of Fisheries and Forestry to address unsustainable watershed management practices which adversely impact the bay. The ridge to reef management model brings into focus the need for wholistic watershed management practice in Dominica. This approach is partially enshrined in the Fisheries Division strategic goal which is "*Sustainable development of the living marine resources to meet human nutritional needs as well as contribute to national social, economic, and development goals, considering traditional knowledge and interests of local communities, small scale/artisanal fisheries and indigenous people.*"

4.2.4 The Physical Planning Division:

The PPD of the Ministry of Planning and Economic Development is the executive unit responsible for all developmental control activities on the island. It is charged with a wide range of functions pertinent to protected areas management including land use conservation, pollution control, flood control, protection of archeological and historic resources, coastal zone management, environmental enforcement, development control and comprehensive planning for Dominica as a whole.

4.2.5 Land and Surveys Division

The State Lands Act Chapter 53:01 and 53:04 provides the legal framework for the Division to undertake land management controls. The Division is mandated to provide high quality regulatory, informational, and managerial services and policy advice to public and private sector agencies for effective management and utilization of land resources of the State in a manner that will optimize sustainable national development. Its role is meant to ensure an equitable, proper and efficient system of land management, distribution, land tenure security, eradication of illegal settlements, and the control of ownership concentration.

4.3 Applicable National and International Conventions

Several national initiatives, international conventions and agreements have helped shape, incentivize, and publicize critical aspects of ecosystems management and watershed resources in Dominica. Such agreements reinforce the need for building resilient mechanisms to enhance the preservation of critical ecosystems. In the context of this watershed plan, the following examples are noteworthy:

4.3.1 National Resilience Development Strategy 2030 of Dominica

Following the devastation caused by Hurricane Maria in 2017, the GoCD supported by several development partners initiated the development of a National Resilience Development Strategy (NRDS) to tackle sustainable development constraints and to institutionalize a programme for anchoring a national resilient strategy. Specifically, in alignment with watershed protection, the strategy recognizes that the restoration of forest and landscapes as paramount to achieving socio-economic growth and sustainable livelihood. As a component of this strategy, bioengineering utilizing resilient species to boost the resilience of watershed catchments and

riparian zones is designed to promote slope stabilization and long-term forest cover in these critical regions. This strategy brings into play a range of stakeholders, applicable polices and legislation to develop plans that are mutually beneficial to multiple stakeholders and interest groups. Such ecosystem-based approaches (EBA) help specific habitats adapt to the impacts of climate change and promote landscape level planning compatible with local norms.

4.3.2 National Biodiversity Strategy and Action Plan (NBSAP)

A NBSAP was developed in 2000 as part of the Government's effort to sustainably manage the diverse ecosystems and natural resources of the island. The NBSAP focuses on conservation and sustainable use of natural resources, promotion of sound and sustainable agricultural and infrastructural development practices, and facilitation of related knowledge transfer island wide. Forestry and watershed protection is at the core of this strategy given the interconnections of watershed systems with the marine ecosystem health. The promotion of best management practices (BMP) in upland areas can promote the recovery of river and embayment ecosystems. As humans and natural disasters continue to stress delicate watershed systems, there is need for knowledge sharing, awareness, and integrated planning strategies. The NBSAP enhances the scope for integrated approaches to be pursued and adopted.

4.3.3 Land Degradation Neutrality Targeting Setting Programme

Dominica is listed among the nearly 120 countries that have officially committed to achieving land degradation neutrality (LDN). To date Dominica has set LDN targets for selected parishes and the entire country and has outlined a strategy for achieving these by 2030.

It is within these national frameworks that the WMP for Quayaneri was conceptualized to improve land use planning and biodiversity conservation for securing the ecosystem services it provides. Appendix B provides a detailed summary of other responsible state agencies.

5 QUAYANERI WATERSHED MANAGEMENT PLAN

5.1 Consultation at Community Level

Planning for the watershed commenced at the community grassroot level in March, 2021. This involved a series of consultations with key stakeholders in the community including extension staff and resource management personnel and stakeholder business ventures. A town hall meeting brought interested parties together to look at ways for restoring watershed health and arresting some of the poor management practices contributing to loss of its vitality. The process also created an opportunity to have open discussions on holistic approaches to conservation and identifying solutions that are mutually beneficial to both resources users and those concerned with conservation and preservation of habitats and ecosystems within it. The outcomes from these meetings shaped the interventions necessary to manage the system more sustainably.

5.2 Consultation at the National Level

EcoApp Inc. also consulted with national stakeholders including DOWASCO, the Forestry and Wildlife Division, Ministry of Blue and Green Economy, Agriculture and National Food Security, and Environmental interest groups to solicit their views on developing a sustainable restoration plan for the watershed. Since these state agencies are responsible for various aspects of resource management, their involvement and active participation is essential. Once a draft version of the document is complete, comments and feedback will be solicited from these actors.

5.3 Overview of the Logical Framework Analysis (LFA)

The LFA was adopted as an objective approach to identifying and grouping stakeholders as well as to formulate and analyze key watershed problems. The objective tree approach helped in the design of strategic goals, objectives, and activities to achieve specific outcomes. Issues related to the current condition of the watershed and potential threats in the future that can lead to degradation of watershed health, its implications on the livelihoods of people and environment were also identified. The problems identified were then consolidated with those raised at the community level consultations and field assessment surveys. Accordingly, the process streamlined the core problems and analysed the type of measures and approaches that is needed to resolve them. The final stages of the LFA included an analysis of intended results. The LFA Matrix is shown in Table 7. Field Surveys and assessment of QW took place between April and May 2021. Refer to Figure 7 for the sampling stations in the watershed where data was collected.

5.3.1 The Watershed Plan

5.3.2 Summary of key issues

The assessment of the QW categorized it as moderate to highly disturbed system. This is mainly due to intense agriculture, hillside cultivation of short-term crops and deforestation which continues to encroach on the national forest reserve and near depletion along the river course. There is also the existential risk of riverine pollution from agrochemical runoff and from animal waste discharges. Compounding human influence that interferes with the regeneration

processes continue to retard recovery of the forests following Hurricane Maria impact in 2017. Therefore, the plan considers all possible issues that may pose a significant threat to the watershed. The core issues are highlighted in Table 9.

Table 9: Summary of core problems within the BW

Specific Issues	Geographical occurrence	Suggested management interventions to address issues
(1) Pollution Influx into water courses from various sources: agrochemical farm runoff, waste disposals, livestock runoff, etc		
Indiscriminate use of weedicides, pesticides, and inorganic fertilizers	All areas where farming is practiced.	Train and support farmers in organic farming, Introduce awareness programs Promote judicious use of chemicals in dry season periods Install and maintain riparian vegetative barriers
Organic waste from animal husbandry practice	Mid and low watershed regions	Proper septic, drainage systems, use of reed beds, streamline waste to composting
(2) Soil erosion/slope destabilization/mass wasting from physical disturbance/land clearance		
Natural water flow in streams/rivers disturbed, siltation of river and stream beds	Mid to lower watershed	Assessment study to monitor trends and modify restoration approaches Establish sediment traps where applicable
Lack of proper drainage within farms or along farm roads	Mid and upper regions of watershed	Unclog drain and waterways on a routine basis Study local hydrology of area to assist in drainage design Construct storm drains where appropriate Reinforce edges of drains with grass barriers
Deforestation & encroachment of farming near national park boundaries		Awareness program to educate stakeholders, Monitoring and enforcement of applicable laws Increase forest patrols in local areas Maintain vegetative buffer
Uncontrolled burning/slash and burn practice		Supervised spot burning where necessary
Intensive cultivation of selected short-term crops on slopes, using high tillage, and without soil conservation measures		Establish on-farm demos of SLM best practice Zone production of certain crops Develop knowledge-based programs in both English and Creole targeted to Haitian farmers and farm workers
(3). Limited enforcement of legislation		
Perception of weak enforcement and lack of human resources to address issues	Throughout the watershed	Promote understanding of various Acts such as Forestry Act, Planning Act, National Parks and Protected Areas Act
(4.) Limited awareness		
Limited access to information for farmers Lack of training opportunities	Throughout the watershed	More regular programming on watershed and natural resources management especially during prime-time periods. More town meetings to educate farmers High impact video/sign boards postings
(5.) Low empowerment		

Weak advocacy from groups/champions in the local community	Throughout the watershed	Establish non-partisan groups consisting of a wide cross-section of society as watchdogs Training to empower groups

5.3.3 Goals, Objectives, and Activities

Based on the concerns and problems elucidated in the previous chapter, a set of goals, objectives and targeted strategies were developed.

5.3.4 Goal

The overall goal of the QWMP is to protect and conserve watershed resources for the provision of ecosystem goods and services to support sustainable local livelihood in the context of climate change.

5.3.5 Objectives

The specific objectives of the QWMP are:

- ✓ To reduce the risk of water pollution from farm runoff and other sources.
- ✓ To promote sustainable farming and land management practices to reduce land degradation.
- ✓ To improve monitoring and enforcement of appropriate laws governing watershed management as a model for other watersheds.
- ✓ To empower local champions to promote and take responsibility for watershed and land resource management.

Objective 1. To reduce the risk of water pollution from farm runoff and other sources

Output 1.1. Capacity developed for Quayaneri farmers to adopt more ecologically friendly alternatives and/or responsibly use agrochemicals and fertilizers

Activities: (a) Design and conduct appropriate training programs targeting farmers
(b) Promote DOMGAP/Organic farm certification (with periodic farm audits)

Output 1.2. Capacity developed to better manage organic waste disposal from animal farms

Activities: (a) Conduct a survey to identify waste streams, types and volumes generated.
(b) Develop and promote composting, waste reduction, reuse, and recycling strategies.

Output 1.3. Zone watershed to indicate critical, sensitive ecosystems, and areas amenable to farming

Activities: (a) Conduct baseline assessments and develop appropriate land use plans
(b) Hold community consultations to validate plans

Output 1.4. Improve riparian buffer along watercourses

Activities (a) Select appropriate spp. and mobilize for restoration of riparian zones

Output 1.5. Water quality monitoring program established

Activities (a) Develop partnership with DOWASCO and Dominica Bureau of Standards (DBOS) for the establishment and operation of a water quality monitoring program

(b) Train community volunteers to conduct water quality sampling and stream flow measurements
(c) Develop and operationalize a water quality monitoring program

Objective 2: To promote sustainable farming and land management practices to reduce land degradation

Output 2.1. Establish SLM model plots to demonstrate good land husbandry practices
Activities (a) Design and establish model plots to demonstrate location-specific SLM best practice
(b) Design and construct site-specific drainage systems as part of model plot establishment
(c) Design and install site-specific soil conservation and slope stabilization measures as part of model plot establishment

Output 2.2. Create awareness on sustainable farming practices within the watershed
Activity (a) develop awareness materials
(b) carry out awareness and education programs
(c) support landowners in the preparation of tenancy agreements that hold tenants accountable for land stewardship
Output 2.3. Training package in soil and land use management best practice developed and implemented
Activity (a) identify suitable resource personnel
(b) hold at least two training workshops and three farmer field days using model plots to reinforce core SLM principles

Objective 3: To improve monitoring and enforcement of appropriate laws governing watershed management as a model for other systems

Output 3.1. Watershed monitoring and enforcement framework established

Activities: (a) Hold consultations to secure commitment and participation of key stakeholders (including DOWASCO, FWPD, DoA, Commonwealth of Dominica Police Force (CDPF), Ministry of Legal Affairs, Salisbury, Village Council, Farmer Groups, Community residents)
(b) Develop watershed monitoring and enforcement plan (WMEP) outlining roles and responsibilities of stakeholders
(c) Prepare recommendations for the approval of supportive and necessary legal provisions
(d) Roll out WMEP
(e) Monitor progress of the WMEP implementation, take appropriate remedial actions and document lessons learnt

Output 3.2 Capacity of key institutions strengthened
Activities: (a) Identify capacity gaps and develop appropriate programs for key institutions involved in natural resource management: FWPD, DoA, DOWASCO, Physical Planning Division (PPD), Salisbury Village Council

Objective 4: To empower local champions to promote and take responsibility for watershed and land resource management

Output 4.1 Local advocates promoting watershed management best practice consolidated for greater effectiveness

Activity (a) undertake focus group meetings and team building workshops to empower groups and local champions

Output 4.2 The QW Management Council (QWMC) is established and formalized

Activity (a) The Ministry of the Environment, Rural Modernization and Kalinago Upliftment (MERMKU) approves and provides the legal, technical, and financial support for the establishment and operation of the QWMC.
(b) Mobilize a cross section of selected representatives from community groups, individual champions and key stakeholders to form the QWMC.
(c) Formal launch the QWMC
(d) Develop an implementation plan to guide the activities of the QWMC
(e) Monitor and report on progress

Output 4.3 A national watershed management council/alliance is established and formalized.

Activity (a) Sensitize for the formation of a national watershed management council/alliance

Table 10: Logical Framework Analysis Matrix

							Years				
Output	**Activities**	**Means of verification**	**Responsible agency for implementation**	**Collaborating partner**	**Milestones**	**Budget** US$ '000	**1**	**2**	**3**	**4**	**5**
Objective 1. To reduce the risk of water pollution from farm runoff and other sources											
1.1. Capacity developed for Salisbury farmers to adopt more ecologically friendly alternatives and/or responsibly use agrochemicals and fertilizers	1.1.1 Design and conduct appropriate training programs targeting farmers	Training material Training reports	MOA	FWPD DOWASCO PPD QWMC	Training modules develop Farmer trainings completed	21	X	X	X	X	X
	1.1.2. Promote DOMGAP/Organic farm certification (with periodic farm audits)	Number of farmers trained and certified	MOA Extension	DBOS IICA	50% of farmers trained by year 1 25% of farmers certified by yr 2	15	X	X	X	X	
1.2 Capacity developed to better manage organic waste disposal from farm	1.1.1 Conduct a survey to identify waste streams, types and volumes generated	Survey Report	QWMC	DSWC Village Council Environmental Health	Survey completed	5	X				
	1.2.2 Develop and promote waste reduction, reuse, and recycling strategies	Waste reduction strategy report	QWMC	DSWC Village Council Environmental Health	At least 2 waste reduction pilot projects completed	15	X	X			
1.3 Zone watershed to indicate critical, sensitive ecosystems, and areas amenable to farming	1.3.1 Conduct baseline assessments and develop appropriate land use plans	Baseline assessment report	QWMC/	FWPD, MoA PPD,	Draft land use plans completed	20	X	X			
	1.3.2 Hold community consultations to validate plans	Validation report	QWMC	FWPD, MoA PPD, L&S, Village Council	Land use plans approved and adopted	2.5	X				
1.4 Improve riparian buffer along watercourses	1.4.1 Select appropriate spp. and mobilize for restoration of riparian zones	Site assessments, area of riparian zone revegetated	QWMC	FWPD, MOA, DOWASCO	At least 50% of target area revegetated by year 2	152	X	X	X	X	X

							Years				
Output	**Activities**	**Means of verification**	**Responsible agency for implementation**	**Collaborating partner**	**Milestones**	**Budget** US$ '000	**1**	**2**	**3**	**4**	**5**
1.5 Water quality monitoring program established	1.5.1 Develop partnership with DOWASCO and Dominica Bureau of Standards (DBOS)	Water Quality Monitoring program report	QWMC	DOWASCO, DBOS, MoA FWPD	Stakeholder partnership agreement formalized	3	X	X	X	X	X
	1.5.2 Train community volunteers to conduct water quality sampling and stream flow measurements	Sampling protocol and training report	QWMC	DOWASCO, DBOS,	At least 5 volunteers trained	8	X	X			
	1.5.3 Develop and operationalize a water quality monitoring program	Program document	QWMC		Water quality monitoring reports prepared quarterly	25	X	X	X	X	X
Objective 2. To promote sustainable farming and land management practices to reduce land degradation											
2.1 Establish SLM model plots to demonstrate good land husbandry practices	2.1.1 Design and establish model plots to demonstrate location specific SLM best practice	Site visits and photographic evidence	QWMC	MoA, FWPD, PPD, L&S, IICA	At least 50% of targeted model plots established	5	X	X	X		
	2.1.2 Design and construct site-specific drainage systems as part of model plot establishment	Drainage design reports	QWMC	MOA, DOWASCO, Farmers, Landowners	Drainage installed on at least 50% of demo plots within year 1	40	X	X	X	X	X
	2.1.3 Design and install site-specific soil conservation and slope stabilization measures as part of model plot establishment	Report on conceptual designs for soil conservation measures completed	QWMC	MOA, DOWASCO, Farmers, Landowners	Appropriate soil conservation & slope stabilization measures implemented on 50% of model plots	100	X	X			
2.2 Create awareness on sustainable	2.2.1 develop awareness materials	Promotion materials	QWMC*	MOA, FWPD, DOWASCO, IICA	A suite of promotional	5	X				

							Years				
Output	**Activities**	**Means of verification**	**Responsible agency for implementation**	**Collaborating partner**	**Milestones**	**Budget** US$ '000	**1**	**2**	**3**	**4**	**5**
farming practices within the watershed					materials compiled						
	2.2.2 carry out awareness and education programs	Implementation report/plan	QWMC	MOA, FWPD, DOWASCO, IICA	75 % of farmers are aware of sustainable farming options	12	X	X	X		
	2.2.3 support landowners in the preparation of tenancy agreements that hold tenants accountable for land stewardship	Training register	QWMC	MOA, FWPD, DOWASCO, Ministry of Legal Affairs	A tenancy Agreement template developed and adopted by 50% of landowners	3	X				
2.3 Training package in soil and land use management best practice developed and implemented	2.3.1 identify suitable resource personnel	Public Ads, Interview reports	QWMC	MOA, FWPD, DOWASCO, IICA	Shortlist of suitable personnel compiled	2.5	X				
	2.3.2 hold at least two training workshops and three farmer field days using model plots to reinforce core SLM principles.	Training reports	BWMC	MOA, FWPD, DOWASCO, IICA	Trainings completed within 6 months from start of implementation	7.5	X	X	X		
Objective 3: To improve monitoring and enforcement of appropriate laws governing watershed management as a model for other systems											
.1 Watershed monitoring and enforcement framework established	3.1.1 Hold consultations to secure commitment and participation of key stakeholders	Consultation meeting reports	QWMC	MOA, FWPD, DOWASCO, Legal Affairs, Village council, community groups	Key stakeholders consulted	3.5	X				
	3.1.2 Develop watershed monitoring and enforcement plan (WMEP) outlining	Document	QWMC		Draft WMEP developed	7	X				

							Years				
Output	**Activities**	**Means of verification**	**Responsible agency for implementation**	**Collaborating partner**	**Milestones**	**Budget** US$ '000	**1**	**2**	**3**	**4**	**5**
	roles and responsibilities of stakeholders										
	3.1.3 Prepare recommendations for the approval of supportive and necessary legal provisions	Copy of recommendations	QWMC		Recommendations prepared and submitted	2	X				
	3.1.4 Roll out WMEP	Media reports, photographic evidence	QWMC	MOA, FWPD, DOWASCO, Legal Affairs, Village council, community groups	WMEP is the tool for monitoring the QW	1.5	X				
	3.1.5 Monitor progress of the WMEP implementation, take appropriate remedial actions and document lessons learnt	Progress reports	QWMC		Reports prepared that accurately reflect the rate and extent of progress of WMEP implementation	15	X	X	X	X	X
3.2 Capacity of key institutions strengthened	3.2.1 Identify capacity gaps and develop appropriate programs for key institutions involved in natural resource management	Report of gap analysis	QWMP	MOA, FWPD, DOWASCO	Programs developed from gap analysis	5	x				
Objective 4: To empower local champions to promote and take responsibility for watershed and land resource management											
4.1 Local advocates promoting watershed management best practice consolidated for greater effectiveness	4.1.1 undertake focus group meetings and team building workshops to empower groups and local champions	Reports	QWMC	MOA, FWPD, DOWASCO, Legal Affairs, Village council, community groups	Two successful meetings/work-shops completed	9	X	X			

							Years				
Output	**Activities**	**Means of verification**	**Responsible agency for implementation**	**Collaborating partner**	**Milestones**	**Budget** US$ '000	**1**	**2**	**3**	**4**	**5**
4.2 The QW Management Committee (QWMC) is established and formalized	4.2.1 The Ministry of the Environment, Rural Modernization and Kalinago Upliftment (MERMKU) approves and provides the legal, technical, and financial support for the establishment and operation of the QWMC	Constitution and by-laws for the QWMC ratified	MERMKU	MOA, FWPD, DOWASCO, Legal Affairs, Village council, community groups	The QWMC formalized	0	X				
	4.2.2 Mobilize a cross section of selected representatives from community groups, individuals and other key stakeholders to form the QWMC	List of Board members and officers of the QWMC	MERMKU	MOA, FWPD, DOWASCO, Legal Affairs, Village council, community groups Public Works Dept, Lands and Surveys Division (LSD)	Full complement of Directors and Officers of the QWMC commissioned	0	X				
	4.2.3 Formally launch the QWMC	Media reports, Agenda photographic evidence	MERMKU		QWMC Launched	1.5	X	X			
	4.2.4 Develop an implementation plan to guide the activities of the QWMC	Report	QWMC		Identify areas for reforestation and type of plants	0	X	X	X	X	X
	4.2.5 Monitor and report on progress	Report	QWMC		Progress reports prepared and submitted	7	X	X	X	X	X

							Years				
Output	**Activities**	**Means of verification**	**Responsible agency for implementation**	**Collaborating partner**	**Milestones**	**Budget** US$ '000	**1**	**2**	**3**	**4**	**5**
4.3 A national watershed management council/alliance is established and formalized	4.3.1 Sensitize for the formation of a national watershed management council/alliance	Sensitization plan	MERMKU		Planned consultations undertaken	2		X			
Total budget US$ '000						**497**					

Note that budgeted amounts per activity and the total sum of **four hundred and ninety-seven thousand United States Dollars (US$497,000.00** are based solely on preliminary estimates of the proposals advanced by the consultants. It will be necessary to conduct a detailed review, analysis and update of the budget prior to implementation of the QWMP.

5.4 Need for a coordinating entity to support implementation

Watershed management in Dominica remains highly fragmented with overlapping responsibilities among departments of Agriculture, Forestry, Physical Planning, and DOWASCO. Critical management gaps also exist in relation to enforcement, monitoring, and reporting. The absence of a coordinated and integrating mechanism presents a challenge for sustainable watershed governance. The need therefore exists for a functional, holistic, and cross-jurisdictional governance system for watershed resource management in Dominica and specifically to support the implementation of the QWMP.

It is widely recognized that governance at the grassroot level is becoming increasingly important in watershed management since local stakeholders and communities alike are the ones who interface with the resource and hold the indigenous knowledge and cultural practices that can best shape its management. Feedback from the community consultations indicate the need to develop a management framework where local stakeholders can play a more centralized role. This model fosters harmonization and better address conflicts inherent in multi-stakeholder processes. A coordinating body such as a Quayaneri Watershed Management Council (QWMC) is therefore necessary to bring all related entities into a single stream to share the same goal. It is recommended that MERMKU takes responsibility for the establishment and functioning of the Council.

This body must be representative of all stakeholder interest groups in the watershed community and of all key state institutions responsible for watershed management. The following steps are important for the proper setup and function of the council.

i) creation of a task force consisting of staff from relevant state institutions.
ii) formulation of tasks, rules and regulations of the council.
iii) authorization of the establishment of the council
iv) Conduct of a general meeting to discuss and ratify the organization setup and implementation of rules and regulations.

It is also proposed that a technical committee be elected under the Council to undertake the technical issues relating to watershed management and to support the implementation of the plan.

5.5 Implementation Strategy

A sound implementation strategy is crucial for achieving the outputs set in the management plan. While the planned activities will be executed according to Table 8, monitoring and evaluation of the outputs and impacts will be carried out by the QWMC, FWPD and Ministry of Agriculture and DOWASCO. Generally, the QWMC will coordinate the overall implementation of the management plan and will work to secure funds from external donors for implementation of activities. Each monitoring authority is required to submit appropriate budgets for undertaking various activities.

5.6 Capacity building and institutional strengthening

The success of this watershed plan will depend on effective leadership, active participation by the watershed stakeholders and local “buy-in” of the plans’ recommendations, as well as the

availability of funding and technical assistance. Fortunately, there is already some level of awareness among various actors and the need to improve watershed management is recognized. Strengthening both the local capacity and that of the key institutions for implementing the plan remains vital. This can be done by providing equipment, training, and expertise for the set-up of a database and information management system to improve monitoring and communication. Support is also needed to enhance greater collaboration among state institutions involved in watershed management and restoration. The ability to de-escalate and resolve conflicts is also critically important.

5.7 Monitoring and evaluation of the watershed plan

Monitoring is described as the periodic or continuous collection of data using consistent methods. This is an indispensable component of the plan and it's the only way to track progress of the remedial actions taken. Measurable progress is critical to ensuring continued support for interventions and it is the basis for decision making. A good monitoring plan will define what parameters need to be measured, by whom, how frequent, the specific indicators to gauge progress and the budget associated with these actions. Communicating results of monitoring activities is also key to keeping stakeholders informed about the ongoing progress and whether their actions are contributing to the desired results. In addition, an evaluation plan with quantitative indicators to measure the inputs and outcomes should also be included as part of the watershed management plan.

To fully engage local partners on the progress of work and any necessary adjustments in implementation, the QWMC supported by state agencies will assume the responsibilities for regular monitoring of the activities during the implementation phase. The frequency of data collection will be dependent on the type of parameters being measured. Reports on the status of the implementation will be produced periodically to update the stakeholders and communities on progress, challenges and way forwards.

In addition, mid-term and end-term evaluations will be carried out to assess the overall watershed health and its functionalities as an outcome of the watershed management plan. Since the watershed management plan is for a period of five years, the plan will be reviewed and amended by the QWMC based on the monitoring and evaluation reports and in consultation with the communities and implementing agencies. A summary of the QW monitoring plan is detailed in Table 11.

Table 11: Monitoring plan for the QW

Objective	Desired output	Suggested evaluation tools/indicators	Measurement frequency	Responsibility	Target	Reporting frequency
To reduce the risk of water pollution from farm runoff and other sources	Improvement in stream and river water quality	Measure of turbidity	Quarterly	QWMC	Within acceptable / tolerable limits for river water	Quarterly
		Biological assessment of stream/river				
		Chemical assessment of the water				
		Pesticide residue monitoring				
To track changes in watershed hydrology	Improvement in watershed hydrology	Stream velocity measurement	Quarterly	QWMC		Quarterly
		Rates of riverbank erosion	Annually			
		Changes in channel morphology and dimension				
		Sediment loading rates				
		Large wood debris counts				
		Frequency and extent of flooding	Monthly			
To promote sustainable farming and land management practices to reduce land degradation	Improvement in farming and land practices	Number of farmers trained and certified	Annually	MOA, DBOS	50% of farmers compliant	Annually
		Number of SLM compliant farmers				
		Absence or presence of cover crops				
		Stream/river turbidity				
		Presence or absence of grass barriers				
To reduce the impact of natural hazards on the watershed	Watershed and ecosystem resiliency increases	Presence/absence of windbreaks	Annually	FWPD, MOA		Annually
		Forest structure and composition				
		Extent of buffer protection				
To establish a watershed watchdog group or similar entity for championing watershed concerns locally and nationally	Formation and functioning of QWMC	Grassroot involvement in watershed planning, increased watershed discussions at the community level greater watershed management advocacy	Annually	MERMKU		Annually
To improve monitoring and enforcement of appropriate laws governing	Greater collaboration among state agencies and community groups	# of incidents reported & persons held accountable	Annually	BWMC		Annually

5.8 Budget planning and resource mobilization

Implementing the activities of the plan will incur costs as estimated in Table 8. In order to acquire enough funding such as from the national budget, trust funds, donor agencies or contributions from the relevant stakeholders, the QWMC will need to coordinate closely with the relevant sectors to expedite fund mobilization to cushion shortfalls. For long term sustainable funding and continued watershed management best practice, it is important to establish a well-defined total cost sharing mechanism to meet the required expenses for implementing the management plan. To this end, a task force team must be formed by and among the QWMC, watchdog groups and relevant government agencies. Thorough discussion on the following mechanisms for cost sharing should be conducted:

- Scope of stakeholders.
- Role and responsibility of stakeholders.
- Fund management.
- Sharing ratio/amount from each stakeholder.
- Modality of cost sharing.
- Necessary organizational structure.

The aim of the task force should also be to assess other revenue generating mechanism such as user entrance fee payment for birdwatching, visits to sites of interest or access to hiking trails within the watershed which could be developed into a revenue generating mechanism to support implementation of the plan.

6 Conclusions and Recommendations

The QW remains crucial to the economic viability of the community of Salisbury although it is one of the most threatened watershed systems along the west coast of the island owing to unsustainable practices caused by human activities. Climate change impacts on the watershed is predicted to become more variable and intense. The absence of a national coordinating framework will hinder efforts at developing sustainable forest and land management plans within the watershed locale. The implementation of a WMP which embraces SLM, and agroforestry principles is urgent to arresting and reversing the declining watershed health. The plan provides a framework for this process and presents a unique opportunity to pilot and scale up watershed management planning from lesson learnt. The following recommendations will rail guard the plan and broaden the scope for long term sustainable watershed management of Quayaneri.

6.1 Recommendations

Improvement of institutional arrangements for QWMP Implementation:
It is inevitable to strengthen the institutional arrangements among the several agencies responsible for resources management in the watershed. Improved cooperation will enhance strategic planning, allow for shared responsibility, and cost sharing ensuring no one agency carries the full cost of implementation. It is recommended that a co-management scheme be established among the involved parties and the process formalized with a MoU.

River/stream bank conservation measures

Conservation strategies throughout the watershed and certainly within and up to the water catchment areas must be prioritized for mitigation against the transfer of pollutants (whether they be sediment, agro-chemicals, or other liquid and solid waste) into the watercourses. The most effective measure is the installation of vegetated buffer zones along the entire length of the water channels to stabilise and promote the settling out of contaminants from farms. However, in Dominica, the present legislative framework to safeguard riparian zones is weak, and landowners are not mandated to adopt appropriate soil and water conservation measures along water channels that may traverse their holdings. It is recommended that that an education program be established to address and encourage farmers to undertake the establishment of fast-growing species such as gliricidia (*Gliricidia sepium*) and bamboo (*Bambusa vulgaris*) along the most vulnerable regions of riparian zones, for stabilization and to arrest surface sediment transport into the watercourse. Inward of these species, tree crops such as citrus, cocoa, mango and timber should be cultivated according to the prevailing agro-ecologic conditions in the area. A minimum buffer width of 25 m should be encouraged for best results. It is also recommended that grass barriers such as vetiver be established on the steeper exposed slopes where active farming is evident to retard the rate of overland transport of sediment (the number of rows of grass barriers should depend on the steepness and length of the slope)

Water Quality Monitoring

Ongoing water quality monitoring is recommended for the QR to obtain a better understanding
of water quality impacts from potential point and non-point pollution sources in the watershed, to measure the progress toward meeting watershed management goals and total maximum daily loads (TMDL) pollutant reductions. Recommended Actions:

(i) Consideration for the establishment a volunteer water quality monitoring program for the QR. Volunteer monitoring is two-ended – it promotes citizen awareness /involvement, and environmental stewardship.

(ii) The annual preparation of a Water Quality Report Card for the QR is recommended. The report card will provide a transparent, timely, and geographically detailed assessment of water quality for the river to inform the public of water quality conditions and actions that are occurring to improve and protect water quality in the river.

(iii) There is also an urgent need to pursue a dedicated financing arrangement to support the long-term monitoring of water quality in the watershed.

Land use management

Agricultural land use accounts for approximately 15% of the land area in the QW.
Agricultural land areas are a significant source of runoff and potential sources of pollutant loads to the QR. The actions of individual farmers can help to reduce runoff and pollutant loading. It is recommended that sloping agricultural land technology (SALT) and low impact development (LID) practices be promoted at the farm level to minimize risk of pollutant runoff.

Protect and Restore Forested Areas

Tree canopy cover provides numerous benefits at both the site and watershed scales. Watershed forest cover intercepts rainfall, reduces stormwater runoff, flooding, and stream channel erosion and at the same time, improves soil fertility and water quality. Forested areas comprise approximately 60% of the QW. Most of the intact forest is located towards the headwaters of the watershed. Maintaining good coverage is key to long term water quality goals. On this basis, it is recommended that, the importance of trees and vegetation be demonstrated as "green infrastructure" through tree canopy demonstration projects to stimulate interest. Protection of vegetative buffer near the national park boundary must also be prioritized. A recommended forestry management plan is detailed in Appendix 1

Capacity Building

Strengthening local capacity for implementing this watershed plan needs to be continuously promoted including building community/citizen science voluntary programs for supporting monitoring. The QWMC's role and effectiveness would be enhanced with the support of a funded watershed coordinator position. As a result, there is need to secure funding for the hiring of a watershed coordinator to assist the QWMC and to lead the watershed management plan implementation activities.

Education and outreach

Education and awareness programs need to be developed and promoted throughout the life of this plan. One of the goals of this watershed plan is to modify the behaviors of individuals and the public to effect positive changes in the watershed. Often, the public is not aware of the impacts that their every-day activities can have on water quality. Public education is critical to the long-term success of watershed management because it raises awareness and reminds people of the individual actions they can take to protect and improve water quality and ecosystem health. This increased understanding has the additional benefit of fostering support for watershed management efforts and cultivating long-term environmental watershed stewardship ethics, particularly with respect to the benefits of green infrastructure.

Need for continued research

Studies are recommended to better determine the impact of climate change on watershed hydrology and the extent to which farming practices and other land uses are contributing to its degradation. In particular, the impact of landslides and subsidence on watershed hydrology needs to be pursued.

There is need to conduct a crop suitability study and include soil fertility parameters to determine the most viable crops and farming systems that can be practiced within the watershed under the existing constraints. Importantly, the most threatened or 'at risk' sections of the watershed must be identified, demarcated and targeted for specific restoration interventions.

7 References

Barclay, J., Wilkinson, E., White, C. S., Shelton, C., Forster, J., Few, R., Honychurch, L. (2019). Historical Trajectories of Disaster Risk in Dominica. International Journal of Disaster Risk Science, 10(2), 149–165. https://doi.org/10.1007/s13753-019- 0215z

Boehm A. B., and Sassoubre L.M., 2014. Enterococci as indicators of environmental fecal contamination. In Gilmore MS, et al. (ed), Enterococci: From Commensals to Leading Causes of Drug Resistant Infection. (Online.) Massachusetts Eye and Ear Infirmary, Boston, MA. https://www.ncbi.nlm.nih.gov/books/NBK190421/

Canefield Met Office**: http://www.weather.gov.dm/**

DeGraff, J. V., Bryce, R., Jibson, R. W., Mora, S., & Rogers, C. T. (1989). Landslides: their extent and significance in the Caribbean. Landslides: Extent and economic significance, 68.

Dillon Consulting Ltd. (2014). Final Draft Dominica National Land Use Policy. https://doi.org/10.1093/spp/10.3.158

Dominica. Water & sewerage catchment area regulations_sro13-1995.pdf.

Dominica Emergency Agriculture Livelihoods and Climate Resilience Project, https://agriculture.gov.dm/images/documents/basic_project_data.pdf

Drigo, A. (2001). Integrated management of watershed and coastal areas in small island developing states in the Caribbean. National Report Commonwealth of Dominica. Roseau

Durand and Jno.Baptiste 2000. The wildlife of Dominica. Forestry Wildlife and Parks (Ministry of Agriculture and the Environment (http://datazone.birdlife.org/userfiles/file/IBAs/CaribCntryPDFs/dominica.pdf)

Goto D.K., Yan, T. 2011. Effects of land uses on fecal indicator bacteria in the water and soil of a tropical watershed. Microbes Environ: 26(3):254–260

Growth and Social Protection Strategy: https://observatorioplanificacion.cepal.org/en/plans/growth-and-social-protection-strategy-2014-2018-dominica

Imamura G.J., Thompson R.S., Boehm A.B. and Jay J.A. 2011. Beach wrack is a reservoir for feacal indicator bacteria along the California coast. FEMS Microbiol Ecol: 77(1):40–49

Lang, D. M. (1967). Soil and Land Use Surveys No. 16, Dominica the Regional Research Centre University of the West Indies, St Augustine, Trinidad.
Lang, D.M. (1998). Dominica Banana Marketing Corporation (DBMC) Soils Handbook.

Layton B.A., Walters S.P., Lam L.H and Boehm A.B. 2010. Enterococcus species distribution among human and animal hosts using multiplex PCR. J Appl Microbiol:109(2):539–574.

National Census, 2011. https://stats.gov.dm/wp-content/uploads/2019/06/Population_and_Housing_Census_2011.pdf

National Resilience Development Strategy Dominica 2030.NRDS: http://www.fao.org/faolex/results/details/es/c/LEX-FAOC188481/

Office, C. S. (2011). Dominica Population and Housing Census. (September

Rainy, W., et al., 1987. Dominica (West Indies) Banana Industry Rehabilitation: A Pesticide. Assessment Island Resources Foundation (IRF), St. Thomas, VI. http://www.oas.org/reia/iwcam/pdf/dominica/report.pdf

Rouse, W.C. (1990): The mechanics of small tropical flowslides in Dominica, West Indies. Engineering Geology, 29(3): 227-239

Rouse, W.C.; Reading, A.J., and Walsh, R.P.D. (1986): Volcanic soil properties in Dominica, West Indies. Engineering Geology, 23(1): 1-28.

Shillingford, J. D. (1972): The Major Agricultural Land Types in Dominica, W.I. and Their Potential for Development. Department of Agricultural Economics, New York State College of Agriculture and Life Sciences, Cornell University

Smith, R.B., Schafer, P., Kirshbaum, D.J., and Regina, E. 2009. Orographic precipitation in the Tropics: Experiments in Dominica. Journal of Atmospheric Sciences Vol 66. Is..6. DOI: https://doi.org/10.1175/2008JAS2920.1

Williams, A. N. (2020). Deluge: Dominica's Water Surplus, The Caribbean Water Crisis and The Global Water Challenge. ACT Press.

Zamore, M.P. (2000). The Wildlife of Dominica, Roseau Dominica: Forestry, Wildlife and Parks Division, Dominica (Ministry of Agriculture and the Environment).

8 APPENDICES

8.1 Appendix A: Recommended forestry management plan for the QW

Land use & vegetation	Slope < 18%	>18% slope <30%	>30% slope <50%	Slope >50%
Mature virgin forest	Allow natural regeneration to take place No harvesting of timber Increase patrolling if suspected activities are reported			
Residual forest	Promote regeneration and restoration High level of control of all activities within the vicinity of residual forest Constant monitoring and surveillance		No harvesting should be permitted Natural regeneration desired	Natural regeneration supported by active restoration effort No harvesting permitted
Sub marginal forest	Natural regeneration No harvesting No human disturbance			
Fallow areas	Permissible agriculture depending on type of practice and crop selection		Reforestation desired Strictly controlled harvesting if permitted	
Agricultural lands under cultivation	Present farming can be allowed but with improved soil condition. The use of protective grass barrier strongly encouraged		Promote regeneration Controlled extraction under supervision of forestry officers	

8.2 Appendix B: Government Agencies and their Responsibilities Relative to Watershed and Coastal Zone Management

Agency	Resource Management Legislation	Resource Management Responsibilities
MINISTRY OF FINANCE AND ECONOMIC DEVELOPMENT		
Economic Development Unit/Physical Planning Division	Town & Country Planning Act (No. 17, 1975) Beach Control Ordinance (No. 21, 1966	Responsibility for development control and physical planning; administers removal permits
Development & Planning Corporation	Development & Planning Corporation Act (No. 19, 1972)	Decision-making authority for planning and Development control: Corporation has delegated much of its authority to a Technical Committee
MINISTRY OF AGRICULTURE AND THE ENVIRONMENT		
Agriculture	Agricultural Small Tenancies Ordinance (Cap. 74, 1953)	Soil and water conservation
Pesticide Control Board	Pesticides Control Act (No. 15, 1974), as amended (No. 4, 1987) with Regulations on Labeling (1986) and Licensing and Registration of Pesticides (1987)	Enforcement of Pesticides Control Act and Regulations

Lands and Surveys	Crown Lands Ordinance (Cap. 169, 1960) (SRO No. 49, 1960; No. 28, 1961; No. 13, 1963)	Responsible for the survey and for the administration of Government lands, and for carrying out surveys for other Ministries
Forestry and Wildlife Division	Forests Ordinance, 1958 (Cap. 80) Forest Rules (SRO No. 17, 1972) Stewart Hall Water Catchment Rules (SRO No. 11, 1975) Forestry and Wildlife Act (No. 12, 1976) Forestry & Wildlife (Amendment) Act (No. 35,1982) Botanic Gardens Ordinance (Cap. 166,1889) National Parks and Protected Areas Act (No. 16, 1975) Cabrits National Park (SRO No. 54, 1986)	Protection and management of the nation's forest and wildlife; watershed management; environmental education; management of national parks
Fisheries Development Division	Fisheries Act (No. 11, 1987)	Promotion and management of fisheries; fisheries research; protection and management of marine reserves
MINISTRY OF TRADE, INDUSTRY AND TOURISM		
National Development Corporation	National Development Corporation Act (No. 17, 1988)	Promote and support tourism and industrial development
MINISTRY OF COMMUNICATION AND WORKS		
Ministry	Water and Sewerage Act (No. 17, 1989)	Issue water and sewerage licenses to the Dominica Water and Sewerage Company Ltd.
MINISTRY OF COMMUNITY DEVELOPMENT AND GENDER AFFAIRS		
Cultural Division National Culture Council	Culture Act (No. 22, 1981	Promote an awareness of the country's cultural heritage and an appreciation of traditional folklore, arts and crafts
Village Councils	Village Councils Ordinance (Cap. 190)	Responsibility within their jurisdictions for sanitation, waste removal, nuisance abatement, beach control
Local Government and Community Development Division		Assist local governments in carrying out their responsibilities, including such areas as disaster preparedness

Adapted From: Rainy et al. (1987)

8.3 Appendix C Soil map of the QW

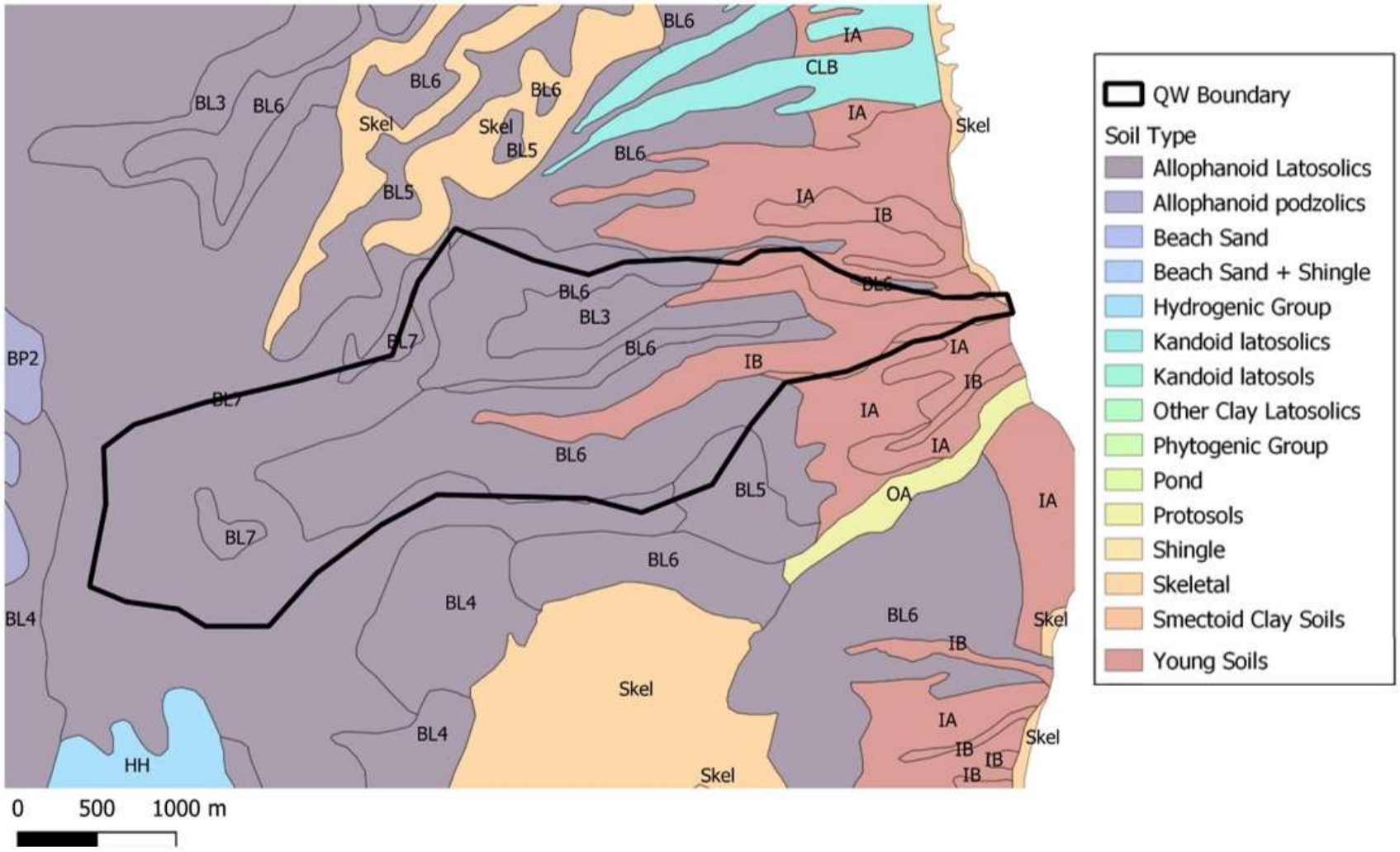

Figure 19 Soil map of the QW with identified soil mapping units