PROJECT:	**SUSTAINABLE LAND MANAGEMENT IN THE COMMONWEALTH OF DOMINICA**
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REPORT /OUTPUT TITLE	**BATALI WATERSHED MANAGEMENT PLAN (Updated) (2023- 2028)**
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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BATALI WATERSHED MANAGEMENT PLAN (2023- 2028)

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VALIDITY PERIOD FOR PLAN

This plan is valid for a period of five years from 2023 to 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) and hurricane-resilient watershed management practices 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 is pending approval from key stakeholders.

ACKNOWLEDGEMENTS

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ACRONYMS

BMP	Best management practice
BR	Batali River
BW	Batali Watershed
BWMP	Batali Watershed Management Plan
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
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
SPCR	Strategic Program on Climate Resilience
TDML	Total Daily Maximum Load
UNESCO	United Nations Education, Scientific, and Cultural Organization
WHO	World health organization
BWMP	Batali Watershed Management Plan
BWMC	Batali Watershed Management Council

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EXECUTIVE SUMMARY

Watershed ecosystems are Dominica's most prized assets yet the most threatened due to unsustainable human activities and repeated impact from severe storm events. Owing to intense farming activities, topography, and high rainfall conditions, the Batali Watershed is particularly vulnerable and is at high risk for loss of hydrologic functions. The loss of critical ecosystems services and function is likely to have profound implications for the everyday watershed users and the communities at large. Unless urgent landscape-level action is taken, it is expected that the watershed system will continue to lose its ability to bounce back, meaning more and more resources will need to be diverted from productive sectors to remedy ecosystem functions at increasingly higher costs.

Recognizing the importance of this watershed system, the Government of Dominica, supported by the Partnership Initiative for Sustainable Land Management through the consultancy under the GEF-financed project "*Strengthening the uptake of Sustainable Land Management (SLM) and hurricane-resilient watershed management practices 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 Batali Watershed is part of the Macoucherie complex draining an area of about 1520 hectares. The watershed also falls under Batali sub-basin encompassing the community of Salisbury. The watershed has a high stream density, steep topography and farming is prevalent in the mid to upper regions of the system. The watershed ecosystem is diverse, with several primitive, endemic and native plant, 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 of virgin forest near the water catchment (abstraction areas) and headwater regions
- altered hydrologic flows and drying up of surface water sources.
- illegal dumping of solid waste and the potential for 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 recommended that:

- Establish a cost sharing mechanism and set up a co-management scheme be 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 25 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 Batali Watershed Management Council (BWMC)
- 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 Batali Watershed (BW). 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. Specifically, investments in major hotel plants are ongoing in the area. These establishments will place greater demands on water resources and possibly spur investments both in agriculture and development of the ecotourism potential of the BW.

- Initiate an induction program targeting Haitian farmers prior to their commencement of operations in the watershed. The program should promote responsible land management practices and increase their involvement in local farming groups to ensure their smoothe integration into existing agricultural production and market support systems..
- Facilitate community participation in forest restoration, including plant propagation and establishment of native forest species.

1. 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 continue to lose their ability to bounce back, meaning 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 has 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 Batali Watershed (BW), 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 Salisbury. 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 Batali 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, 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 Batali Watershed Management Plan (BWMP)

The watershed ecosystems within the upper and mid sections of the Batali 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 BWMP 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 Batali Watershed

2.1 Physical description

The BW is part of the Macoucherie Complex draining an area of about 1520 hectares. The watershed also falls under the Batali sub-basin, which in turn forms part of the Morne Diablotin river basin (Figure 1). The upper watershed (above 600 m) is characterized by steep hills and a farming-modified landscape compared to the mid-watershed (above 150 and less than 600 m) where rock outcrops and shallow skeletal soils allow only shallow-rooted shrub forest to dominate the landscape. This area is not amenable to any form of agricultural activities. The topography changes rapidly in the lower watershed (less than 150 m) and is gentler in slope with deeper soils.

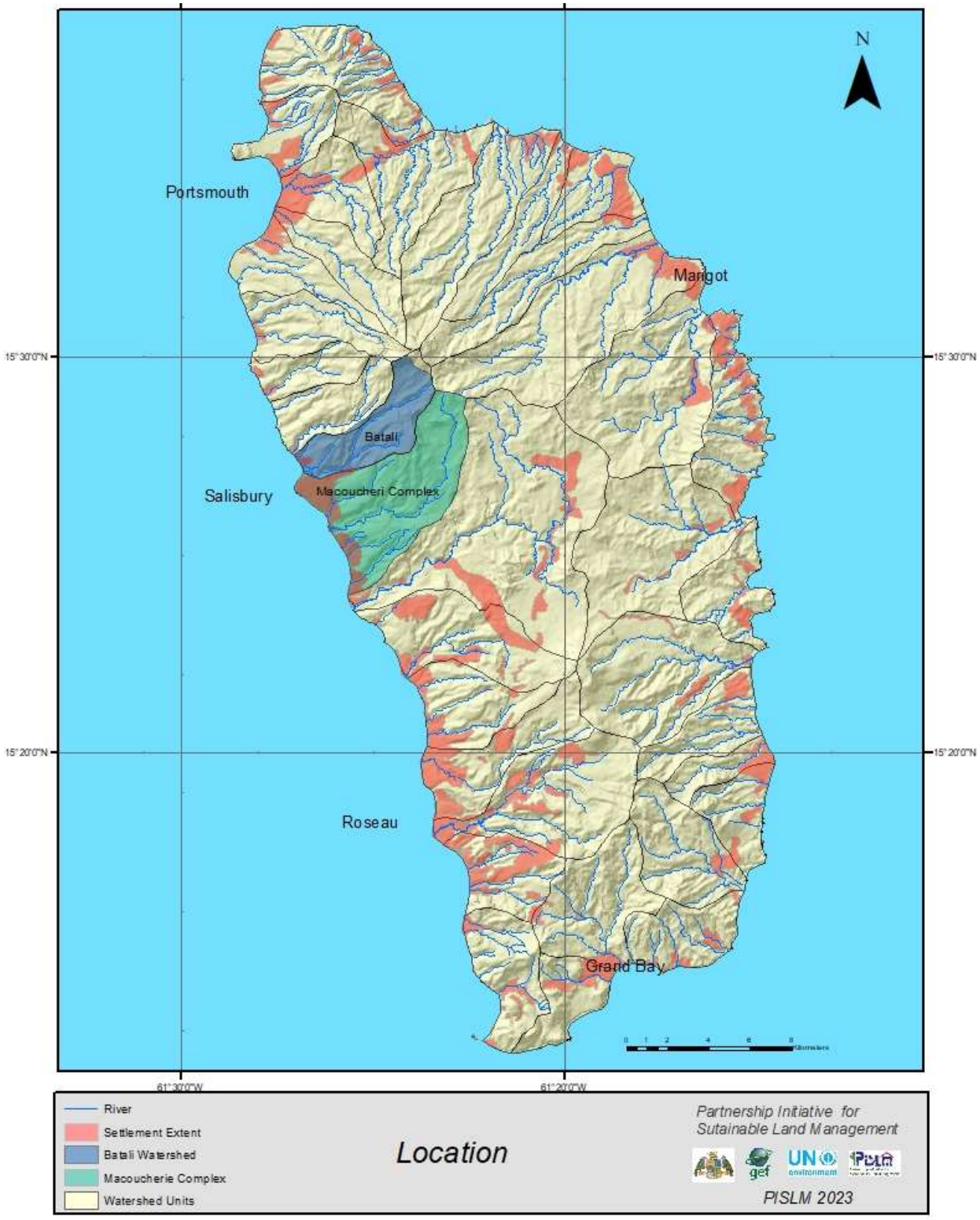

Figure 1: Batali Watershed Extents

2.1.1 The watershed drainage system

The BW has a characteristic dendritic stream network where the tributaries converge into the main Batali 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 also consists of a complex of smaller streams originating from several mountainous peaks most of which have seasonal surface flows.

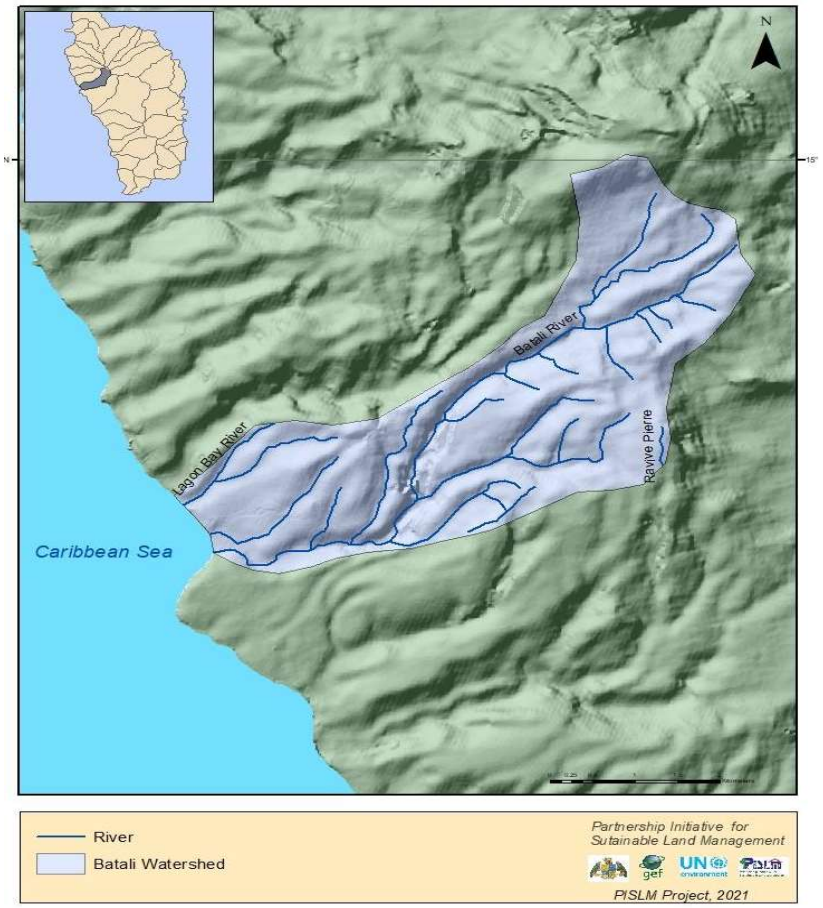

Figure 2: Drainage pattern of Batali Watershed

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 BW (Figure 3). Approximately thirty four percent of surface area of the watershed falls within the slope class 15-22^0, 28 percent in the slope class 23-32^0, 21.8 percent in slope class 0.5-14^0 and 12.6 percent within slope class 33-45^0. Only 3.7 percent are within slope class 45-75^0 where the skeletal soils are dominant.

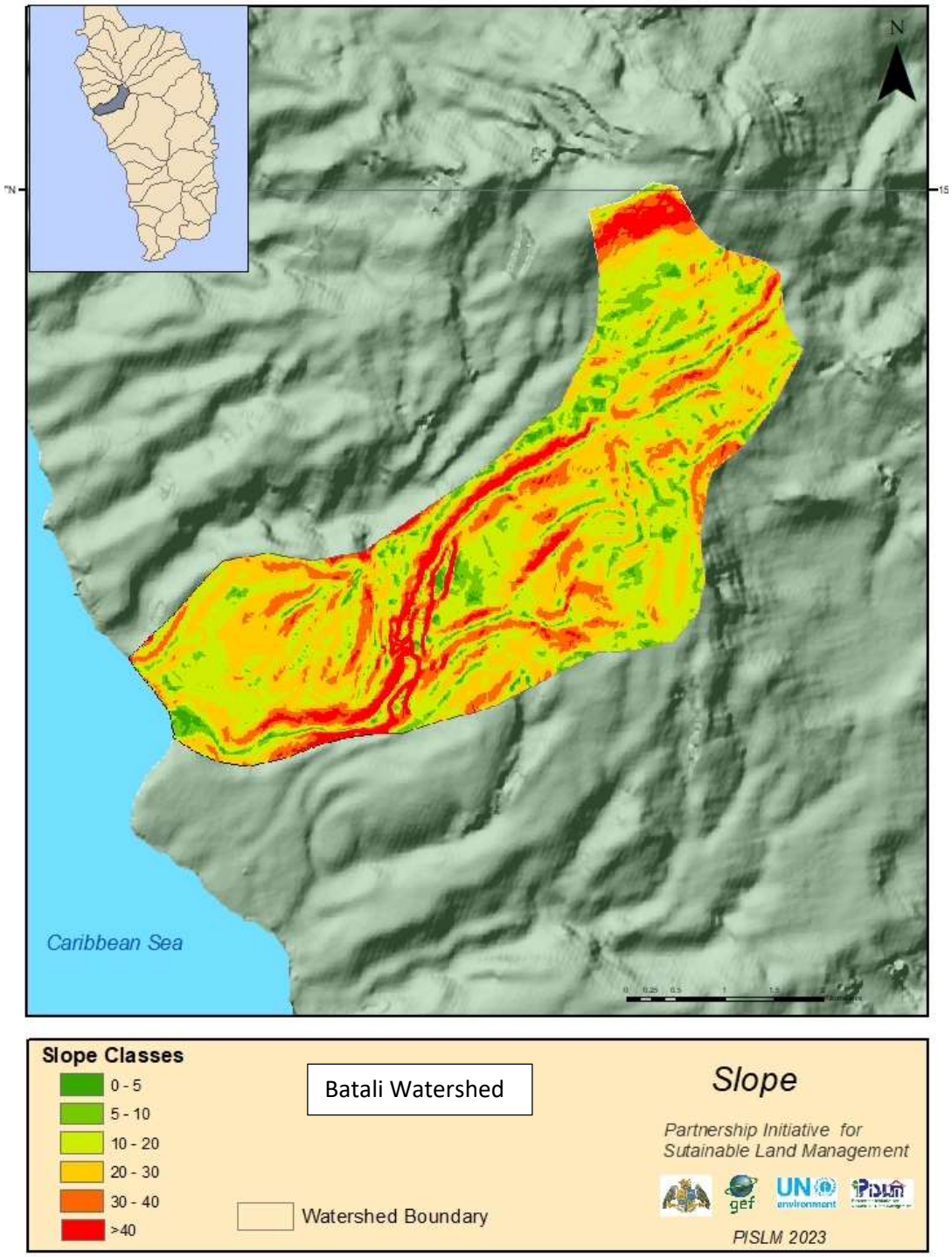

Figure 3: Slope characterization of the Batali Watershed

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 20-year period (2000-2020) for Salisbury based on data from the nearest meteorological centre is 3736 mm (See Figure 4). Monthly average rainfall over this period is 144 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 August averaging 247 mm. Within the last 10 years, Salisbury has experienced three years (2011, 2013 & 2017) where rainfall exceeds 4,000 mm annually compared to the period 2000-2010 having a single year (2004) where rainfall exceeded that total. 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. Some smaller streams may dry up during the driest months.

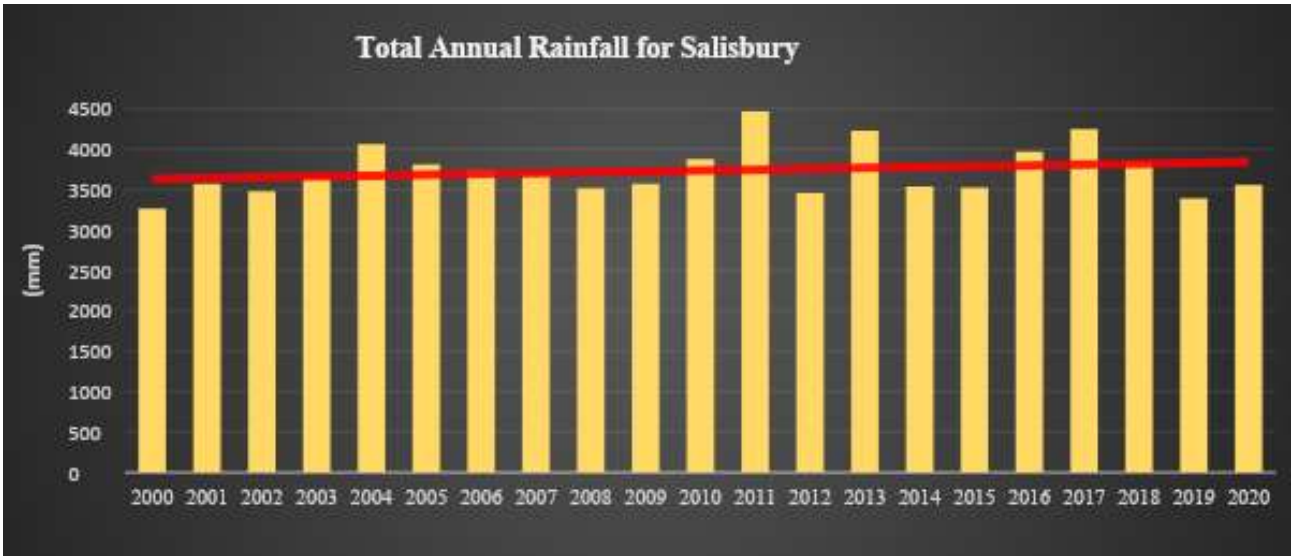

Figure 4: Total Annual rainfall for Salisbury based on a 20-year average for Canefield Met Office data. Redline is the running average for the period. (Source: Canefield Met Office)

[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

In recent decades there has been reducing flow regimes in the watershed and growing concerns about the quality and reliability of potable water for the Salisbury community (anecdotal evidence) Climatic variation and or change in land use, especially in the upper watershed is considered the main drivers precipitating decline of this essential ecosystem service. More research needs to be conducted using historic rainfall 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 tends to be greater for lower intensity rainfall. No long-term systematic monitoring of flows at the Batali River has ever been undertaken.

2.2.1 Temperature

Figure 5 shows the annual mean temperature for the west coast regions of the island. The 20-year mean temperature for Salisbury is 27.2 ^{0}C. The lowest mean annual temperature (26.4) for the area was recorded for 2008. Mean temperature since 2014 has been above the 20-year average with the highest annual mean recorded for 2017.

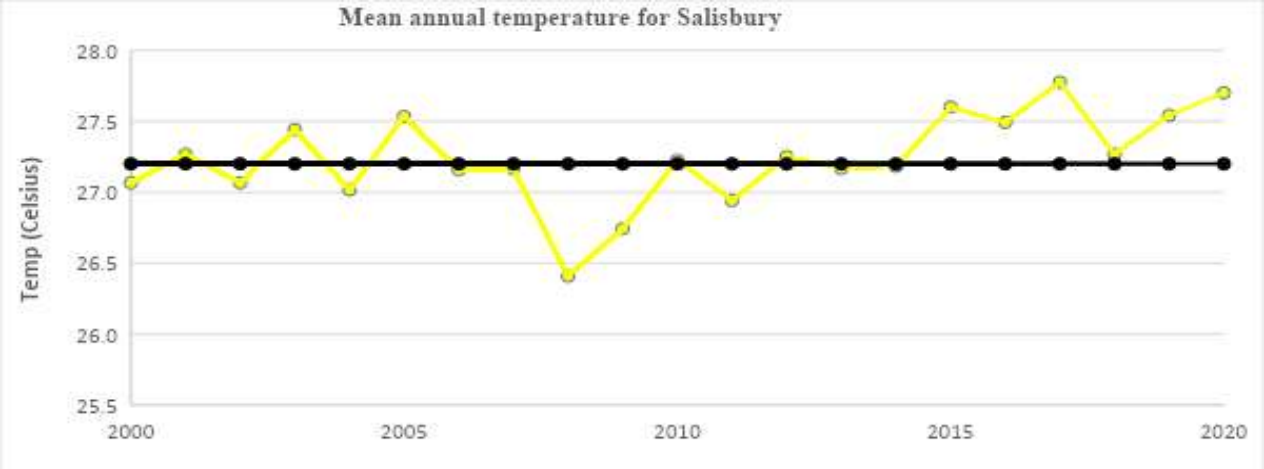

Figure 5: Mean Annual temperature for Salisbury based on a 20-year average for Canefield

Source: Canefield Met Office

2.2.2 Insolation

Average insolation over the 19-year period is 226 hours (See Figure 6). The highest annual average (242 hours) was recorded in 2007 compared to the lowest average of 206 hours recorded in 2011.

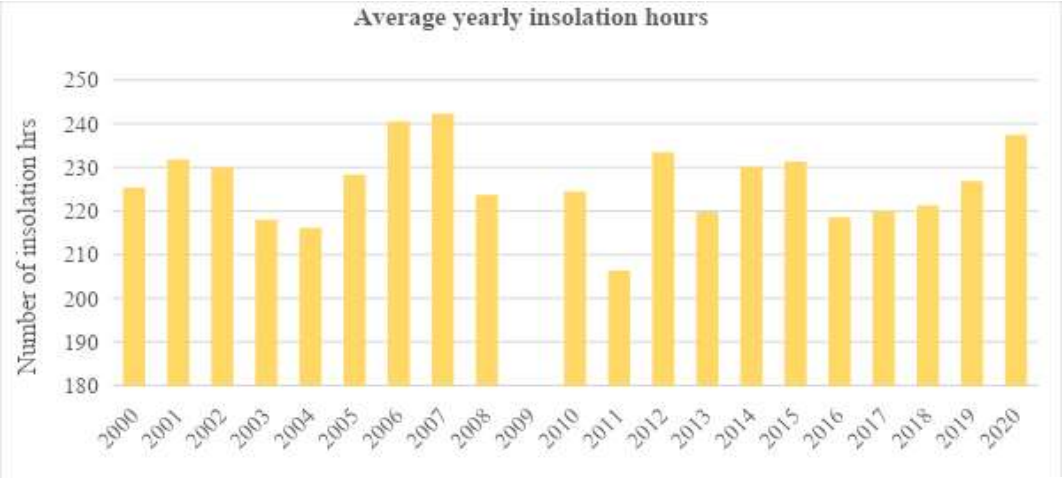

Figure 6: Mean Annual Insolation for Salisbury. Data for 2009 is absent. (Source: Canefield Met Office)

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 both irrigation and domestic needs and 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 relatively high stream density (1520 ha/25) i.e., for every 60 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 7) 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 a 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.

[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 Batali River

Assessment Element	Watercourse sections Stream Assessment Scoring		
	lower	mid	upper
Sediment deposition in pool	8	11	5
Channel flow status[3]	19	18	10
Water clarity	7	15	17
Channel Alteration	17	16	5
Channel Sinuosity	-	13	8
Bank Stability -Left bank	15	10	5
Bank Stability-right bank	20	10	5
Riparian vegetative Zone width -left bank	20	3	10
Riparian vegetative zone width-right bank	20	3	10
Observed aquatic life in stream	19	18	0
Presence of coarse wood debris	15	1	0
Channel width at station (m)	9	3	2.5
Wetted width of channel (m)	9	3	2.5
% wetted width	100	100	100
Right bank slope Steep (S), Moderate (M), Flat (F)	S	S	S
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

Twenty-five tributaries and one main river drain the entire Batali 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 flow for each section of the river.

[3] Based on the SVAP score card, an optimal score of (16 – 20) can be assigned for channel flow status, Where: "Water reaches the base of both lower banks, and minimal amount of channel substrate is exposed." Alternatively, a score of five or less is attributed to flow status where the water is confined to small part of the channel with much of the bed exposed.

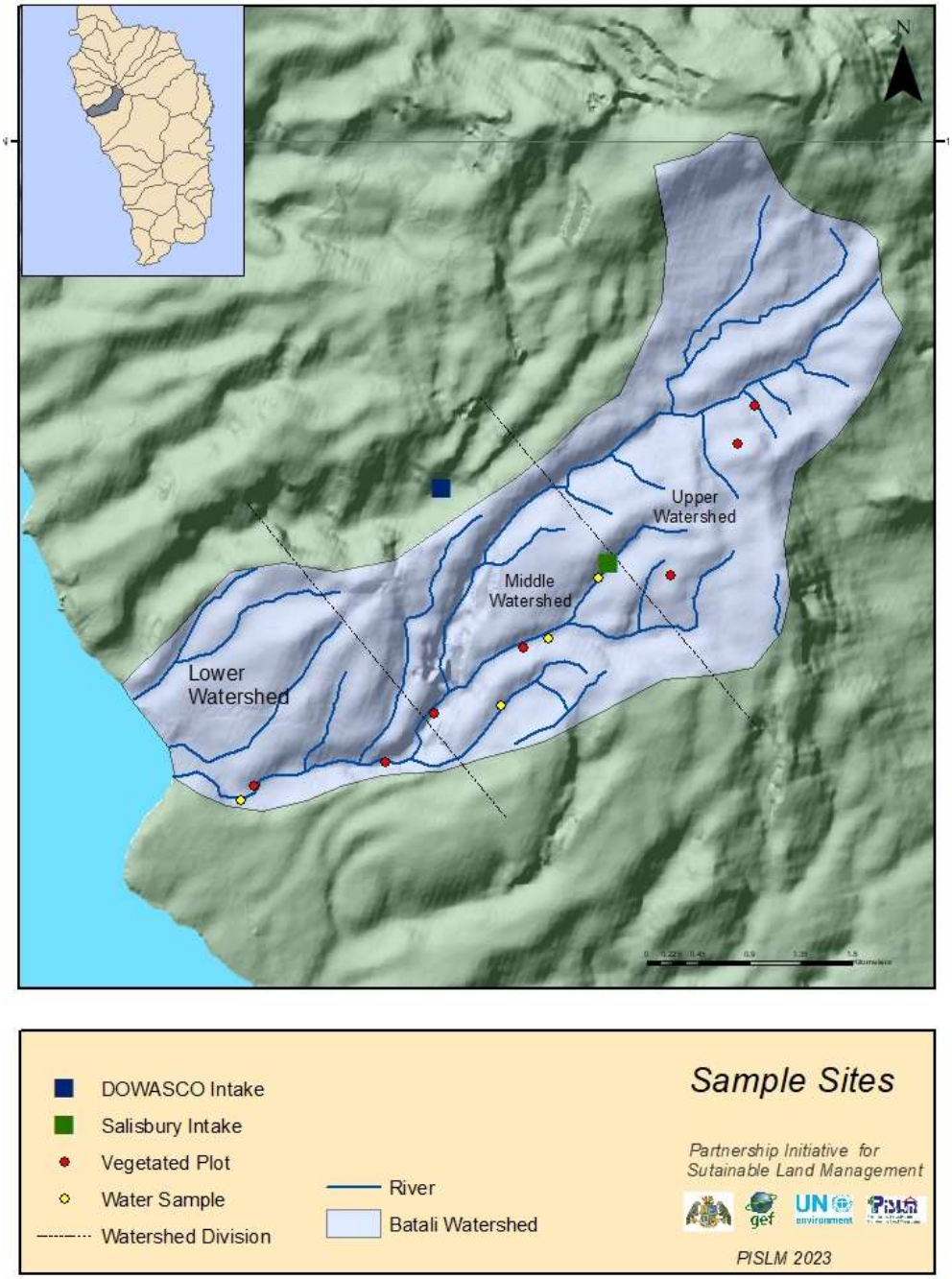

Figure 7: Sampled locations in the BW.

Three water quality monitoring station and measurement of stream flow are highlighted with 12 sample plots to characterize the vegetation of the area. Sample plots and points were largely dictated by access in this rugged terrain.

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

Location	M^3/S
Upper watershed	0.001
Mid watershed	0.18
Lower Watershed	0.566

Flow rate increases by two orders of magnitude from the upper to the mid sections of the watershed. In the lowest reaches of the watershed, flow per unit time is significantly greater than the in the upper sections.

Table 3 summarizes the microbiological and pesticidal analysis for water samples taken at two sample sites along the main BR (Sa_Ba_Lo_01 and Sa_Ba_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 Batali River (Sampled on 08/16/2021)

Test/Parameter	**Sample ID**	**Method**	**Result**
Microbiological			**CFU/100 mL**
E. coli count	Sa_Ba_Lo_01	EPA1103.1	38
Enterococci	Sa_Ba_Lo_01	CEHILSM-4	28
E. coli count	Sa_Ba_Mi_02	EPA1103.1	34
Enterococci	Sa_Ba_Mi_02	CEHILSM-4	**54**
Pesticidal Analysis			mg/L
Diquat	Sa_Ba_Mi_02	EPA549.1	<0.002
Paraquat	Sa_Ba_Mi_02	EPA549.1	<0.002
Diazinon	Sa_Ba_Mi_02	EPA3510C/8270 D	<0.02
Malathion	Sa_Ba_Mi_02	EPA3510C/8270 D	<0.02
Dimethoate	Sa_Ba_Mi_02	EPA3510C/8270 D	<0.06
pH			7.26
Phosphate			0.22 mg/L
Nitrate			1.9 mg/L

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 mid watershed levels are high. Note that this is a single sampling effort and does not show a trend.

Enterococci levels detected in samples retrieved in the mid sections of the BR is 54 CFU/100 mL This is significantly 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[4].but their presence in animal feaces[5], soil[6] and on plants[7] makes them less reliable. It is likely that elevated levels of enterococci in the mid watershed regions is from a single or combined source, possibly: farm sewage, agricultural runoff, stormwater, plant debris or direct input by human and or animals via defecation.

Research has shown that runoff generated by storm events around intensively farmed areas can 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[8]. 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 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, now as Tapis Vert. It is at the base of a narrow river valley with relatively steep slopes on both sides. The sample point is approximately 200 m downstream of the convergence point of two smaller tributaries. Riparian buffers are absent 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 the slope characteristics, proximity to farms and absence of vegetated buffers, groundwater infiltration is a probable cause of high enterococci levels in the mid regions.

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.

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[4] 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/.

[5] 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.

[6] 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

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2.4 Soils

Soil type within the watershed is variable and depending on where they occur, can include:

2.4.1 Allophanoid Latosolics

From the map, it can be observed that the main soil type within the watershed is the Allophanoid Latosolics dominating the upper watershed regions. 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[9].

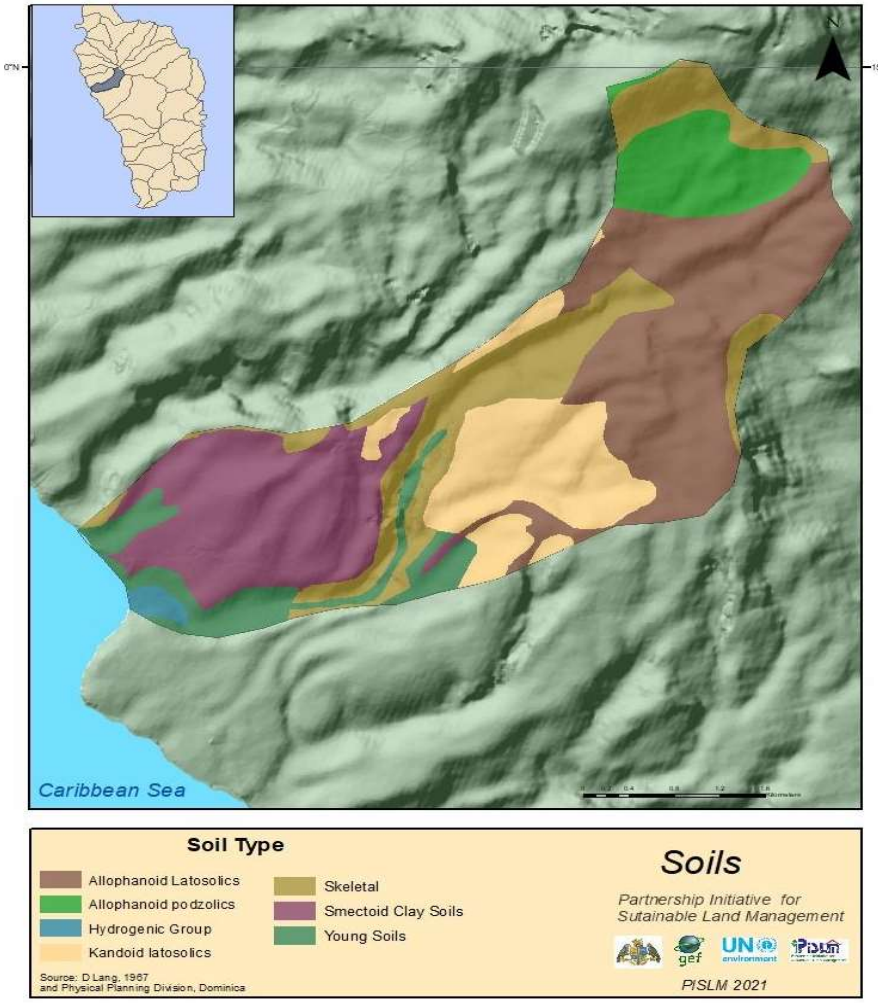

Figure 8: Soil map of the BW

2.4.2 Allophanoid Podzolics

These are confined to regions near the headwaters of the watershed where rainfall is highest (usually >7,000mm per annum) and where leaching is extremely high. The allophane podzolics are characterized by deep litter and organic humic Ah horizons, a bleached highly leached

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

subsoil, and a subsoil pan formed by accumulation of complex organic matter and amorphous sesquioxides. Their dry unit weights and porosities are higher than for allophane Latosolics[10].

2.4.3 Kandoid Latosolics

These are most dominant in the mid regions with the largest expanse on the southern flank of the watershed. The kandoids latosolics in that area usually occur on mixed alluvial colluvial materials and are dominated by immature kaolin clays. Drainage is moderately slow and mainly lateral. A root limiting layer occurs at depth as compact parent material or a high water table[11]. Localized water logging can be a challenge for land use in that area[8].

2.4.4 Smectoid clays

Smectites are overwhelmingly important clays, dominated by expanding type minerals, principally montmorillonite, which influence their behaviour and properties. These soils are prone to movement, as they expand and become sticky when wet and shrink and become rock-hard when dry. The negative charge of smectite clay minerals cause them to be extremely reactive. Having relatively high cation exchange capacity, they influence adsorption and exchange reaction of K^+, Ca^{2+}, Mg^{2+}, Na^+, and many other cations essential for plant growth. Smectoids are predominantly found in the low-mid to low regions of the watershed and in other similar regions on the west coast of Dominica where annual rainfall usually does not exceed 2100 mm, leaching is low and seasonal base removal is incomplete[12]. Expansive montmorillonite minerals in conjunction with a cemented silica hardpan at the base of the B horizon makes these shallow soils very impermeable when wet[13] and highly susceptible to erosion and subsidence.

2.4.5 Hydrogenic groups

These occurs at the lowest elevation within the watershed typically within the floodplain and is the least common soils in the area. The water table occurs near the surface and drainage is variable.

2.4.6 Young Soils

Present in the lower regions of the watershed. They are unstable, shallow and consist of compact parent material at their base. As a result, drainage is moderately rapid and lateral. They are most highly prone to erosion as is evident in the watershed where most of the landslides and slippage occurred.

2.4.7 The Skeletals

Dominant in the mid sections of the watershed and at the highest elevations where the parent material is subjected to continuous weathering. Skeletals are very shallow, prone to erosion and can support little, if any agricultural activities. They are quite low in fertility with little topsoil development.

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[10] 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.

[11] Lang, D.M. (1998): DBMC Soils Handbook

[12] Lang, D.M. (1967): Soil and land-use surveys No.21. Dominica. Report. Regional Research Centre, University of the West Indies. pp 1-58. St. Augustine, Trinidad, and Tobago

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

2.4.8 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 Batali 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 (i) stable (ii) moderately stable and (iii) fragile. As indicated earlier the allophanoid latosolics (BL) are inherently more stable and display greater resistance to erosion. Kandoid latosolics (CLF) occurring in the mid to upper watershed region are fragile with a moderately high susceptibility to erosion. The young soils (IE) young soils on slopes in the lower watershed region are most fragile and presents the highest erosion risks within the watershed.

Table 4: Land capability classes and recommended management regimes

<table>
<tr><th></th><th colspan="2">Stable</th><th colspan="2">Moderately stable</th><th colspan="2">Fragile</th></tr>
<tr><td>Slope classes</td><td colspan="2">Erosion hazard classes
• Nil
• None
• Low to very Low</td><td colspan="2">Erosion hazard classes:
• Moderately low
• Moderate
• Moderately high</td><td colspan="2">Erosion hazard classes:
• High or moderately high
• High if cultivated
• Very high</td></tr>
<tr><td></td><td>Soil type</td><td>Soil map #:</td><td>Soil type</td><td>Soil map #:</td><td>Soil type</td><td>Soil map #:</td></tr>
<tr><td></td><td>BL</td><td>10,12,16</td><td rowspan="4">CLB</td><td rowspan="4">26</td><td>BP3</td><td>4,</td></tr>
<tr><td></td><td>CLA</td><td>25</td><td>CLF</td><td>34, 35,</td></tr>
<tr><td></td><td>HPH</td><td>88</td><td>MB+MC</td><td>52, 53, 49,</td></tr>
<tr><td></td><td></td><td></td><td>IE</td><td>70</td></tr>
<tr><td>0 ° – 5°</td><td colspan="2" rowspan="5">A1 Intensive agriculture
Annual crops or animal husbandry; soil conservation measures where required; tree crops optional</td><td colspan="2" rowspan="2">B1 Intensive agriculture
Annual crops or animal husbandry; soil conservation measures where required; tree crops optional</td><td colspan="2">C1 Intensive agriculture
Annual crops or animal husbandry; soil conservation measures where required; tree crops optional</td></tr>
<tr><td>5 ° – 10</td><td colspan="2">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 colspan="2">B2 Agroforestry
Alley cropping annual crops and tree crops</td><td colspan="2" rowspan="3">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><td colspan="2" rowspan="3">B3 Production/ protection forestry
Timber plantations, tree crops, forest enrichment, non-mechanized selective harvesting where permissible, forest recreation</td></tr>
<tr><td>20 ° - 25 °</td><td colspan="2" 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 colspan="2">A3 Production/protection forestry
Timber plantation, tree crops, forest enrichment, non-mechanized selective harvesting where permissible, forest recreation</td></tr>
</table>

BL - Allophane Podzolic; **BP** – Allophane Latosolic; **CLA & CLF** – Kandoid Latosolic; **MB & MC** – Smectoid; **HPH** – Hydrogenic group; **IE** – Young soils (After Lang (1967).

2.5 Floristic Diversity and land cover

The BW has been significantly disturbed owing to agriculture and deforestation practices especially in areas near the headwaters and mid to upper regions of the watershed. This means that the removal of forest cover for agriculture has the potential to diminish the water storage capacity of the watershed and the likelihood for increase above ground runoff.

Elsewhere, the vegetation is dominated by scrub woodland in the lowest rainfall and elevation areas (See Figure 10). The scrub woodland forest contrast markedly with mature rainforest closer to the mid and upper sections of the watershed where rainfall is higher. A relatively sizeable pocket of secondary forest is tucked near the headwaters. Most of the headwater region is dominated by Montane Rain Forest, Montane Thicket and Elfin, Alpine Meadow.

The forest is the largest natural resource base for the community which supports, protects, and conserves water and biological diversity in the area. To better quantify species diversity and evenness, EcoApp Inc. conducted a baseline assessment of the watershed in April 2021. The Shannon Diversity Index (sometimes called the Shannon-Wiener Index), H, and the Shannon Equitability, $E_{H,}$ was calculated. Typically, the higher the value of H, the higher the diversity of species in a particular community and vice versa (top of the index scale is 2). 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 and Figure 9.

Table 5: Summary of values for the Shannon Diversity Index and Evenness for surveyed vegetation in the BW

Watershed Section	Value
Salisbury Upper H	1.85
Batali Upper E_H	0.74
Batali Middle H	1.98
Batali Middle E_H	0.86
Batali Low H	1.67
Batali Low E_H	0.93

From the data, the lower watershed has more evenness than the upper. On the contrary, the mid watershed has the highest H value meaning, the diversity of species in this region was the highest.

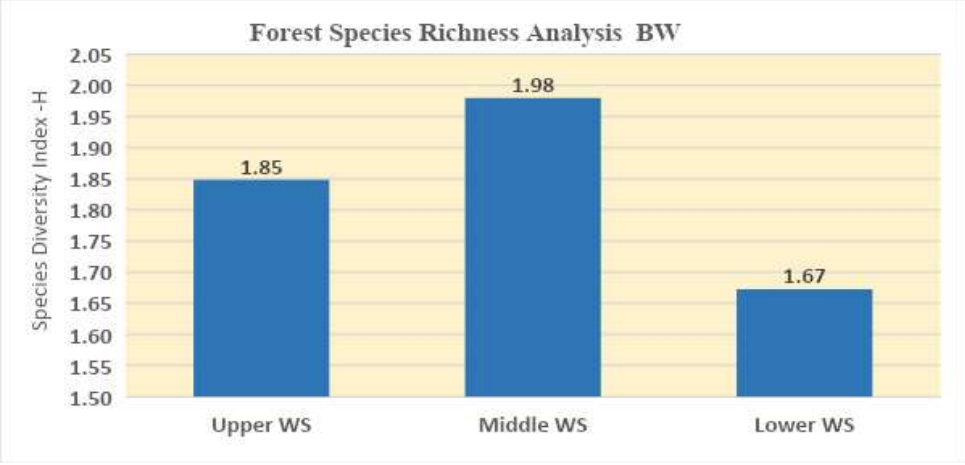

Figure 9: Forest species analysis of the BW

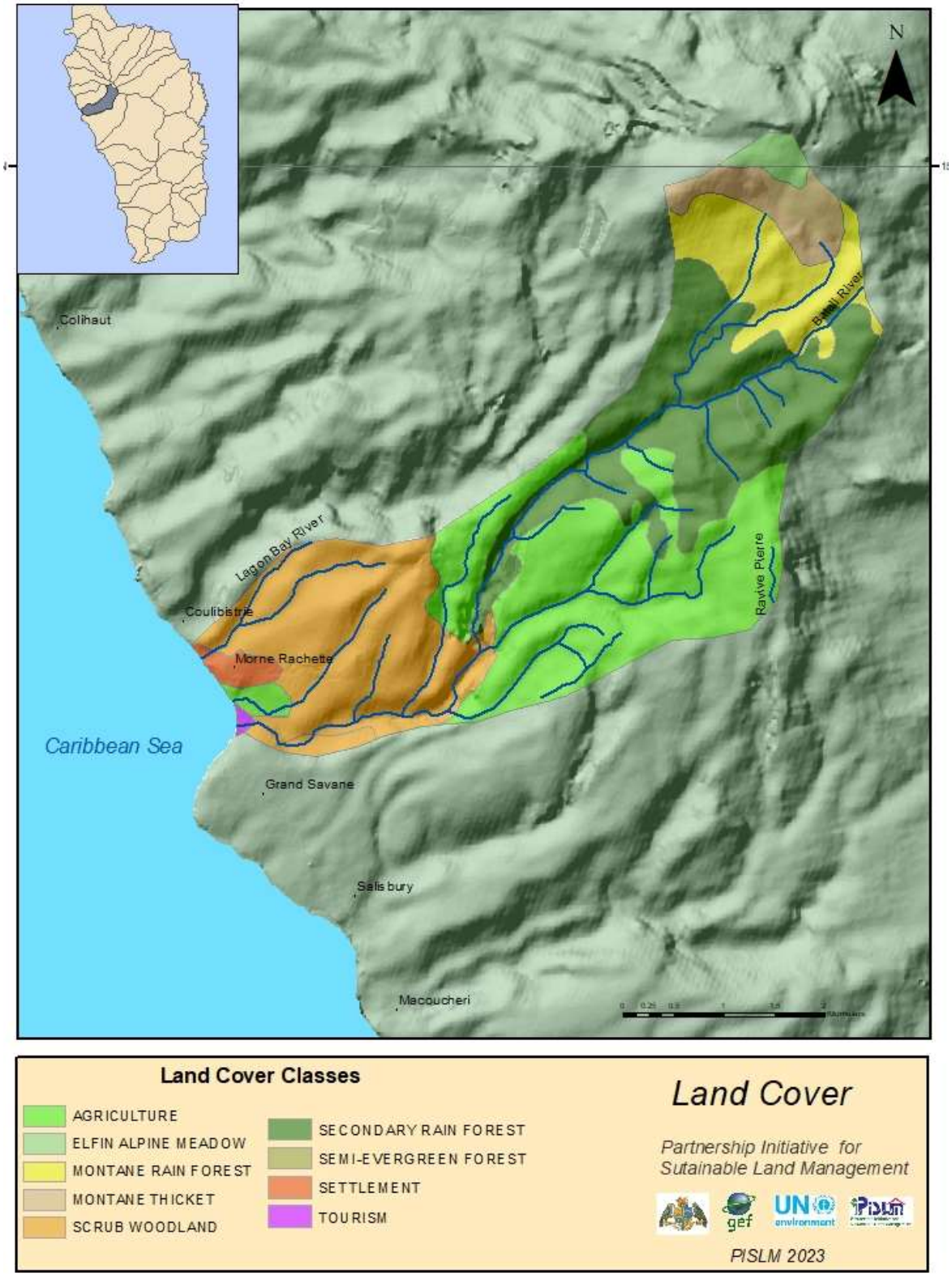

Figure 10: Land use cover map of the BW

2.6 Faunal Diversity

According to Durand and Jno. Baptiste (2000), the Morne Diablotin National Park, which is in the vicinity of the watershed catchment, is home to several of Dominica's wildlife species. The endangered endemic Dominican Tink frog, *Eleutherodactylus amplinympha*, and the Vulnerable Lesser Antillean Iguana, (*Iguana delacatissima)* (Figure 11), are present in the area. The area also supports the endemic Dominica anole *Anolis oculatus* and the regionally endemic least gecko, (*Sphaerodactylus vincenti)*. In addition, the endemic subspecies of agouti (*Dasyprocta leporina)* and opossum, (*Didelphys marsupialis insularis)*, are also present as well as the endemic Dominica Boa (*Boa nebulosa)*. Although these were not sampled, it is widely expected that they are generally present within the watershed study area.

Figure 11 Lesser Antilles Iguana

2.7 Birds

One of the island's four important bird areas (IBA) is located within the Morne Diablotin Forest Reserve, on the peripheries of the uppermost sections of the watershed. This area was identified on the basis of the presence of 25 key bird species associated with the area. Of these 25 species, at least three globally threatened birds, all 19 restricted-range species, and six congregatory seabirds are found there[14]. It is well known that the Forest Reserve was 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 healthy population of the vulnerable Forest Thrush (*Turdus lherminieri)* also occurs, according to (Durand and Jno. Baptiste 2000).

A total of 176 species of birds have been recorded for Dominica, of which about 66% are Neotropical migrants and 34% are resident species[15]. Diverse species of birds are associated with all sections of the watershed according to a bird survey conducted by EcoApp Inc. Figure 12 shows percent recorded per region of the watershed. Highest bird counts were recorded for the lower and mid regions of the watershed. Table 6 presents bird counts per watershed sub-section while Table 7 collectively shows the main species associated with the general watershed.

[14] 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)

[15] 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)

Table 6: Bird counts per watershed section

Salisbury	Watershed Section ID	Quantity	%
Lower only	L	7	18.4
Lower & mid	L & M	15	39.5
Mid only	M	3	8
Mid & upper	M & U	1	2.6
Upper only	U	4	10.5
Upper, mid & lower	UML	8	21

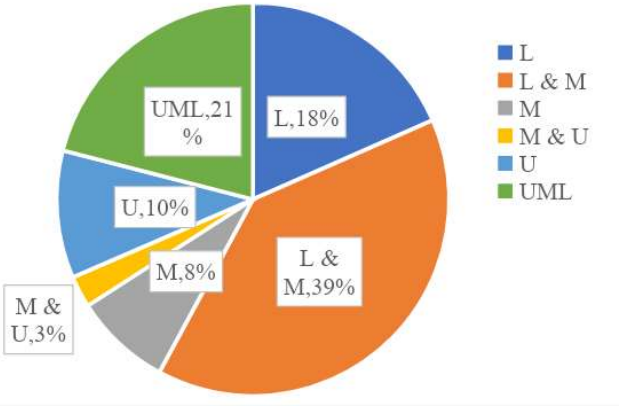

Figure 12 Distribution of birds throughout the BW

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 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[16]. The recent impact of Hurricane Maria (2017) also had major consequences for both species of parrots.

[16] 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)

Table 7: List of bird species associated with the BW

Name of Bird	Scientific Name	Criteria
Magnificent Frigatebird	*Fregata magnificens*	Congregatory bird
Spotted Sandpiper	*Actitis maculoria*	
American Kestrel	*Falco sparverius*	
Common Ground Dove	*Columbina Passerina*	
Bare Eyed Robin	*Turdus nudigenis*	
Yellow Warbler	*Dendroica petechial*	
Carib Grackle	*Quiscalus lugubris*	
Scaly Naped Pigeon	*Columba squamosa*	
Zenaida Dove	*Zenaida aurita*	
Mangrove Cuckoo	*Coccyzus minor*	
Smooth Billed Ani	*Crotophaga ani*	
Antillean Crested Hummingbird	*Orthorlynius cristatus*	Restricted-range bird
Green Throated Carib	*Eulampis holosericeus*	Restricted-range bird
Caribbean Elaenia	*Elaenia martinica*	Restricted-range bird
Red Legged Thrush	*Turdus plumbeus*	
Plumbeous Warbler	*Dendroica plumbea*	Restricted-range bird
Black Faced Grassquit	*Tiaris bicolor*	
Lesser Antillean Flycatcher	*Myiarchus oberi*	Restricted-range bird
Gray Kingbird	*Tyrannus dominicensis*	
House Wren	*Troglodytes aedon*	
Scaly Breasted Thrasher	*Allenia fusca*	
Lesser Antillean Saltator	*Saltator albicollis*	Restricted-range bird
Ringed Kingfisher	*Ceryle torquata*	
Lesser Antillean Pewee	*Contopus latirostris*	Restricted-range bird
Antillean Euphonia	*Euphonia musica*	Restricted-range bird
Red – Necked Parrot	*Amazona arausica*	Vulnerable, Restricted-range bird
Black Swift	*Cypseloides niger*	
Blue Headed Hummingbird	*Cyanophaia bicolor*	Restricted-range bird
Brown Trembler	*Cinclocerthia ruficauda*	Restricted-range bird
Rufous Throated Solitaire	*Myadestes genibarbis*	Restricted-range bird
Little Blue Heron	*Egretta caerulea*	
Yellow Crown Night Heron	*Nyctanossa violicea*	
Green Heron	*Buteorides virescens*	
Broad Winged Hawk	*Buteo platypterus*	
Purple Throated Carib	*Eulampis jugularis*	Restricted-range bird
Black Whiskered Vireo	*Vireo altiloqus*	
Bananaquit	*Coereba flaveola*	
Lesser Antillean Bullfinch	Loxigilla noctis	Restricted-range bird

2.8 Agriculture and land use

Like any other agriculture dependent community in Dominica, open-field production occurs in the mountainous interior although the Grand Savanne area (part of the lower watershed) extensively utilizes intensive greenhouse cultivation systems. Without exception, agricultural production in Dominica and this watershed is characterized by clear felling of forests, high use of agricultural inputs including inorganic fertilizers and agro-pesticides[17].

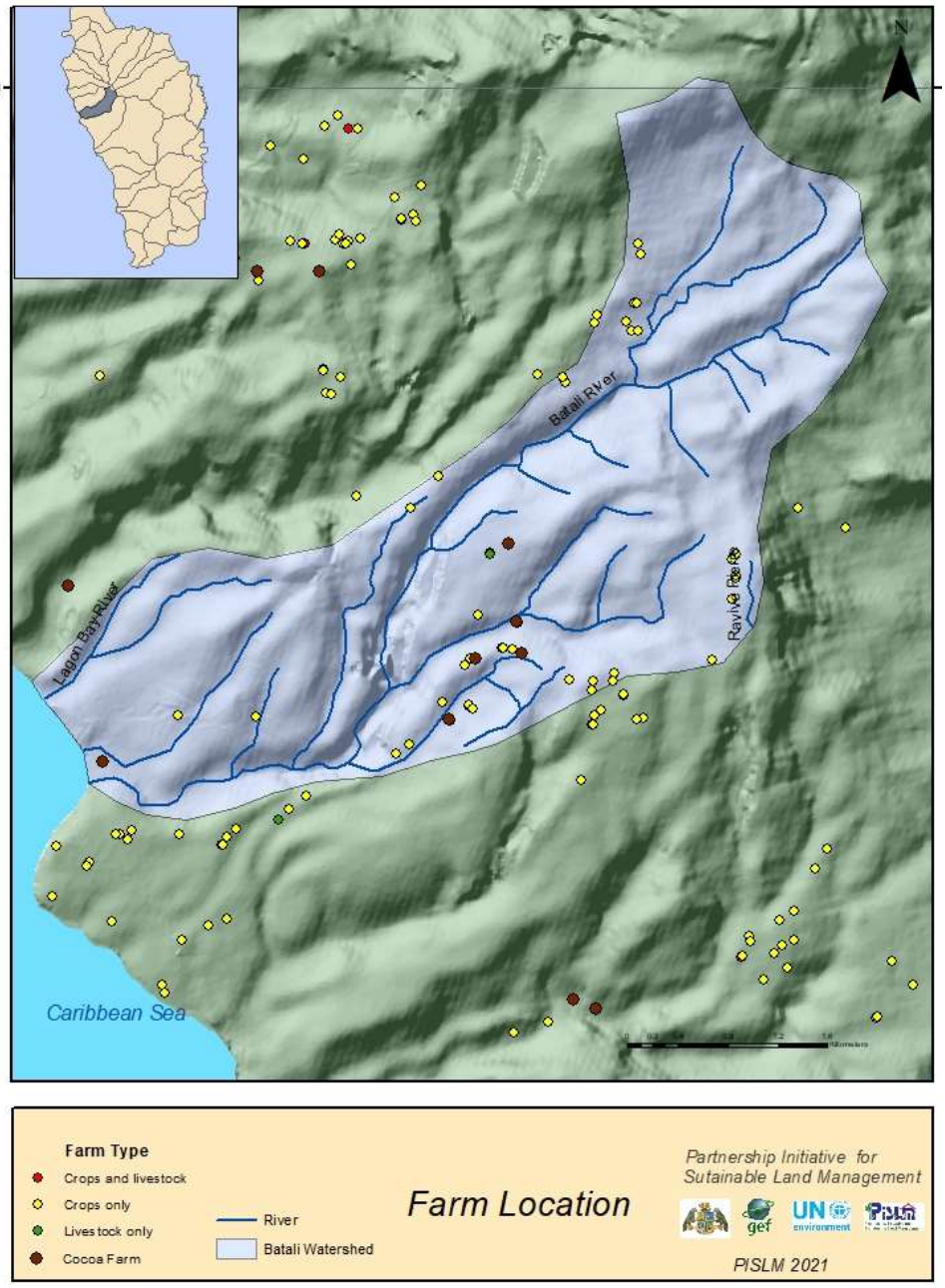

Figure 13: Location of major farms throughout the BW

Given the topographical features and entrenched subsistence farming culture, the agricultural sector and notably, farming within the BW, 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[18].

As a result of the historical importance of the watershed to agriculture some of the original vegetation has been substantially modified especially in areas more amenable to agricultural production. Presently, agricultural holdings cover approximately 15-20% of the total land area in the watershed where more than 170 farmers operate on a full-time basis. Throughout the

[17] 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

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

watershed, 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 increase the potential for erosion and soil loss. There are also substantial tree crop production systems in place (avocadoes, mango, citrus, cocoa) although in recent years with the influx of migrant Haitian farmers, the focus has shifted to short term crops. Farm locations within the watershed are depicted in Figure 13.

2.9 Socio-economic Status

Salisbury is a hilly community with the greatest expanse of flat land in the Grand Savanne area. It is flanked by deep valleys on either side. The village extends to the heights of Grand Savanne and along the southern ridge of the Batali River valley.

The community of Salisbury falls within the parish of St. Joseph. Salisbury and its hamlets have a combined population of 2174 people with a total of 901 households (Table 8). There are 1060 dwelling units with an average of 2.4 persons per household according to the Dominica Census Report 2011[19].

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

Communities	Non-Institutional Population	No. of households	No. of persons per household	No. of dwelling units
Salisbury	2174	901	2.4	1060

Source: 2011 National Census

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

Houses are clustered mostly in the lower and low-mid watershed regions where the terrain is more hospitable. Figure 14 shows major population settlement in Salisbury.

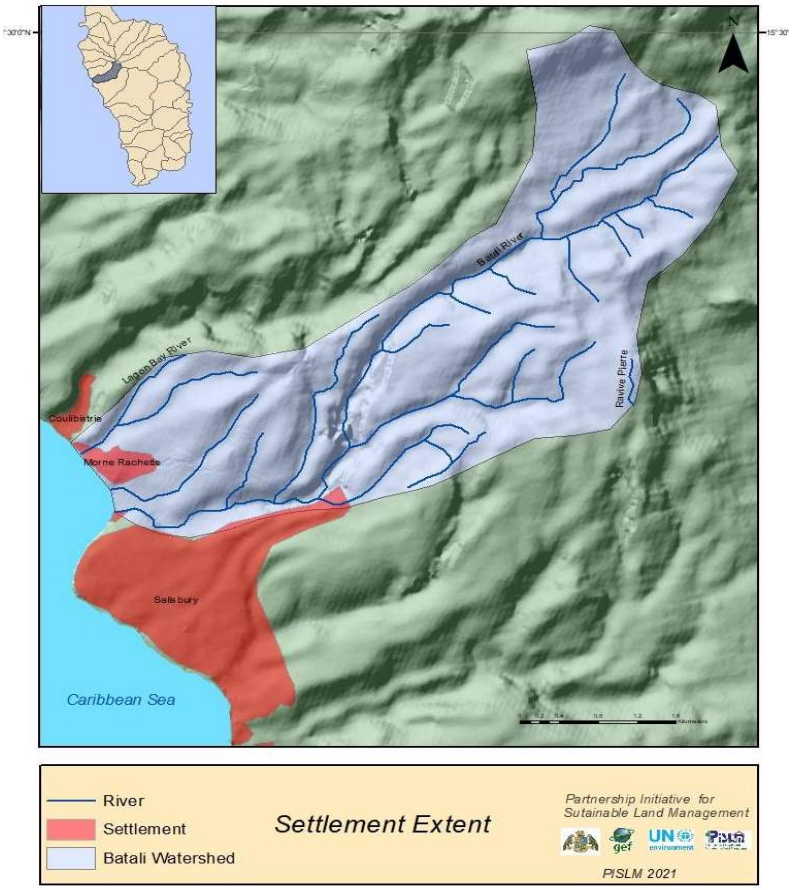

Figure 14: Settlement within the BW

Many households are dependent on subsistence agriculture and fishing. Sustaining these industries will depend on maintaining the ecological intactness of the watershed ecosystem and the health of the reef system in the nearshore coastal waters. Shifts in the ecological balance induced by climate change, debris flows from upland areas, pollution and other anthropogenic effects could seriously impair the health of the embayment**.**

Communities in the Batali Watershed also depend on the forest ecosystem as a part of their livelihood. The forests provide provisioning services including fuelwood, timber, food, fodder, fibre, shelter, medicines, household implements, and handicrafts. The Haitian immigrants have been steadily exploiting wood for staking yams and charcoal making.

2.10 Use of water resources

The DOWASCO intake in the Tapis Vert area in the upper BW, is the main drinking water source for the Salisbury community. Another intake located about 400 ft below this DOWASCO intake is used strictly for irrigation of the Grand Savanne farming area just outside the southern flanks of the lower watershed boundaries. It is a farmer/community managed system that has been operated successfully for over three decades.

As in other watershed systems, small weirs or dams are used for water abstraction and storage. The rugged terrain offers the benefit of water being gravity fed throughout the network without need for the use of pumps. Given the geology of the island, Dominica's 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 Batali Watershed

3.1 Introduction

The BW is one of the most intensively farmed watersheds and perhaps one of the most threatened nationally. Intensive agriculture and land clearing continue to diminish the ecological resilience of the system. Annually, swathes of virgin forest are cleared for cultivation according to anecdotal information. Fields left to fallow over a 5-year period are recultivated within a few years with not enough time to replenish nutrients and restoration of soil health. If this trend continues, the sustainability of subsistence farming and water resources within the watershed could be strained with long-term implications for the people of the community. The problem is aggravated by changes in farming practices brought about by the influx of migrant Haitian farmers and farm workers who now appear to dominate the farmlands in the watershed. The watershed health is likely to get worse because of extreme weather events and poor land use practices in highly vulnerable regions. This chapter provides an overview of the major issues presently affecting the watershed.

3.2 Landslide vulnerability of the Batali 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 higher elevations[20]. There are four dominant soil types: Kandoids, Allophanoid latosolics, Allophane podzolics, and Smectoids. They differ primarily based on the types and quantities of clay minerals they contain, characteristics that are highly influenced by climatic factors and time. Soils 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. Landslides on Dominica are typically triggered by high intensity rainfall during tropical storms and hurricanes but are

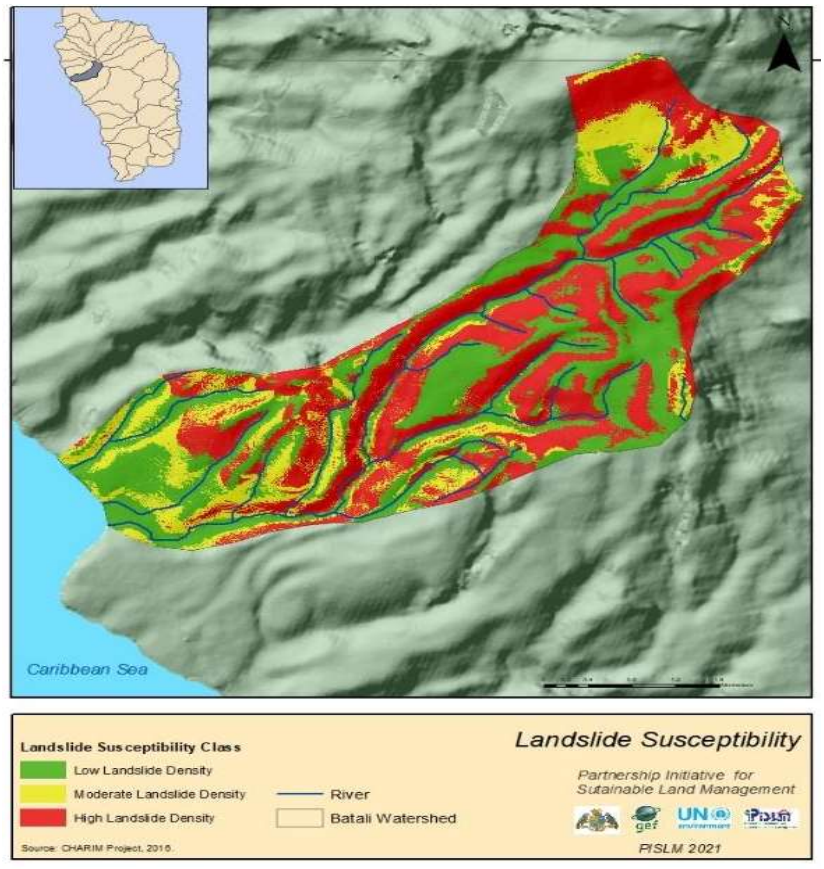

Figure 15: Landslide susceptibility within the BW

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

also caused by human activities such as deforestation and poorly designed road construction[21].

The landslide susceptibility map of the BW (Figure 15) shows areas in the watershed where landslides 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.

Landslide risks within the BW are high and variable. Highest vulnerability exists in areas where the skeletal soils (loose unconsolidated rock fragments) are dominant in the mid and highest reaches of the watershed. Moderate to low risk is associated with the allophanoid podzolics in the upper watershed whilst lowest risks are in the Grand Savanne areas where slope averages between 0.5- 14^0. At present, landslide prone areas are intensively farmed.

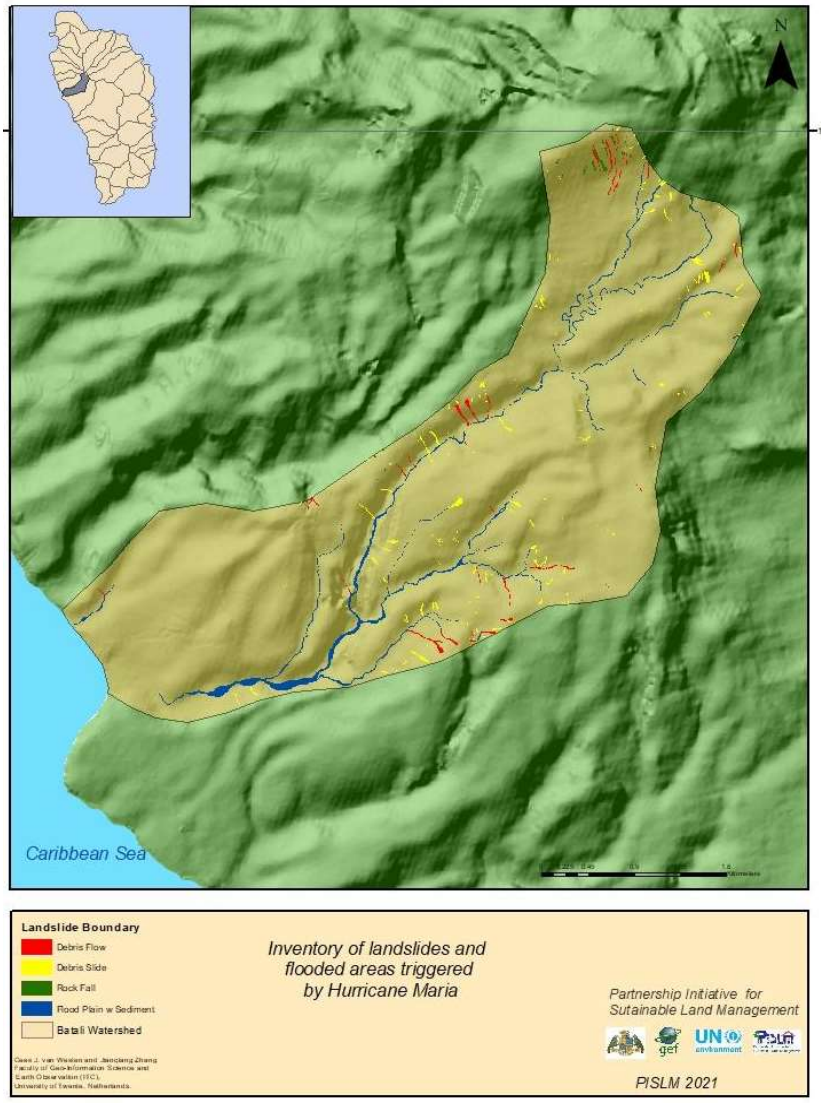

Figure 16: Landslides in the BW attributed to Hurricane Maria

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[22]. The effects on farm productivity needs to be studied as well.

Figure 16 illustrates areas in the watershed impacted by slides during the passage of Hurricane Maria in 2017. Thirty-four (34) debris flows (fast moving mudslides often referred to as mudflows, or debris avalanche) occurred in areas of the upper catchment and in small pockets in the mid watershed along the steepest slopes. Most debris slides (mass of unconsolidated and incoherent soil and rock

[21] 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.

[22]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

fragments that slide or roll rapidly down a steep slope) occurred in the mid watershed regions and in the high elevation regions within the headwaters. Several of the of the 191 landslides impacting the area occurred within the vicinity of active farming areas. More studies are required to determine the root causes of landslides.

Hurricane Maria exposed the impacts 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 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 continues to encroach on forested land in several areas in the watershed. Deforestation also causes 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 has been removed or altered.

Figure 17: Deforestation along steep hillside in BW where secondary succession is relatively slow.

Figure 18: 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. This practice significantly increases soil erosion and elevates the risk of water pollution. Farming in these areas may also alter watershed hydrology and diminish the water retention capacity of the system.

The BW is well noted for the cultivation of vegetables and short-term root crops such as ginger, dasheen and yams. The cultivation of these crops involves intense soil disturbance. 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 these conditions can easily reach the water course during rainfall events. Figure 19 shows a farm in the upper watershed where erosion is likely to be high.

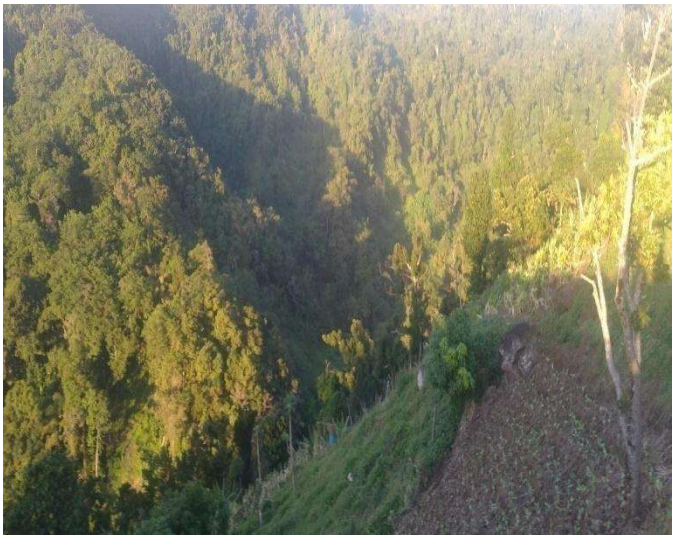

Figure 19: Poor farming practices along a steep slope in the upper BW

Figure 20: Soil preparation for yam cultivation in the upper region of the BW

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 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 also stifles investments in long-term crops and capital investments like on-farm drainage.

3.4 Illegal dumpsites for solid waste

At least in one section of the mid-watershed approximately 500 m above a residential section of the Salisbury Village known as La Savanne (Figure 21). Illegal disposal of solid waste has the potential to contaminate the water course. At this point, damaged TV sets, computers, fridges, corrugated zinc, plastics, tires and such like are thrown over the cliffs' edge. This practice has been continuing for several years with little indication that it will stop. Most of the disposed items can persist in the natural environment for several years increasing the potential for contamination.

Figure 21: Dump site in BW

3.5 Water supply and quality

Water is the major transport agent connecting the upper with the lower watershed regions. Good water quality is a major function of the watershed system however, human actions have largely contributed to poor water quality in many watersheds in Dominica. The indiscriminate use of agrochemicals and chemical fertilizers are the major sources of contaminants to riverine water supply. Biological contamination from humans or wildlife can also impair water quality. (Figure 22).

Figure 22: Water quality impairment near the irrigation abstraction point (upper section of the BW)

It is also important to note that the water supply for the community is reportedly more irregular in recent years. Greater variability in rainfall due to climate change, deforestation, and changing watershed hydrology closer to the headwaters of the watershed are possible causes for this change.

3.6 Weak monitoring and enforcement

There is no regulated zoning or land use management plan for the BW. Crop selection, farm location, and road access are all left to the choice of the individual farmers. Although 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 Central 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 is 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, social learning, negotiation, and the development of adaptive plans that are accepted by diverse stakeholders in the community[23]. Unfortunately, no organized voices or community groups have been able to echo concerns to the relevant authority. For watershed management plans to be

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

effective, local champions are needed. When done right, watershed governance can help resolve complex water problems and conflicts which otherwise would be daunting.

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

4.1 Introduction

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.

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 BW, 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 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 Batali 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 BATALI 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. A town hall meeting brought several interested parties together to look at ways for restoring watershed health and arresting some of the poor management practices contributing to loss of 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. Figure 23 shows some of the participants during the initial consultation in the community of Salisbury

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.

Figure 23: Community consultation to discuss the present situation of the BW

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 analyse 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 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 BW took place between April and May 2021. Refer to Figure 7 for the sampling stations in the watershed where data was collected.

5.4 The Watershed Plan

5.4.1 Summary of key issues

The assessment of the BW categorized it as one of the most disturbed watersheds of the three systems studied. This is mainly due to intense agriculture and hillside farming practices up to and within the watershed catchment with the existential risk of riverine pollution from agrochemical runoff. 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 and inefficient use of weedicides, pesticides, and inorganic fertilizers	Mostly in mid to upper sections of the watershed Mostly in mid-section of the watershed.	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
Continuance of solid waste disposal in mid sections of watershed		Erect "no dumping" signage. introduce awareness programs. increase community receptacles to collect solid waste
(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
Monocropping of short-term crops on hillside resulting in heavy soil disturbance		Careful crop selection on sloping lands Inter-plant mix of permanent and short-term crops where applicable Use of leguminous crops for restoration of soil nutrients
Deforestation		Awareness program to educate stakeholders, Monitoring and enforcement of applicable laws Increase forest patrols in local areas
Uncontrolled burning/slash and burn practice		Supervised spot burning where necessary

Absentee land ownership challenges promote unsupervised land use/land management		Introduce lease agreements for new farmers with specific land management clauses and educate landowners accordingly Introduce farm registration/eligibility criteria
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
Encroachment of farming in headwater regions and protected areas of watershed	Upper watershed	Proper monitoring and control on farming Establishment of vegetation buffers
(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 wide cross section of society as watch watchdogs Training to empower groups

5.4.2 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.

5.4.3 Goal

The overall goal of the BWMP 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.

5.4.4 Objectives

The specific objectives of the BWMP 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 Salisbury farmers to adopt more ecologically friendly alternatives and/or responsibly use agrochemicals and fertilizers

Activities: (a) Design and conduct appropriate training programs targeting farmers and other residents

(b) Promote DOMGAP/Organic farm certification (with periodic farm audits)

Output 1.2. Capacity developed to better manage solid and liquid waste disposal from farm and household sources

Activities: (a) Conduct a survey to identify waste streams, types and volumes generated.

(b) Develop and promote waste reduction, reuse, and recycling strategies.

(c) erect "no-dumping" signage and surveillance systems at illegal dumping sites

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. At least four appropriate and effective SLM model plots established

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 BW Management Council (BWMC) 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 BWMC.
(b) Mobilize a cross section of selected representatives from community groups, individual champions and key stakeholders to form the BWMC.
(c) Formal launch the BWMC
(d) Develop an implementation plan to guide the activities of the BWMC
(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

Output	Activities	Means of verification	Responsible agency for implementation	Collaborating partner	Milestones	Budget US$ '000	Years 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 and other residents	Training material Training reports	MOA	FWPD DOWASCO PPD BWMC	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	
1.1 Capacity developed to better manage solid and liquid waste disposal from farm and household sources	1.1.1 Conduct a survey to identify waste streams, types and volumes generated	Survey Report	BWMC	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	BWMC	DSWC Village Council Environmental Health	At least 2 waste reduction pilot projects completed	15	X	X			
	1.2.3 erect "no-dumping" signage and surveillance systems at illegal dumping sites	Surveillance system developed & effected Photographic evidence	BWMC	DSWC Village Council Env. Health Dept.	Illegal dumping sites abandoned within year 1	2	X				
1.3 Zone watershed to indicate	1.3.1 Conduct baseline assessments and develop	Baseline assessment report	BWMC/	FWPD, MoA PPD,	Draft land use plans completed	20	X	X			

Output	Activities	Means of verification	Responsible agency for implementation	Collaborating partner	Milestones	Budget US$ '000	Years 1	2	3	4	5
critical, sensitive ecosystems, and areas amenable to farming	appropriate land use plans										
	1.3.2 Hold community consultations to validate plans	Validation report	BWMC	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	BWMC	FWPD, MOA, DOWASCO	At least 50% of target area revegetated by year 2	152	X	X	X	X	X
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	BWMC	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	BWMC	DOWASCO, DBOS,	At least 5 volunteers trained	8	X	X			
	1.5.3 Develop and operationalize a water quality monitoring program	Program document	BWMC		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 At least four appropriate and effective SLM model plots established	2.1.1 Design and establish model plots to demonstrate location-specific SLM best practice	Site visits and photographic evidence	BWMC	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	Drainage design reports	BWMC	MOA, DOWASCO,	Drainage installed on at least 50% of		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**
	systems as part of model plot establishment			Farmers, Land owners	demo plots within year 1						
	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	BWMC	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 farming practices within the watershed	2.2.1 develop awareness materials	Promotion materials	BWMC*	MOA, FWPD, DOWASCO, IICA	A suite of promotional materials compiled	5	X				
	2.2.2 carry out awareness and education programs	Implementation report/plan	BWMC	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	BWMC	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	BWMC	MOA, FWPD, DOWASCO, IICA	Shortlist of suitable personnel compiled	2.5	X				

							Years				
Output	**Activities**	**Means of verification**	**Responsible agency for implementation**	**Collaborating partner**	**Milestones**	**Budget** US$ '000	**1**	**2**	**3**	**4**	**5**
	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											
3.1 Watershed monitoring and enforcement framework established	3.1.1 Hold consultations to secure commitment and participation of key stakeholders	Consultation meeting reports	BWMC	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 roles and responsibilities of stakeholders	Document	BWMC		Draft WMEP developed	7	X				
	3.1.3 Prepare recommendations for the approval of supportive and necessary legal provisions	Copy of recommendations	BWMC		Recommenda-tions prepared and submitted	2	X				
	3.1.4 Roll out WMEP	Media reports, photographic evidence	BWMC	MOA, FWPD, DOWASCO, Legal Affairs, Village council, community groups	WMEP is the tool for monitoring the BW	1.5	X				
	3.1.5 Monitor progress of the WMEP implementation, take appropriate	Progress reports	BWMC		Reports prepared that accurately reflect the rate	15	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**
	remedial actions and document lessons learnt				and extent of progress of WMEP implementation						
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	BWMC	MOA, FWPD, DOWASCO, Legal Affairs, Village council, community groups	Two successful meetings/work-shops completed	9	X	X			
4.2 The BW Management Committee (BWMC) 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 BWMC	Constitution and by-laws for the BWMC ratified	MERMKU	MOA, FWPD, DOWASCO, Legal Affairs, Village council, community groups	The BWMC formalized	0	X				
	4.2.2 Mobilize a cross section of selected representatives from community groups, individuals and other key	List of Board members and officers of the BWMC	MERMKU	MOA, FWPD, DOWASCO, Legal Affairs, Village council,	Full compliment of Directors and Officers of the BWMC commissioned	0	X				

							Years				
Output	**Activities**	**Means of verification**	**Responsible agency for implementation**	**Collaborating partner**	**Milestones**	**Budget** US$ '000	**1**	**2**	**3**	**4**	**5**
	stakeholders to form the BWMC			community groups							
	4.2.3 Formally launch the BWMC	Media reports, Agenda photographic evidence	MERMKU	Public Works Dept, Lands and Surveys Division (LSD)	BWMC Launched	1.5	X	X			
	4.2.4 Develop an implementation plan to guide the activities of the BWMC	Report	BWMC		Identify areas for reforestation and type of plants	0	X	X	X	X	X
	4.2.5 Monitor and report on progress	Report	BWMC		Progress reports prepared and submitted	7	X	X	X	X	X
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						**371.5**					

Note that budgeted amounts per activity and the total sum of **Three hundred and seventy one thousand five hundred United States Dollars (US$371,500.00** 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 BWMP.

5.5 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 BWMP.

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 Batali watershed management council (BWMC) 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.

5.6 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 BWMC, FWPD and Ministry of Agriculture and DOWASCO. Generally, the BWMC 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.

5.7 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.

5.8 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 BWMC 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 BWMC based on the monitoring and evaluation reports and in consultation with the communities and implementing agencies. A summary of the BW monitoring plan is detailed in Table 11.

Table 11: Monitoring plan for the BW

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	BWMC	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	BWMC		Quarterly
		Rates of riverbank erosion	Annually			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 BWMC	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

5.9 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 BWMC 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 BWMC, 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 BW 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 Batali.

6.1 Recommendations

Improvement of institutional arrangements for BWMP 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 riverbank slope)

Water Quality Monitoring

Ongoing water quality monitoring is recommended for the BR 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 Batali River. 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 BR 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 15-20% of the land area in the BW. Agricultural land areas are a significant source of runoff and potential sources of pollutant loads to the BR. 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 50% of the BW. 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.
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 BWMC'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 BWMC 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.

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8 APPENDICES

8.1 Appendix A: Recommended forestry management plan for the BW

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

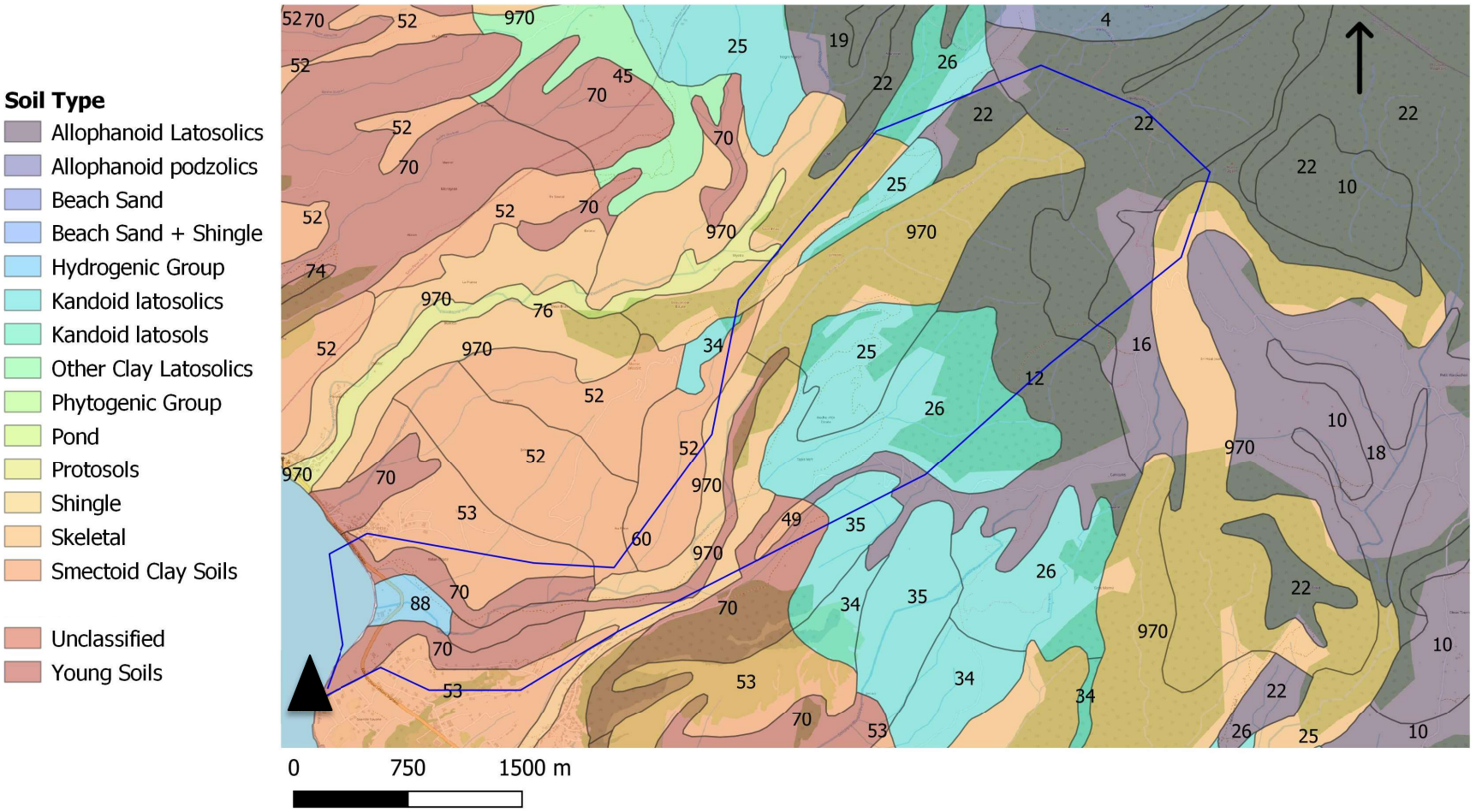

Figure 24: Soil map demarcating an outline of the Batali Watershed showing soil types and related soil map numbers