 	 
PROJECT:	**SUSTAINABLE LAND MANAGEMENT IN THE COMMONWEALTH OF DOMINICA**
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COULIBISTRIE WATERSHED MANAGEMENT PLAN

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This report was prepared by EcoApp Inc.

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VALIDITY PERIOD FOR PLAN

This plan is valid for a period of five years from June 2023 to May 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.

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ACRONYMS

BMP	Best management practice
CR	Coulibistrie River
CW	Coulibistrie Watershed
CWMC	Coulibistrie Watershed Management Council
CWMP	Coulibistrie 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
FWPD	Forestry Wildlife and Parks 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
WSSDP	Water Sector Strategic Development Plan
WTP	Water Treatment Plant

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EXECUTIVE SUMMARY

Watershed ecosystems are Dominica's most prized national assets, yet they are most threatened due to unsustainable human activities and repeated impact from severe storm events. The Coulibistrie Watershed although in many ways are similar to other watershed systems in Dominica, is extremely steep and consists of very shallow and fragile soils that are highly erodible. High intensity rainfall in the upper watershed and topographic formations make the area extremely vulnerable to flash floods and debris-flow movements. Recent flooding events have significantly impacted the community leaving physical, emotional and psychological scars of it residents. Damage to homes and property, the collapse of the main link feeder road and displacement to the water abstraction infrastructure have affected the socio-economic situation there and have raised fresh concerns for flood control and the need for more active management of the watershed. Agriculture, a once dominant activity in the watershed has declined owing to the loss of farmlands and road access. Unless actions are taken to address and improve land management and watershed hydrology, the risk for occurrence of future floods remains high even with lower intensity rainfall. Part of the problem also stems from elevation of the riverbed from silt deposition and morphological changes to the water course. The present prognosis is that it will become harder and harder for this watershed to rebound from successive storm impact, and more and more resources will need to be diverted from productive sectors to remedy the situation, unless key intervention are implemented urgently.

Cognizant of the prevailing threats and recognizing that the potable water supply for multiple west coast communities, including Coulibistrie, Morne Rachette and Grand Savanne (Salisbury) is sourced from the CW, 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 this system as a case study and pilot for the implementation of sustainable land management approaches in watershed restoration. Consequently, a watershed management plan was developed for Coulibistrie 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 restoring the watershed hydrology to diminish flood risk and land loss. The plan is a blueprint to guide groups, farmers, state agencies to work collaboratively for the protection of watershed systems in Dominica.

The CW is a characteristic V-shaped system draining an area of about 1313 hectares on the northwest coast of Dominica. Several watershed units form part of this complex. The topography throughout the watershed is mostly steep with fragile shallow soils and is unsuitable for arable farming following the collapse of the feeder road system due to the passage of Hurricane Maria. The watershed has been highly altered from storm-related disturbance and is prone to flash flood.

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

- High landslide vulnerability
- High risk of flash flood to community
- Absence of robust riparian vegetation
- Weak monitoring and enforcement
- Lack of awareness on sustainable 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 to enable the implementation of the WMP.
- Stabilize the most vulnerable riparian zones with fast growing tree species and where practicable and enrichment planting where major gaps have developed with native species and or economic species. Other bioengineering interventions to retard the rate of overland transport of sediment and stabilization of riverbank is also necessary.
- Establish a volunteer water quality monitoring program for continuous and cost-effective monitoring of the CR 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 Coulibistrie Watershed Management Council (CWMC)
- 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.
- 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 have elevated the urgency with which climate change adaptation objectives must be factored into national development plans.

It is within this abbreviated context that watershed management becomes relevant, highlighting the need to pursue more coordinated approaches to conservation. Dominica NRDS emphasizes that conservation, sustainable use of natural resources, and the preservation of biodiversity, is an essential prerequisite for the island to strengthen its adaptive capacities and to create sustainable livelihood opportunities for resource-dependent communities. This watershed management plan for Couilibistrie 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 Coulibistrie Watershed (CW), 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 domestic needs for the communities of Coulibistrie. The link between watershed health, ecosystem function and the social and economic wellbeing of the community is 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 Coulibistrie 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 for concerted action to better protect and restore watershed health. It will also complement other sustainable land management initiatives presently ongoing in the area.

1.3 Purpose of the Coulibistrie Watershed Management Plan (CWMP)

The Coulibistrie Watershed remains extremely 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 CWMP 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 Coulibistrie Watershed

2.1 Physical description

The CW is a characteristic V-shaped system draining an area of about 1313 hectares on the northwest coast of Dominica. Several watershed units form part of this complex including:

Colihaut, Dublanc, Jargie, Picard, and Indian River. The Coulibistrie complex is also part of the Morne Diablotin river basin (Figure 1). The topography throughout the watershed is mostly steep with rock outcrops and a narrow valley not conducive to any form of development. This area is unsuitable for arable farming following the collapse of the feeder road system due to the passage of Hurricane Maria and subsequent storm. The watershed has been highly altered from storm-related disturbance and is prone to flash flood.

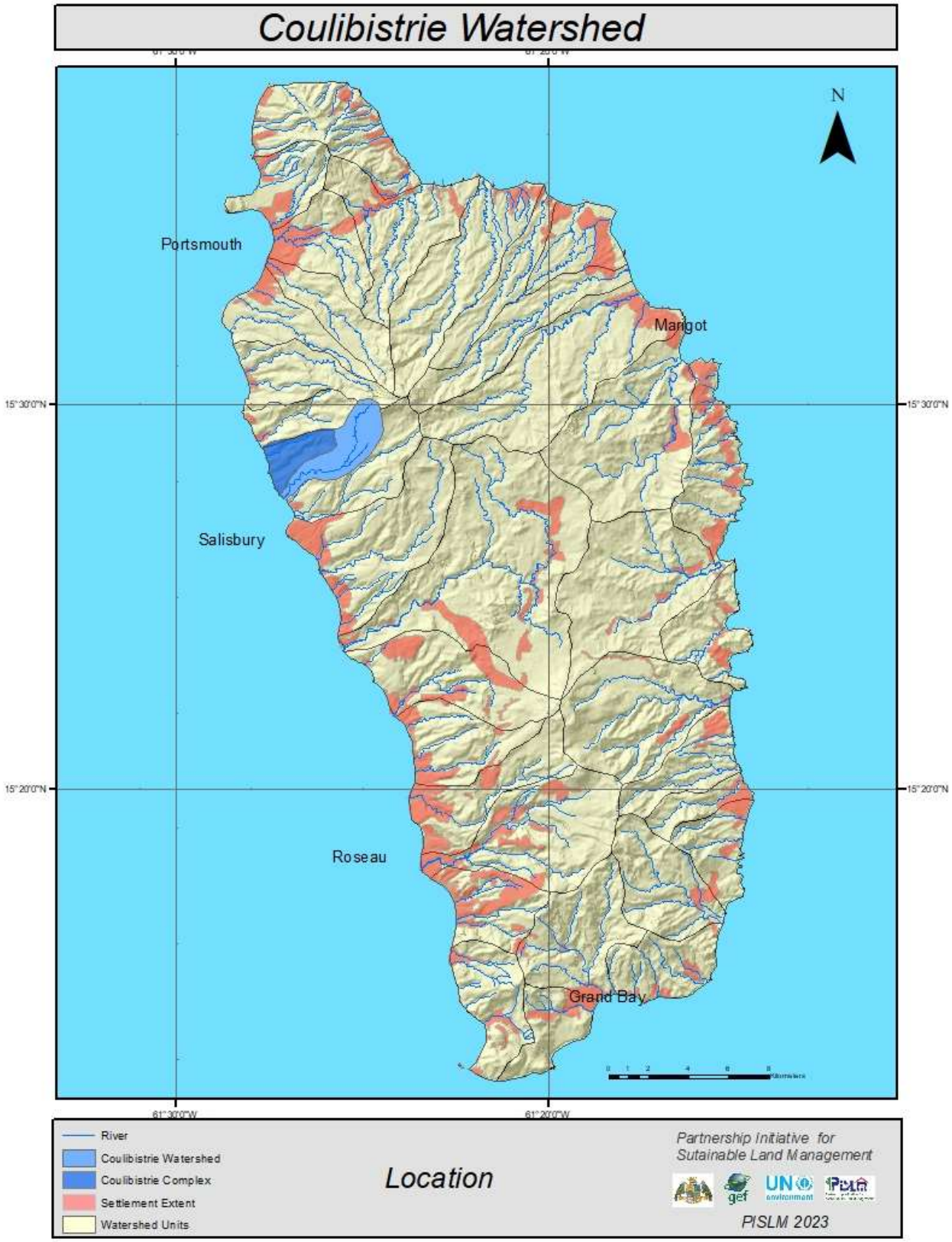


Figure 1. Coulibistrie Watershed Extents

2.1.1 The watershed drainage system

The CW has a characteristic dendritic stream network where several tributaries converge into the main Coulibistrie River in the mid watershed region (Figure 2). This is an indication that throughout the watershed, sub-surface rocks are composed of homogeneous materials, and 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.

Like most other watershed systems in Dominica, the watershed length and slope determine the

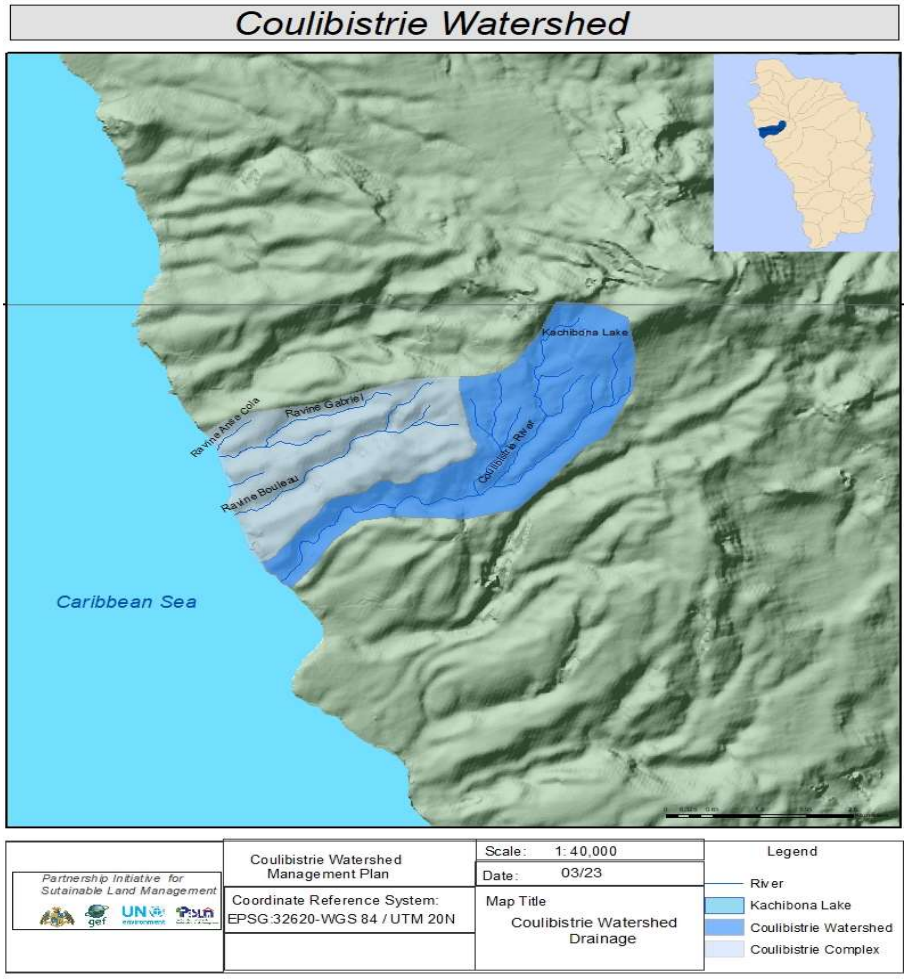


Figure 2: Drainage pattern of Coulibistrie Watershed

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 generally steep throughout the CW (Figure 3) with the lower to mid-section of the watershed averaging above 40°. This area is dominated by steep impassable slopes with rock outcrops.

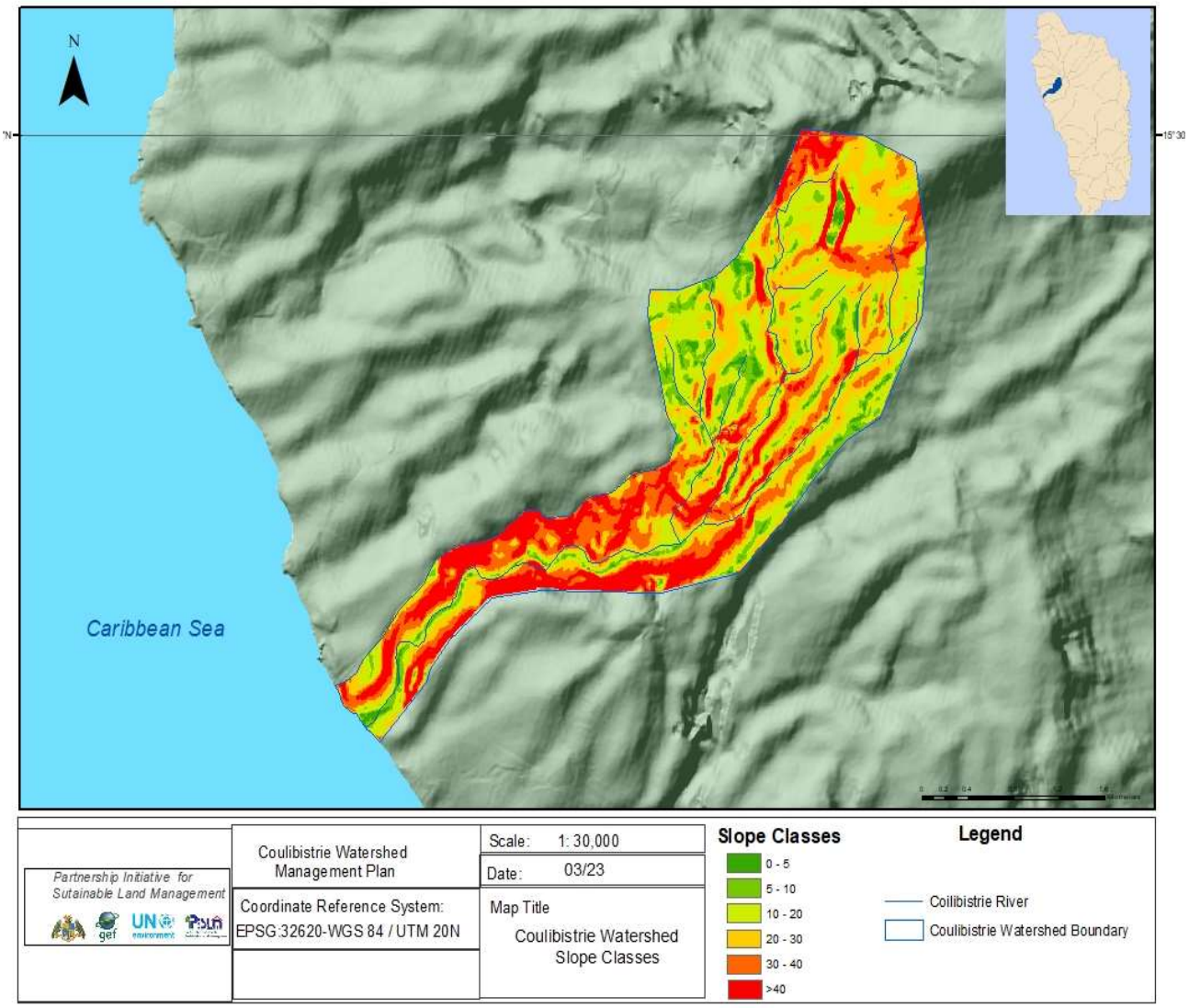


Figure 3: Slope characterization of the Coulibistrie Watershed

The average slope of the watershed, rainfall intensity and duration, vegetation cover, and soil saturation significantly influences the transition time and the volume of runoff that is transported into the watercourse.

This attribute gives rise to the watershed hydrographic network. Other factors including geology, climate, and environment also contribute to the formation and orientation of the hydrographic network. The hydrographic network is one of the most defining characteristics of any watershed.

2.2 Seasonal climate (rainfall)

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

Rainfall is variable throughout the year and is lowest for regions near the coast. Average rainfall computed for the 12-year period (1999-2010) for Coulibistrie based on data from the nearest rainfall data collection site at Carholm (15.42457, -61.38448) is 3686 mm (See Figure 4). Monthly average rainfall over this period is 307 mm. The driest month (least rainfall) is March with an average of 144.6 mm while the wettest (highest rainfall) over the same period is July averaging 466.7 mm. During the reporting period annual rainfall exceeded 4,000 mm only in 2004. Because of relatively high rainfall in uppermost regions, surface flows continue for nearly all the major streams in watershed, even though there are noticeable volume changes in the peak dry season. Some smaller streams may dry up during the driest months.

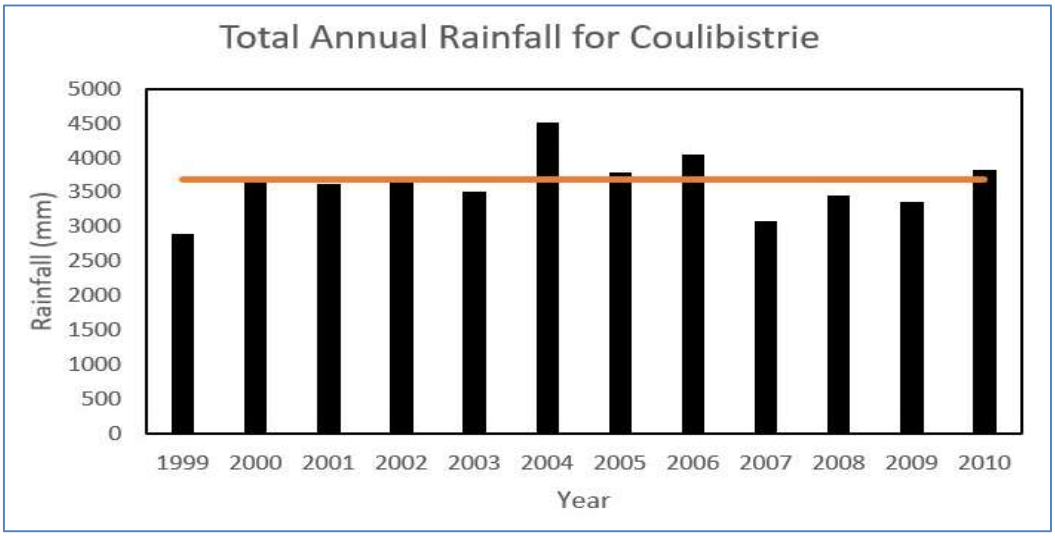


Figure 4: Total Annual rainfall for Coulibistrie based on a 12-year data set for lower Carholm. Orange line is the average for the period. (Source: Arlington James, Former Senior Forestry Officer, FWPD)

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 Coulibistrie community (anecdotal evidence). Climatic variation and storm related impacts, 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. This may be contributing to observed changes in watershed hydrologic responses, whereby peak flows following rainfall

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

events tend to be greater for lower intensity rainfall. No long-term systematic monitoring of flows at the Coulibistrie 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 Coulibistrie 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.

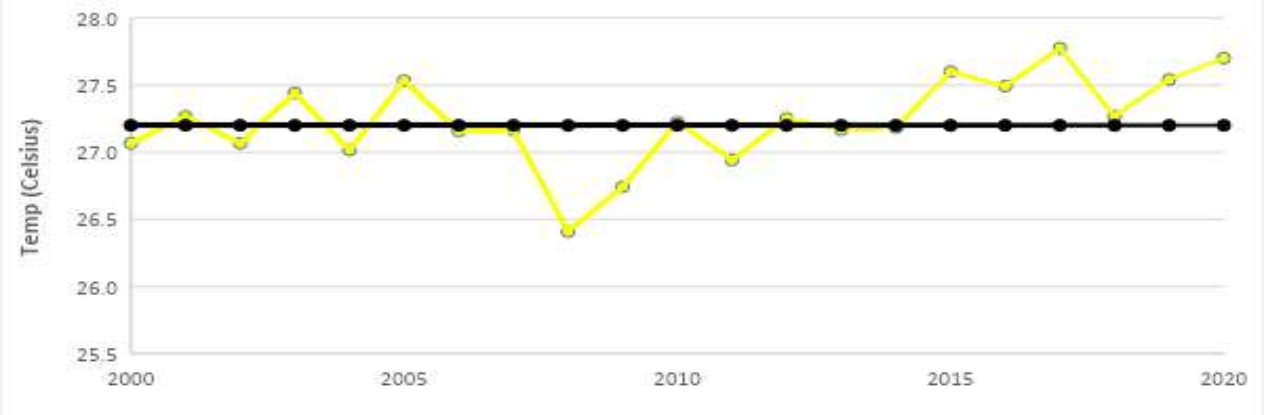


Figure 5: Mean Annual temperature for Coulibistrie based on a 20 year average for Canefield

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.

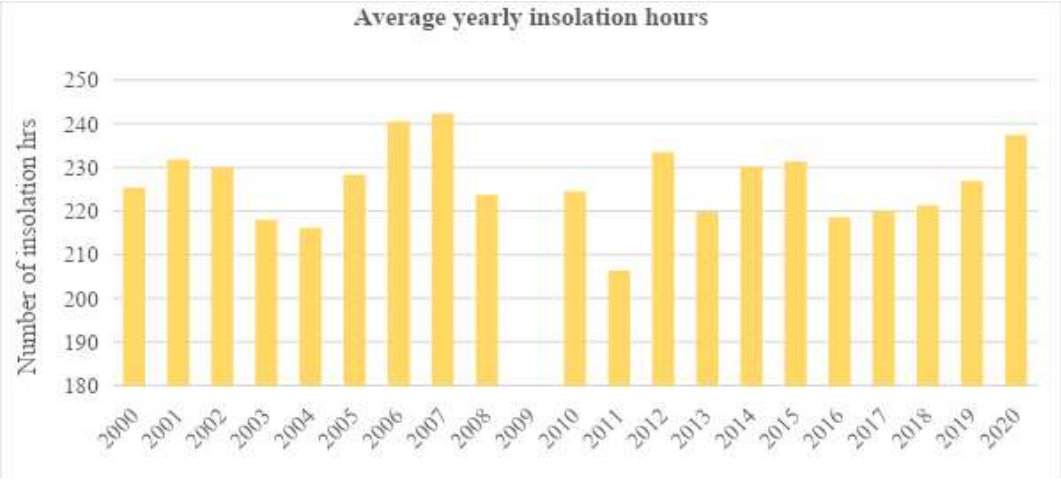


Figure 6: Mean Annual Insolation for Coulibistrie. Data for 2009 is missing

(Source: Canefield Met Office)

Climate change and 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 increase erosion risks with lower and short intense rainfall. On the contrary, higher temperatures are likely to increase demand for water to meet 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 moderate stream density (1313 ha/12) i.e., for every 109 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 sections as shown in Figure 7. The United States Department of Agriculture Stream Visual Assessment Protocol (SVAP)[2] was used to ascertain the general health and stability of the watercourse. The SVAP method is regarded as the first step of a four-part assessment protocol to assess ecosystem health associated with streams. This first level assessment provides information on the basic health of the stream, specifically associated with the physical conditions within the assessment area. The results of these assessments are useful in deciding whether further ecological assessments are necessary and to inform stream restoration planning. Overall assessment scores are summarized in Table 1 and fall into four distinct categories namely Optimal/(Excellent) (16-20), Sub-Optimal/(Good) (11-15), Marginal/(borderline) (6-10) and Poor (≤5). The general ecological parameters in all sections of the stream appear to be good however vegetation and bank stability is an issue across the board. Aquatic life in the upper watershed is poor. As per the results of the hydrologic assessment, the watershed health and the stability of streams appear to be threatened by loss of forest cover and the recent 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 Coulibistrie River

Assessment Element	Watercourse sections Stream Assessment Scoring		
	lower	mid	upper
Sediment deposition in pool	18	17	5
Channel flow status[3]	19	19	19
Water clarity	18	18	19
Channel Alteration	17	17	17
Channel Sinuosity	18	18	18
Bank Stability -Left bank	10	8	17
Bank Stability-right bank	5	8	12
Riparian vegetative Zone width -left bank	2	3	2
Riparian vegetative zone width-right bank	2	3	2
Observed aquatic life in stream	15	17	0
Presence of coarse wood debris (count)	0	0	1
Channel width at station (m)	5.5	3.4	2.9
Wetted width of channel (m)	5.5	3.4	2.9
% wetted width	100	100	100
Right bank slope Steep (S), Moderate (M), Flat (F)	M	S	S
Left bank slope Steep (S), Moderate (M), Flat (F)	M	M	F

Results Key: Excellent | Good | Borderline | Very Poor

2.3.1 Stream flow and water quality

Twelve tributaries and one main river drain the entire Coulibistrie water catchment. Stream flow data for the area is scanty but two measurements were taken, one 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). A flow measurement was repeated only for the lower section on 09/02/2023, this was specifically done for determining sediment load of the CR discharge. Table 2 gives the summary of the 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.

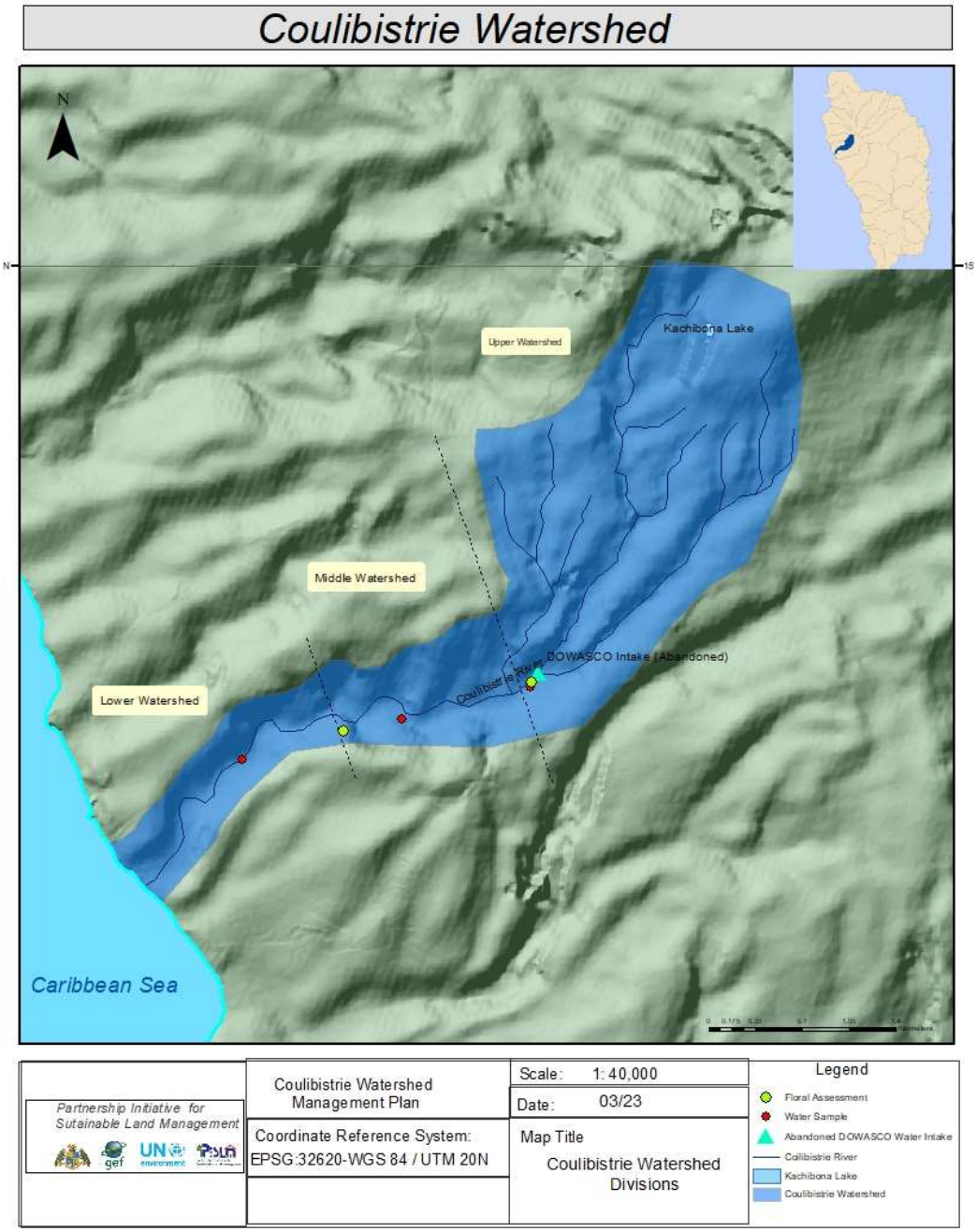


Figure 7: Sampled locations in the CW.

Three water quality monitoring stations at which, stream flow was also measured are highlighted with two 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 Coulibistrie River (Streamflow measurements conducted 30/04/2021 and 09/02/2023)

Date	Location	M^3/S	GPD
30/04/2021	Upper watershed	0.237	4,504,264
30/04/2021	Mid watershed	0.473	8,989,523
30/04/2021	Lower Watershed	0.379	7,203,021
09/02/2023	Lower Watershed	0.273	6,231,079

The flowrate is highest in the mid watershed region where the upper tributaries converge and exceeds 8.9 m GPD. In the lowest reaches of the watershed flow decreases to 0.379 M^3/S with a discharge of 7.2 m GPD. Above this sample point, is an abstraction area where water is channeled for feeding makeshift domestic temporary storage facility. It is very interesting that the flow rate at the lower Watershed point decreased by 18% from 0.379 to 0.273 or by 971,942 GPD. This is probably explained by rainfall data retrieved from the nearest meteorological station at the Canefield Airport (Figure 8). While the month was overall wetter than normal there was apparent no significant rainfall from January 16th 2023 up to the sampling date February 2nd, 2023, (17-18 days).

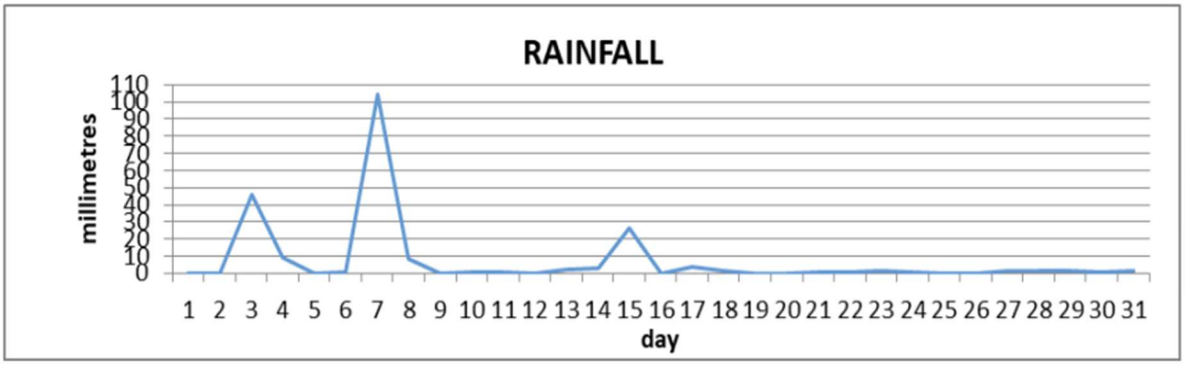


Figure 8 Summary of daily rainfall for January 2023 recorded at the Canefield Airport and used to represent rainfall for the Coulibistrie Watershed for that period **Source: Dominica Met Office**

Table 3 summarizes the chemical and microbiological analyses for water samples taken in the lower section of the Coulibistrie River (Co_Lo_01). Please refer to Figure 7 for sample locations. Due to time constraints and processing costs, sampling in the mid and upper region of the watershed was not possible to allow same-day transfer of samples to Saint Lucia. Pesticide analysis could not be rationalized for that watershed primarily due to minimal human impacts versus high processing cost. Microbial samples were processed by the CARPHA-Environmental Health and Sustainable Development Department Laboratory in Saint Lucia. The Dominica Bureau of Standards (DBOS) conducted the chemical analysis.

Table 3: Water quality parameters for Coulibistrie River (Sampled on 08/16/2021)

Test/Parameter	Sample ID	Method	Result
Microbiological			**CFU/100 mL**
E. coli count	Co_Lo_01	EPA1103.1	21
Enterococci	Co_Lo_01	CEHILSM-4	<1
pH	Coul	ISO 10523:2008	7.44
Phosphate	Coul	Ascorbic Acid Method	0.05
Nitrates	Coul	Salcylate method	1.2

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

Along the entire stretch of the CR, there is no significant agricultural activity, housing or farm discharge point that can contribute sewage to the stream. It was not surprising that microbial levels in the water were quite low. The sample point is approximately 300-400 m upstream of the closest housing development in the community. It should be noted that prior to the sampling event, no significant rainfall was recorded for the area. Microbial levels are generally good indicators of water quality.

2.3.2 Sediment load

Sediment load (SL) or sediment transport is the movement of organic and inorganic particles by water. In general, the greater the flow, the more sediment that can be transported. Sediment movement in streams and rivers take several forms. Suspended sediment is the finer particles which are held in suspension by the eddy currents in the flowing stream, and which only settle out when the stream velocity decreases, such as when the streambed becomes flatter, or the stream discharges into a pond or lake[4]. Larger solid particles are rolled along the streambed and called the bedload.

The relative quantities moved in suspension and as bedload vary greatly from one watershed to the next. At one extreme, during high rainfall events, sediments originating from eroded fine-grained soil, such as allophanoid clays, may remain almost entirely in suspension during

[4] Hudson, N.W. (1993) Field Measurement of Soil Erosion and Runoff Silsoe Associates Amptill, Bedford, UK for the Food and Agriculture Organization of the United Nations. Accessed 10 Jun. 2023. From https://www.fao.org/3/t0848e/t0848e-10.htm#P1452_136573

transport. This is typical of the characteristic chocolate brown colour of rivers during and after high rainfall events. On the other hand, a fast-flowing clear mountain stream may have negligible amounts of suspended matter and almost all the movement of gravel, pebbles and stones are restricted to the on the streambed.

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

The tendency for sediment transport and loading in the Coulibistrie embayment is notably high during high intense rainfall given the inherent vulnerability of the CW to erosion and soil loss. When this occurs, the embayment ecosystems critical to sustaining fisheries and tourism are smothered adversely affecting coral reef systems. The decline in pelagic fisheries within the general rea is attributed to high sediment loading rates from terrigenous sources and longshore drift of sediment laden waters from quarry activities in the nearby communities.

Sediment transport is a good indication of how a watershed responds to various interventions. In order to a establish baseline as part of long-term monitoring strategy for the CW, basal and storm-induced sediment load was estimated by the total suspended solid (TSS) method. Unfortunately, a prolonged dry season during the study period precluded storm-induced measurements. **Basal-flow suspended sediment load calculated for the CR on 09/02/2023 was 109.2 mg/s or 9 kg/d**. There was no measurable rainfall for several weeks prior to this measurement and net sediment transport was expected to be low. It is however difficult to gauge whether this value is within a normal range of variability for this system given the general lack of sediment transport studies and data for Dominica. Continuous dry and wet season measurements over an extended period are required to determine average seasonal loads. In one study conducted in two small watersheds in St. Lucia, which are of comparable size and under contrasting land management regimes, showed that the soil losses from an intensively cultivated agricultural watershed were 20-times higher in magnitude than that of a forested watershed both for peak rainfall events and for total duration of analysis[5]. This was due to higher surface runoff rates and exposure of soil to direct raindrop impact within cultivated areas.

[5] Cox, CA, Sarangi, A., Madramootoo, CA. 2006. Effect of lnd management on runoff and soil losses from two small watersheds in St. Luica. Land Degrad. Dev. 17, 55-72

2.4 Soils

Soil type within the watershed is dominated by the Skeletals and Kandoid Latosolics with smaller pockets of Allophanoid Latosolics, Smectoids and young soils

2.4.1 Skeletals

Skeletals include sand, gravel and unconsolidated rock that are known to be prone to landslides (Lang, 1967)[6]. They are dominant in the low, mid and uppermost sections of the watershed where the terrain is most steep. Skeletals are very shallow, prone to erosion and cannot support any agricultural activities. They are quite low in fertility with little topsoil development.

2.4.2 Kandoid latosolics

These are most dominant along the northern flanks of the watershed and in the upper regions. The Kandoid latosolics in these areas usually occur on mixed alluvial 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. Localized water logging can be a challenge for land use in these areas.

[6] 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

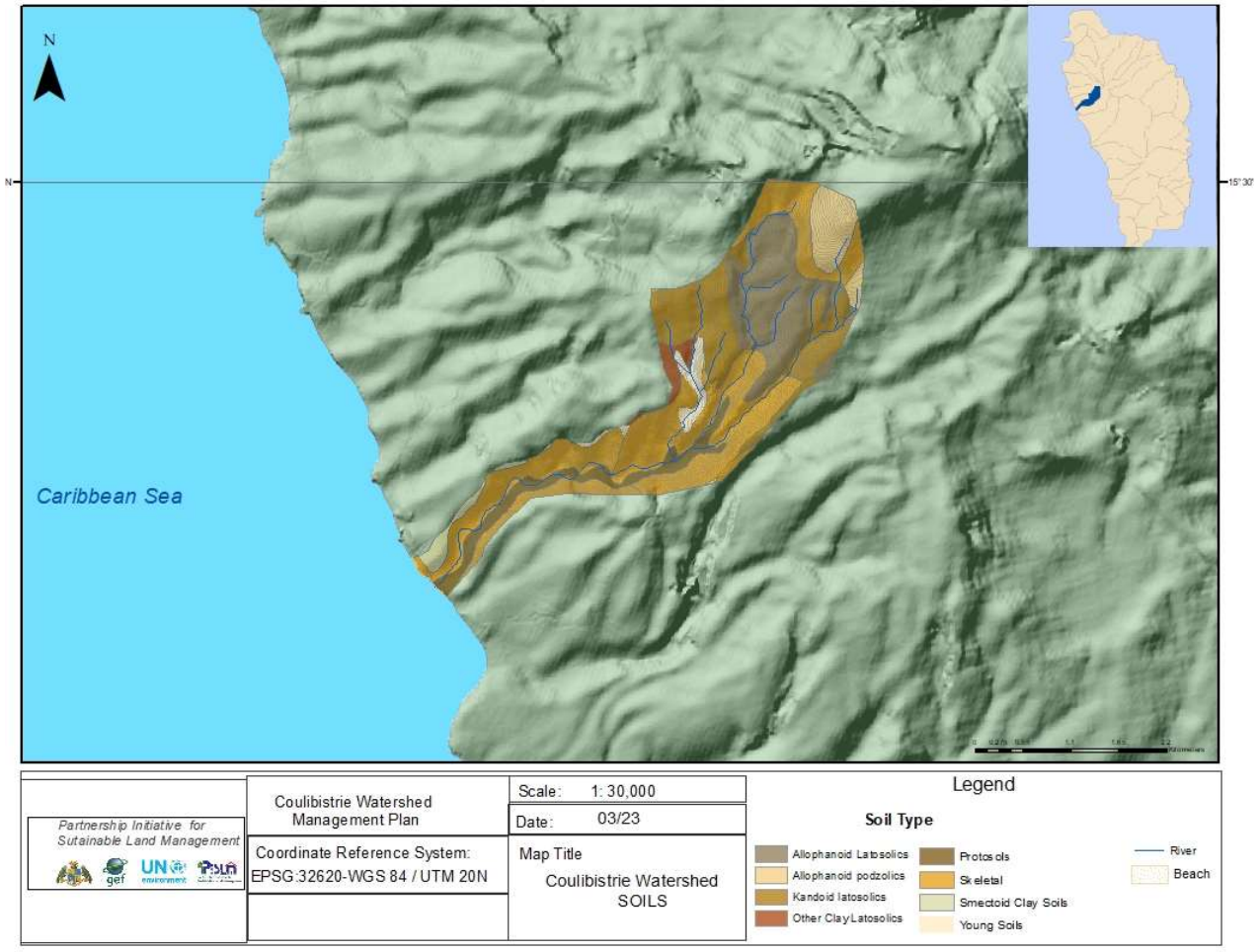


Figure 9 Spatial distribution of the main soil types within the CW

2.4.3 Allophanoid latosolics

Allophanoid latosolics is dominant mainly in the upper watershed regions. They are highly permeable, have 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.

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 causes 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.

Only small patches persist along the northern flanks in the low watershed regions. 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[7].

2.4.5 Young Soils

Confined to a relatively small area in the upper mid watershed regions. Young soils are typically unstable, shallow and consist of compact parent material at their base. As a result, drainage is moderately rapid and lateral. They are also highly prone to erosion.

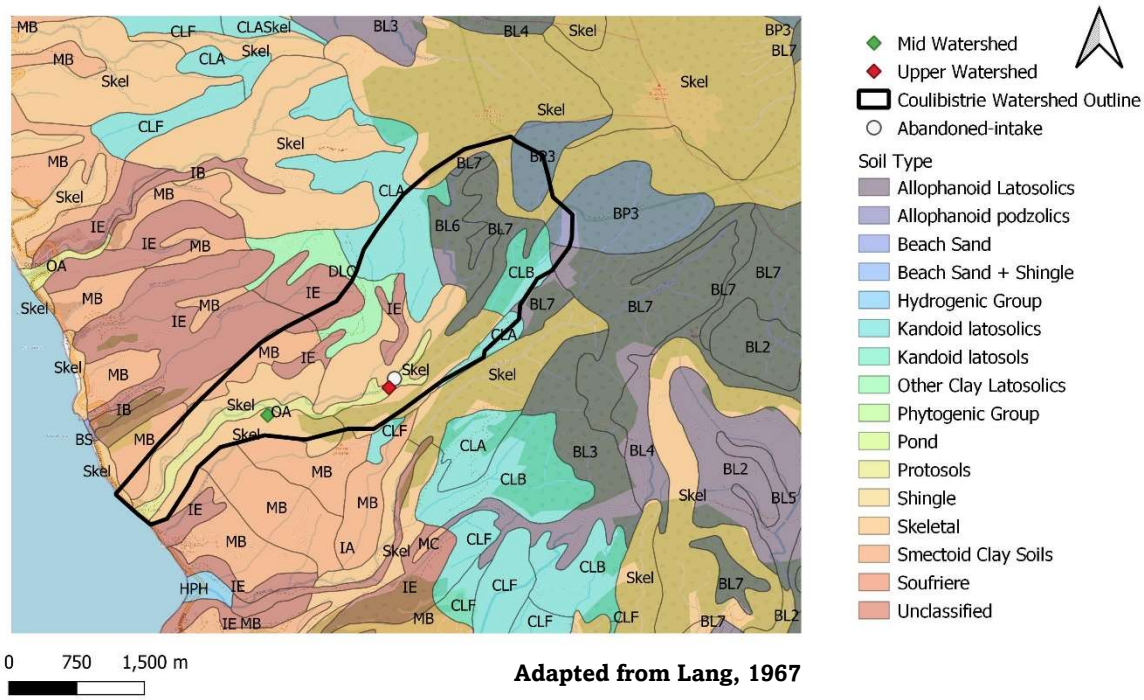
2.4.6 Allophanoid Podzolics

Found at the highest elevations in the headwaters regions 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 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.

2.4.7 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 Coulibistrie Watershed 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 fragile. As indicated earlier the allophanoid latosolics (BL) are inherently more stable and display greater resistance to erosion. Skeletals (Skel) are dominant throughout the watershed and prone to erosion. Kandoid latosolics (CLA and CLB) are dominant in the northern flanks of the watershed and in the upper regions kaolin is the dominant clay which is fairly mature in CLA and immature in CLB. These soils have good internal drainage and generally have low erosion risk except on steep slopes ($>15^{o}$). Vertical drainage is normally rapid. The young soils (IE) on the slopes of the upper-mid watershed regions are most fragile and present the highest erosion risks within the watershed.

[7] 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



Adapted from Lang, 1967

Figure 10. Soil types within the Coulibistrie Watershed

Table 4: Land capability classes and recommended management regimes

Capability	**Fragile**	
	Erosion hazard classes: • High or moderately high • Very high	
	Soil map reference (Fig 9)	**Soil type**
	Skel	Skeletal
	CLA+CLB	Kandoid latosolics
	BL6 +BL7	Allophanoid latosolics
	MA+MB	Smectoid
	IE	Young soils
Slope classes	**Recommended land management practice**	
0° – 5°	**C2 Agroforestry/forestry** Tree crops with dense crown cover intercropped with annual crops; tree orchard, natural or plantation forest	
5° – 10		
10° – 15°	**C3 Production/protection forestry** Generally, allow for natural restoration of native forest species. Where accessible, promote maintenance of dense land cover with suitable timber species and tree crops.	
15° - 20°		
20° - 25°		
25° - 30°		
>30°		

(Modified from Lang (1967).

2.5 Floristic Diversity and land cover

The CW is a significantly disturbed system dominated by pioneer species. The nature of the terrain and largely unconsolidated rock surface is not conducive to large timber species. Recent storm impact and floods have contributed to loss of vegetation within the valley floor and along the riparian areas of the watercourse. This makes the area extremely vulnerable to flash flooding and debris flows.

The watershed is dominated by pioneer shrub vegetation which covers 45% or (586 hectares) and spans an area from the mid to upper watershed regions (See Figure 11). Mature rainforest is less widespread and is mainly found in the upper mid sections where soil conditions are more favourable. Mature rainforest covers approximately 28% of the watershed surface area or (370 hectares). By comparison, montane rainforest is tucked in the headwater regions covering an area of 233 hectares or 18% of the watershed surface area. It plays a critical role in drainage regulation in the headwater regions and is therefore critical for conservation. The scrub woodland forest which persists in the lower regions of the watershed where conditions are characteristically drier and surface soils are shallower covers about 8% of surface area or 106 hectares. Less than 1.5 % (18 hectares) of the watershed is human settlement

Coulibistrie has suffered episodic flooding in the past, causing widespread damage to property and livelihoods. Good forest management and recovery is considered essential to mitigating flood risk and restoring traditional livelihoods. The forest is also central to water course management, which remains one of the main challenges for the community. To better

determine how the forests in the watershed have been recovering since the last major storm disturbance and to better guide management actions, EcoApp Inc. conducted a baseline assessment of the watershed in April 2021 to quantify species diversity and evenness. The Shannon Diversity Index (sometimes called the Shannon-Wiener Index), H, and the Shannon Equitability, EH, were calculated from these assessments. 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. From the data, the upper watershed has the higher H value meaning, the diversity of species in this region was greater. Some of the dominant species in this region include: Bamboo (Bambusa vulgaris), Bwa Kanno (Cercropia schreberiana), Bwa Wivyè (Chimarrhis cymosa), Coco poul (Cordia reticulata), Ficus (Ficus spp.), Mal l'estomac (Lepianthes peltata), Pwadou Mawon (Igna ingoides) and wild eggplant (Solanum torvum). Species evenness in the upper and lower regions are similar. Owing to the ruggedness and inaccessible nature throughout the middle regions of the watershed, vegetation sampling was not possible.

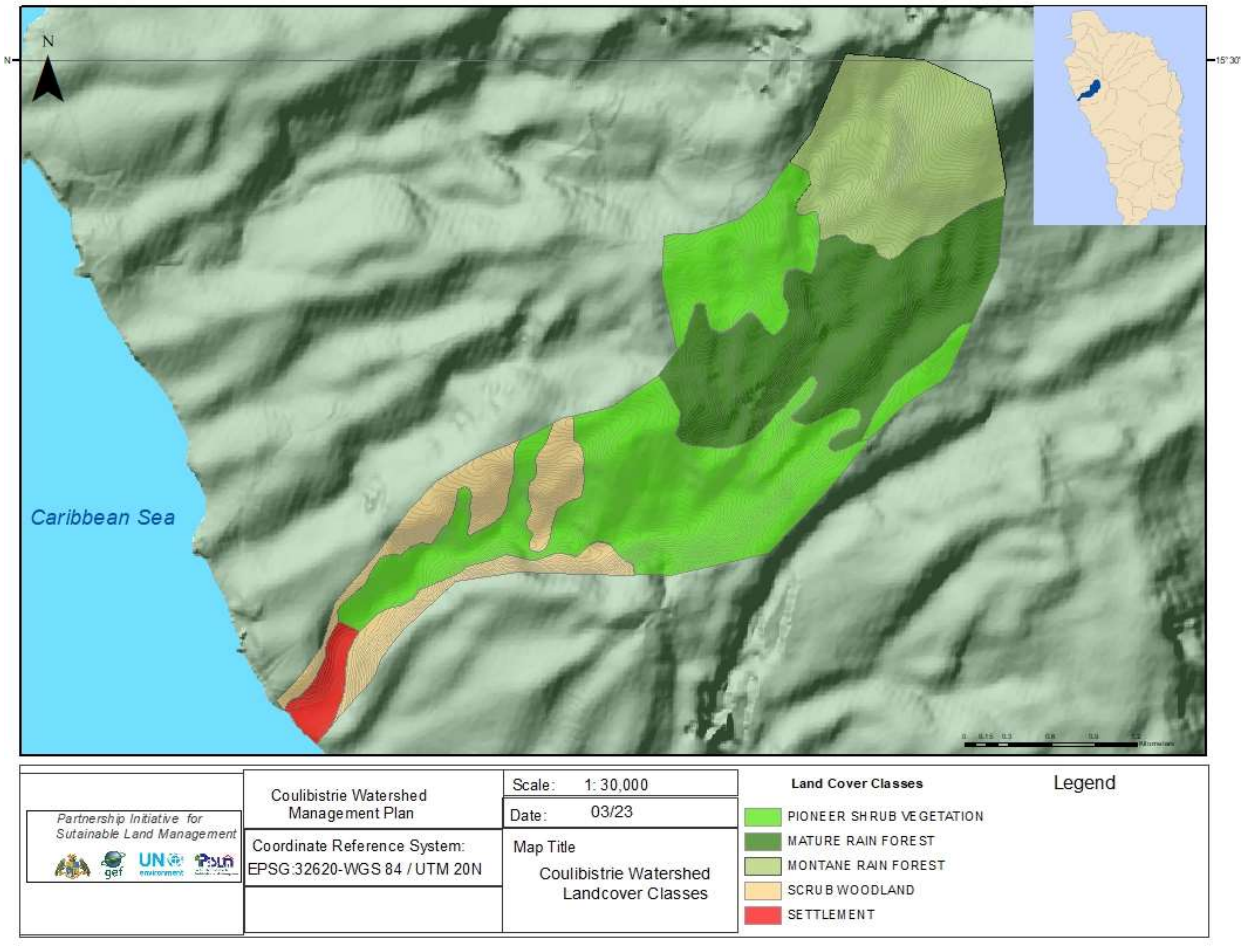


Figure 11: Land use cover map of the CW

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

Watershed Section	Value
Coulibistrie Upper H	2.27
Coulibistrie Upper E_H	0.99
Coulibistrie Middle H	2.08
Coulibistrie Middle E_H	1.00

2.6 Faunal Diversity

Figure 12 Lesser Antilles Iguana

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 13), are present in the area. The area also supports the endemic Dominica *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.

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[8]. 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).

[8] 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)

A total of 176 species of birds have been recorded for Dominica, of which about 66% are Neotropical migrants and 34% are resident species[9]. Diverse species of birds are associated with all sections of the watershed according to a bird survey conducted by EcoApp Inc. Figure 14 shows the percentage of the total birds (seen or heard) and recorded per each region of the watershed. The highest bird counts for a single section of the CW was recorded in the lower region (18.2%). Table 6 presents bird counts per watershed sub-section while Table 7 collectively shows the main species associated with the general watershed.

Table 6: Bird counts per watershed section

Coulibistrie	Watershed Section ID	%
Lower only	L	18.2
Lower & Mid	L & M	30.3
Mid only	M	2.6
Mid & Upper	M & U	5.3
Upper only	U	6.1
Upper, Mid & Lower	UML	36.4

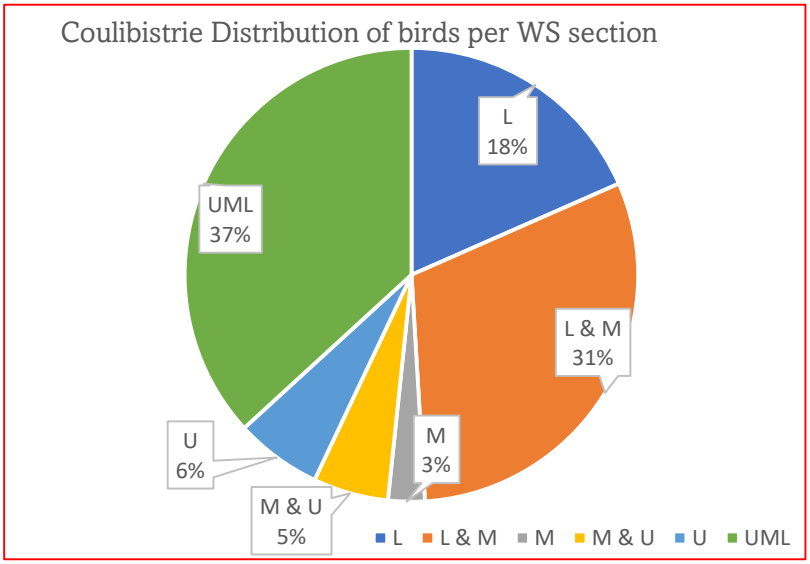


Figure 13 Distribution of birds throughout the CW

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). On of Dominica's endemic parrots, the Red-necked Parrot (*Amazona arausica*) was identified during the survey. Gonmyè (*Dacryodes excelsa*) is a premier food source for the parrots, but no trees were identified in the flora survey. These trees are sought after for lumber and resin extraction. 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[10]. The recent impact of Hurricane Maria (2017) also had major consequences for both species of parrots.

[9] 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)

[10] 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 CW

No	Common Name of Bird	Scientific Name	Status
1	American Kestrel	Falco sparverius	Neotropical migrant
2	Antillean Crested Hummingbird	Orthorhyncus cristatus	Caribbean endemic
3	Antillean Euphonia	Euphonia musica	Caribbean endemic
4	Bananaquit	Coereba flaveola	
5	Black-faced Grassquit	Tiaris bicolor	
6	Black-whiskered Vireo	Vireo altiloquus	
7	Broad-winged Hawk	Buteo platypterus	
8	Carib Grackle	Quiscalus lugubris	
9	Caribbean Elaenia	Elaenia martinica	Caribbean endemic
10	Common Ground Dove	Columbina passerina	
11	Gray Kingbird	Tyrannus dominicensis	
12	Green Heron	Butorides virescens	
13	Green-throated Carib	Eulampis holosericeus	Caribbean endemic
14	House Wren	Troglodytes aedon	
15	Lesser Antillean Bullfinch	Loxigilla noctis	Caribbean endemic
16	Lesser Antillean Flycatcher	Myiarchus oberi	Caribbean endemic
17	Lesser Antillean Pewee	Contopus latirostris	Caribbean endemic
18	Lesser Antillean Saltator	Saltator albicollis	Caribbean endemic
19	Little Blue Heron	Egretta caerulea	
20	Mangrove Cuckoo	Coccyzus minor	
21	Plumbeous Warbler	Setophaga plumbea	Caribbean endemic
22	Purple-throated Carib	Eulampis jugularis	Caribbean endemic
23	Red-necked Parrot	Amazona arausica	Dominican endemic
24	Red-legged Thrush	Turdus plumbeus	Caribbean endemic
25	Ringed Kingfisher	Megaceryle torquata	
26	Rufous-throated Solitaire	Myadestes genibarbis	Caribbean endemic
27	Scaly-breasted Thrasher	Allenia fusca	
28	Scaly-naped Pigeon	Patagioenas squamosa	Caribbean endemic
29	Smooth-billed Ani	Crotophaga ani	
30	Spotted Sandpiper	Actitis macularius	Neotropical migrant
31	Yellow-crowned Night Heron	Nyctanassa violacea	
32	Yellow Warbler	Setophaga petechia	
33	Zenaida Dove	Zenaida aurita	

2.8 Agriculture and land use

Like any other agriculture dependent communities in Dominica, open-field production systems were once a dominant activity in this watershed. Most of the farming activity was concentrated on the valley floor and other pockets where the soil development was more favourable given the steep topography dominated by skeletals. Where this was the case, clear felling, high use of agricultural inputs including inorganic fertilizers and agro-pesticides was common.

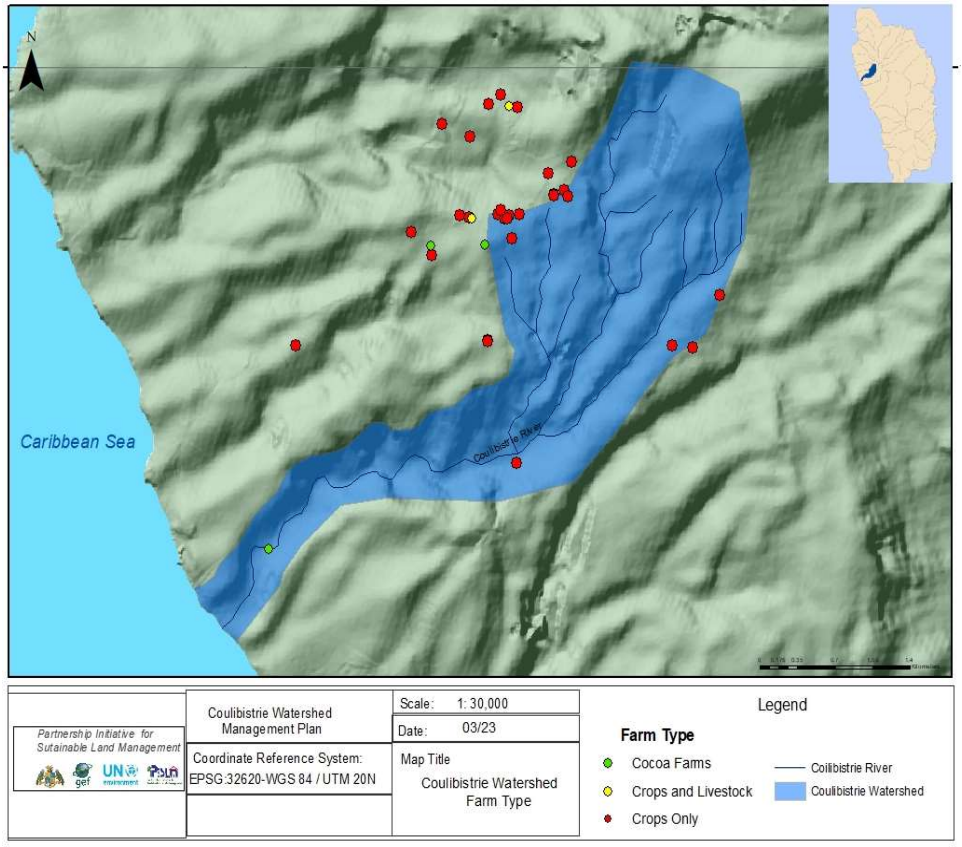


Figure 14: Location of major farms throughout the BW

Given the topographical features and highly fragile soils in this watershed, subsistence farming within the CW suffered significant damage and losses following the passage of Tropical Storm Erika and Hurricane Maria in 2015 and 2017, respectively. The loss of topsoil, access roads and overburden from riverine deposits 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[11]. Damage estimates logged for the areas were comparable.

Of the many farmers who once farmed the area, all but four have relocated to the Syndicate Estate. Only established surviving tree crops and minor subsistence farming is presently practiced with no new cultivation. Farm locations within the watershed are depicted in Figure 15. This shows mainly farms in neighbouring areas like the heights of Colihaut and Morne Rachette.

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

2.9 Socio-economic Status

Coulibistrie is a flood prone community clustered along the banks of the main river with the greatest expanse of flat land near the sea. It is flanked by deep valleys on either side. The village extends about 1 km from the shoreline to the interior and its expansion is restricted by towering cliffs on either side.

Coulibistrie is the northernmost community in the parish of St. Joseph. It has a population of 419 people with a total of 163 households (Table 8). There are 212 dwelling units with an average of 2.6 persons per household according to the Dominica Census Report 2011[12].

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

Communities	Non-Institutional Population	No. of households	No. of persons per household	No. of dwelling units
Coulibistrie	419	163	2.6	212

Source: 2011 National Census

Houses are clustered mostly in the lower watershed regions where the terrain is more hospitable. Figure 16 shows major population settlement in Coulibistrie.

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

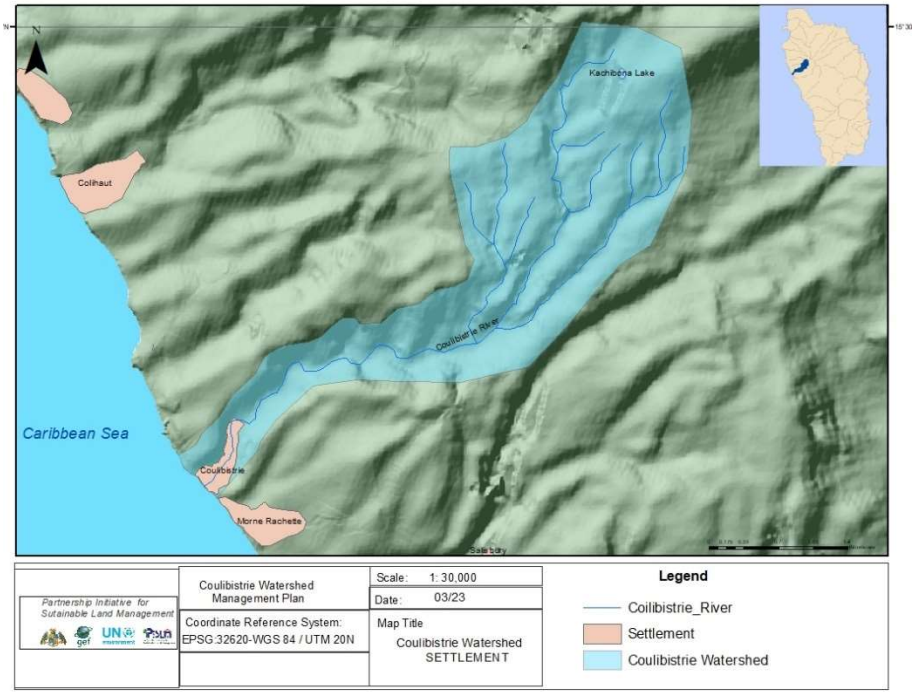


Figure 15: Settlement within the CW

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

could seriously impair the health of the embayment.

The community also depends on the forest ecosystem as a part of their traditional livelihood. The forests provide provisioning services including fuelwood, timber, food, fodder, fibre, shelter, medicines, household implements, and handicrafts.

2.10 Use of water resources

The old DOWASCO intake in the upper watershed in nonfunctional and the infrastructure has been mostly destroyed from the last significant storm event. Consequently, water abstraction for community use is in the lower watershed region via a single transfer line to a holding tank approximated 300 meters downstream. The local topography offers the benefit of water being gravity fed to the makeshift holding tank. With significant decrease in farming in the areas above the abstraction point, the risk of contamination from agricultural runoffs is diminished. The results of water quality tests show that microbial levels are relatively low. Like most other systems across the island, 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 Coulibistrie Watershed

3.1 Introduction

The CW is one of the most vulnerable watershed systems in Dominica. The watershed is very steep with shallow soils owing to slow soil genesis affected by low rainfall levels, high erosion rates and topography. These poorly developed skeletals are prone to rockslides and mass movement which can modify the water channel and flow regiment of the river. The combination of steep slopes, varied topography and often alternating dry and wet spells in this area requires a combination of biological and structural soil and water conservation measures to provide a protective vegetation cover and minimize the downward transport of soil. The maintenance of good vegetative cover and reintroduction of native species in areas where disturbance is most acute, must be considered as part of any restoration effort for this watershed system. Without these measures, the watershed's health is likely to get worse because of the severity and frequency of extreme weather events and the recovery lag times for certain species. This chapter presents a summary of the main issues relating to this watershed.

3.2 Landslide vulnerability of the Coulibistrie Watershed

The watershed is a characteristic V-shaped valley with most of the land surface greater than 40 degrees. The upper elevation receives high rainfall which may exceed 8000 mm annually[13]. The dominant soil types are : skeletals, allophanoid latosolics, allophanoid podzolics smectoids and young soils. They differ primarily on the types and quantities of clay minerals they contain. Their characteristics are highly influenced by climatic factors and stage of weathering.

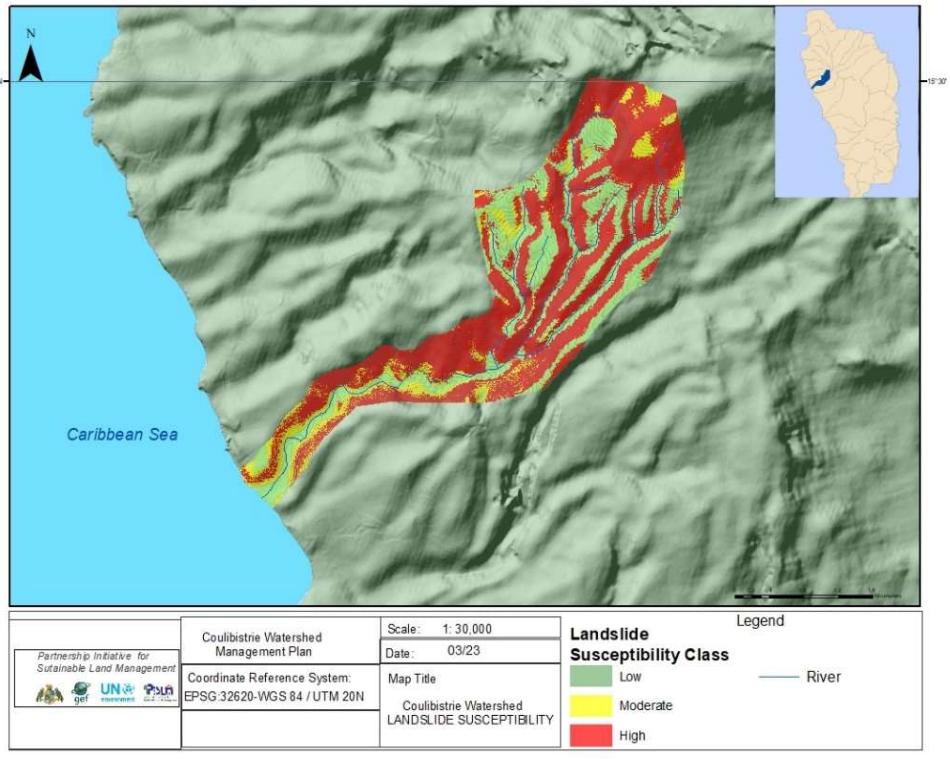


Figure 16: Landslide susceptibility within the Coulibistrie

Soil type and rainfall play a large role in the occurrence of landslides in Dominica. A landside is essentially, the movement of soil, rocks or

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

debris down a slope. Landslides on Dominica are typically triggered by high intensity rainfall during tropical storms and hurricanes but are also caused by human activities such as deforestation and poorly designed road construction[14].

The landslide susceptibility map of the CW (Figure 19) 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 CW are high and variable. Highest vulnerability exists in areas where the skeletal soils exists and on very steep slopes, irrespective of soil type. Generally the Allophanoid and clay soils are more stable. Moderate to low risk is limited to small pockets associated with the allophanoid latosolics. The low-risk areas are generally within the valley floors.

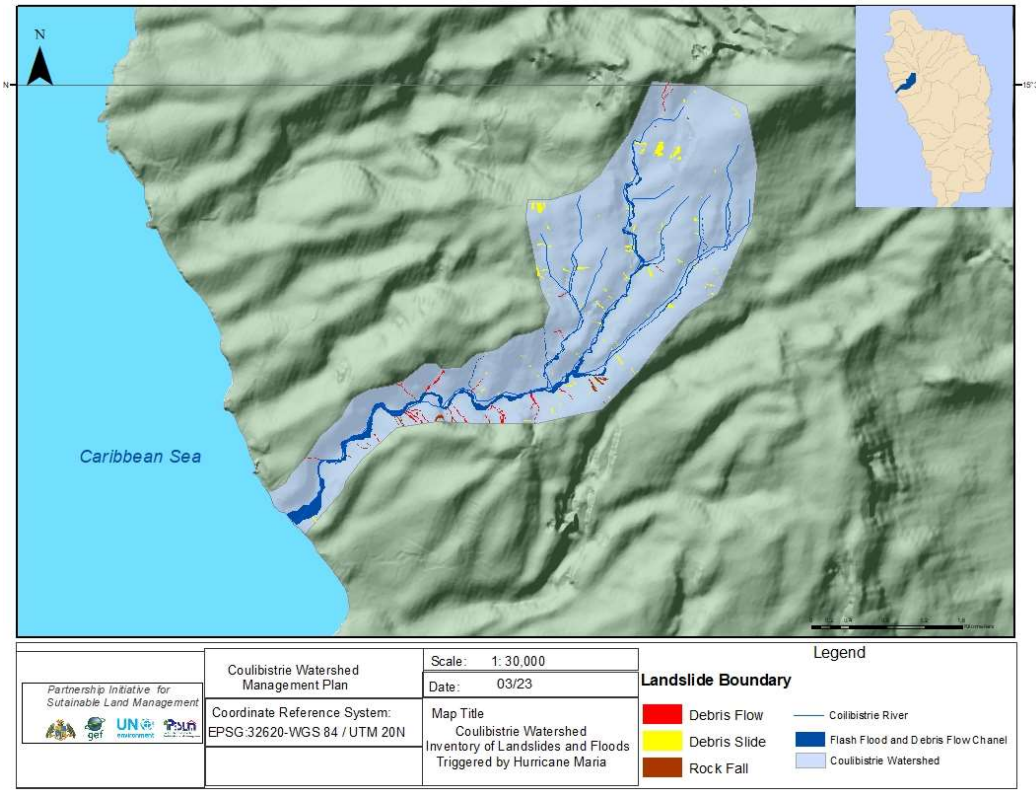


Figure 17: Landslides in the CW attributed to Hurricane Maria

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 the effect of making recovery from intensive events harder15. Figure 19 illustrates areas in the watershed impacted by slides during the passage of Hurricane Maria in 2017. At least eighteen (18) debris flows (fast moving mudslides), twelve (12) rock fall areas and greater than fifty (>50) debris-

[14] 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.

[15]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

slides of various sizes occurred throughout the watershed along the steepest slopes. Most debris slides (mass of unconsolidated and incoherent soil and rock fragments that slide or roll rapidly down a steep slope) occurred in the mid watershed regions and in the high elevation regions within the headwater regions. Several of the debris slides occurred in the upper watershed areas. More studies are required to determine the root causes of landslides in this area.

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

The community of Coulibistrie is at high risk for flash floods because of its narrow and highly restricted valley and potential for water induced debris movement. Flash floods are characteristically of short duration with a relatively high peak discharge. The nature of the watershed formation promotes conditions that can trigger the occurrence of these events. The most recent floods were triggered by high intensity rainfall which caused widespread damage to the community. The modification to the water course and deposition of silt on the riverbed further elevates the risk for future flooding events with lower intensity rainfall. The geographical and hydrometeorological conditions and characteristics of the area support the view that there is a high possibility that the community will be affected by riverine floods. This perception resonates within the local community at every level. In one study conducted by 2017[16], residents were asked whether they have experienced flooding events in the area. More than 90% of respondents experienced at least one to two flooding events in the recent past (Table 9). Thirty-nine (39%) and forty-one (41%) of those surveyed in the community are also of the opinion that the community remains very vulnerable to extremely vulnerable to flash floods (Table 10).

[16] Pascal, 2017. Flood Risk Perception, Risk Communication and Flood Management in the Commonwealth of Dominica: A case study of Coulibistrie.

Table 9. Frequency of flooding events experienced by respondent

# of flooding events experienced		
	Frequency	**Percent**
NA	1	2
1-2	46	90.2
3-4	2	3.9
>4	1	2
Total	50	98
Missing	1	2
Total	51	100

Adapted from Pascal, 2017

Table 10. Respondents view on the current level of vulnerability of the community to floods

View on current level of vulnerability of the community to floods		
Response	**Frequency**	**Percent**
Don't know	2	3.9
Not vulnerable	2	3.9
Slightly vulnerable	6	11.8
Very vulnerable	20	39.2
Extremely vulnerable	21	41.2
Total	51	100

Adapted from Pascal, 2017

3.4 Absence of robust riparian vegetation

There is a general absence of well establish vegetative buffers along the main water course. The dominance of pioneering species indicates succession from recent storm impacts and rock movement in some areas. Where the cliffs do not armor the riverbank, the potential for collapse is elevated. Selective species which are capable of colonizing these highly unstable conditions must be considered in any effort to protect the riparian zones and loss of soil.

3.5 Weak monitoring and enforcement

There is no regulated zoning or land use management plan for the CW. The impact of recent storms and collapse of the road infrastructure contributed to the demise of farming in the area. While significant reduction in farming activities will improve the watershed overall health, active management and re-establishment of native species is needed to accelerate recovery. At present, the Forestry Division Central Range staff oversees activities in the area but there is a lack of manpower to cover this vast area. Coordination between DOWASCO and FWPD is necessary to address hydrology and flood risk issues within this system. Regular monitoring is essential to developing and modifying actions plans. 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. This is particularly worrying given that since the destruction of the DOWASCO intake (in the upper watershed region) during Hurricane Maria in 2017, the domestic water supply serving Coulibistrie, Morne Rachette and Grand Savanne is harvested in lower section of the watershed. According to DOWASCO's Chief Engineer, among several of the initiatives included in the Water Sector Strategic Development Plan (WSSDP) is a water treatment plant for water sourced from the CW (Appendix C).

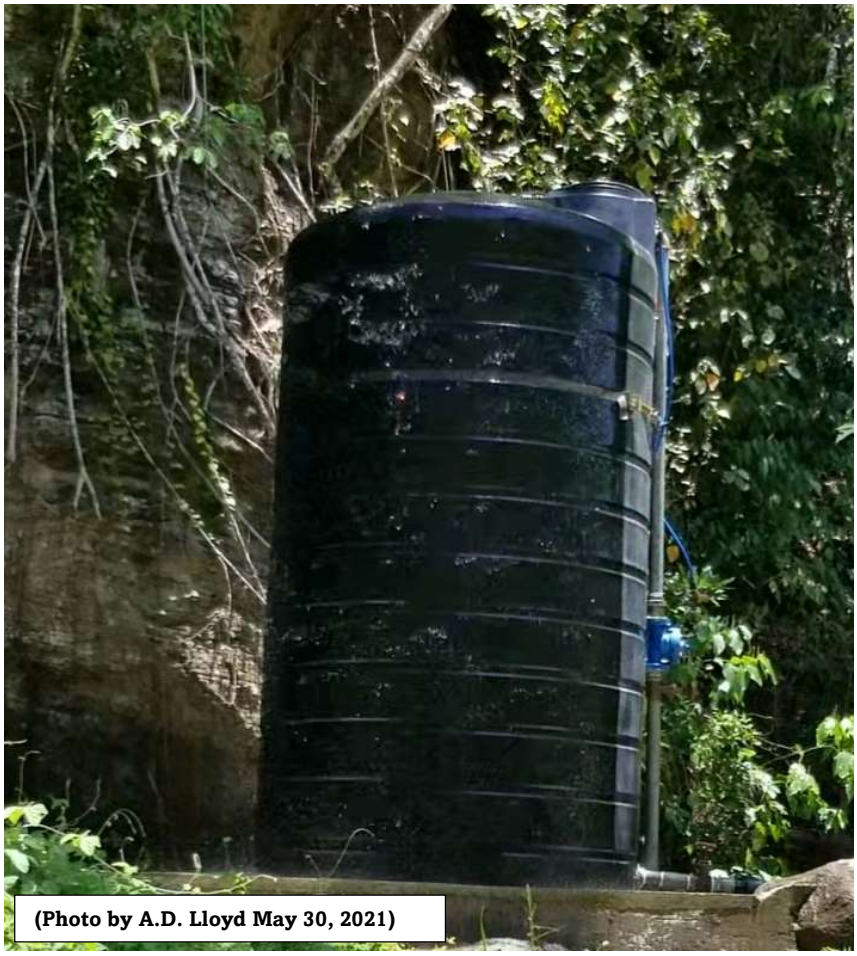


Figure 18 Temporary water storage at Coulibistrie. Water is abstracted from the lower section of the Watershed

3.6 Lack of awareness on sustainable watershed management

Concern for watershed protection is growing in light of recent catastrophic flooding events, 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.

3.7 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[17]. Unfortunately, no organized voices or community groups have been able to echo concerns to the relevant authority. For watershed management plans to be effective, local champions are needed. When done right, watershed governance can help resolve complex water problems and conflicts which otherwise would be daunting.

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

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) 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 Forestry, Wildlife and Parks Division (FWPD) to promote landscape restoration using appropriate native species.

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 CW 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 Coulibistrie 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 COULIBISTRIE WATERSHED MANAGEMENT PLAN

5.1 Consultation at Community Level

Planning for the watershed commenced at the community grassroots level in March 2021. This involved a consultation with key stakeholders in the community including extension staff and resource management personnel. The meeting was aimed at addressing the concerns of

residents of Coulibistrie regarding land, forest management, and watershed hydrology to diminish risks that the community faces. The consultation also created an opportunity to have open discussions on holistic approaches to conservation and identifying solutions that are mutually beneficial to all parties. Subsequent to the initial consultation, following meetings were organized with the parliamentary representative of the area with the goal to inform and develop local political support for watershed planning. The outcome from these meetings were instrumental in shaping the interventions needed to address present challenges.

5.2 Consultation at the National Level

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

5.3 Overview of the Logical Framework Analysis (LFA)

The LFA was adopted as an objective approach to identifying and grouping stakeholders as well as to formulate and 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 analyzed 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 11.

Field Surveys and assessment of CW 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 CW categorized it as one of the most disturbed watersheds of the three systems studied. This is mainly due to its topography, soil type, past and ongoing impacts of climate change and variability and the existential risk of riverine flooding. The negative impact of agriculture has reduced significantly since only very few farmers remain in the area. However interventions are necessary to restore land cover with more resilient, native species. This is

necessary to support regeneration processes post Hurricane Maria. Therefore, the plan considers all possible issues that may pose a significant threat to the watershed. The core issues are highlighted in Table 11.

Table 11: Summary of core problems within the BW

Specific Issues	Geographical occurrence	Suggested management interventions to address issues
(1) Soil erosion/slope destabilization/mass wasting from physical disturbance/land clearance		
History of poor land use management on fragile soils prone to erosion	Mid & upper watershed	Promote natural revegetation and soil cover
Lack of riparian buffers	Patchy but in all sections	Re-establish native species in bare areas along the watercourse
(2) Predisposition to debris flow and flash flooding		
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
(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 on watershed management 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 CWMP 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 promote sustainable land management practices and the restoration of key watershed functions.
- ✓ To reduce the risk and severity of flash flooding events.

- ✓ 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 promote sustainable land management practices and the restoration of key watershed functions

Output 1.1. Develop training package in soil and land use management for best practice

Activity (a) identify suitable resource personnel

(b) hold at least two training workshops on sustainable land and forestry management

(c) develop a capacity for community-led reforestation program

Objective 2: To reduce the occurrence and risk of flash floods events.

Output 1.1. Watershed hydrology and function is improved

Activity (a) select native species for enrichment planting where practicable

(b) select appropriate spp. and mobilize for stabilizing riparian zones

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, Coulibistrie 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 CW Management Council (CWMC) 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 CWMC.
(b) Mobilize a cross section of selected representatives from community groups, individual champions and key stakeholders to form the CWMC.
(c) Formal launch the CWMC
(d) Develop an implementation plan to guide the activities of the CWMC
(e)Develop partnerships with DOWASCO, FWPD & Dominica Bureau of Standards (DBOS) for watershed monitoring.
(f) Train community volunteers to undertake watershed monitoring
(g) Develop and operationalize a watershed monitoring program

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 9: 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 promote sustainable land management practices and the restoration of key watershed functions											
1.1 Training package in soil and land use management for restoring key forest functions developed	1.1.1 Identify suitable resource personnel	Public Ads, Interview reports	CWMC	MOA, FWPD, DOWASCO,	Shortlist of suitable personnel compiled	2.5	X				
	1.1.2 develop training materials	Training materials	CWMC*	MOA, FWPD, DOWASCO,	A suite of training materials compiled	5	X				
	1.1.3 carry out at least two training and programs	training report/plan	CWMC	MOA, FWPD, DOWASCO,	50 % of residents are aware of sustainable watershed management options	12	X	X	X		
	1.1.4 Develop capacity for community-led reforestation program	Requisite trainings completed Access to resources	CWMC	MOA, FWPD, DOWASCO	Reforest of critical areas completed		X	X	X	X	
Objective 2. To reduce the occurrence and risk of flash floods events											
2.1 Watershed hydrology and function is improved	2.1.1 select native species for enrichment planting and soil cover	List of native species identified	FWPD/CWMC	DOWASCO, Village Council	At least 50% of target areas revegetated or stabilized by year 2	152	X	X	X	X	X
	2.1.2 select appropriate spp. and mobilize for stabilizing riparian zones										
Objective 3: To improve monitoring and enforcement of appropriate laws governing watershed management as a model for other systems											
3.1 Watershed monitoring and	3.1.1 Hold consultations to secure commitment and	Consultation meeting reports	CWMC	MOA, FWPD, DOWASCO, Legal Affairs,	Key stakeholders consulted	3.5	X				

							Years				
Output	**Activities**	**Means of verification**	**Responsible agency for implementation**	**Collaborating partner**	**Milestones**	**Budget** US$ '000	**1**	**2**	**3**	**4**	**5**
enforcement framework established	participation of key stakeholders			Village council, community groups							
	3.1.2 Develop watershed monitoring and enforcement plan (WMEP) outlining roles and responsibilities of stakeholders	Document	CWMC		Draft WMEP developed	7	X				
	3.1.3 Prepare recommendations for the approval of supportive and necessary legal provisions	Copy of recommendations	CWMC		Recommenda-tions prepared and submitted	2	X				
	3.1.4 Roll out WMEP	Media reports, photographic evidence	CWMC	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 remedial actions and document lessons learnt	Progress reports	CWMC		Reports prepared that accurately reflect the rate and extent of progress of WMEP implementation	15	X	X	X	X	X
3.2 Capacity of key institutions strengthened	3.2.1Identify capacity gaps and develop appropriate programs for key institutions involved in natural resource management:	Report of gap analysis	CWMP	MOA, FWPD, DOWASCO	Programs developed from gap analysis		x				

							Years				
Output	**Activities**	**Means of verification**	**Responsible agency for implementation**	**Collaborating partner**	**Milestones**	**Budget** US$ '000	**1**	**2**	**3**	**4**	**5**
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	CWMC	MOA, FWPD, DOWASCO, Legal Affairs, Village council, community groups	Two successful meetings/work-shops completed	9	X	X			
4.2 The CW Management Committee (CWMC) 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 CWMC	Constitution and by-laws for the CWMC ratified	MERMKU	MOA, FWPD, DOWASCO, Legal Affairs, Village council, community groups	The CWMC formalized	0	X				
	4.2.2 Mobilize a cross section of selected representatives from community groups, individuals, and other key stakeholders to form the CWMC	List of Board members and officers of the CWMC	MERMKU	MOA, FWPD, DOWASCO, Legal Affairs, Village council, community groups Public Works Dept, Lands and Surveys Division (LSD)	Full complement of Directors and Officers of the CWMC commissioned	0	X				
	4.2.3 Formally launch the CWMC	Media reports, Agenda photographic evidence	MERMKU		CWMC Launched	1.5	X	X			

							Years				
Output	**Activities**	**Means of verification**	**Responsible agency for implementation**	**Collaborating partner**	**Milestones**	**Budget** US$ '000	**1**	**2**	**3**	**4**	**5**
	4.2.4 Develop an implementation plan to guide the activities of the CWMC	Report	CWMC		Identify areas for reforestation and type of plants	0	X	X	X	X	X
	4.2.5 Develop partnerships with DOWASCO, FWPD & Dominica Bureau of Standards (DBOS) for watershed monitoring.	Report of meetings and consultation	CWMC		Stakeholder partnership agreement formalized	3	X	X	X	X	
	4.2.6 Train community volunteers to undertake watershed monitoring	Sampling protocol and training report	CWMC		At least 5 volunteers trained	8	X	X			
	4.2.7 Develop and operationalize a watershed monitoring program	Program documents	CWMC		Watershed monitoring reports prepared quarterly	25	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						**249.0**					

Note that budgeted amounts per activity and the total sum of **Two hundred and forty-nine thousand United States Dollars (US$249,000.00)** are based solely on preliminary estimates of the proposals advanced by the consultants. It will be necessary to conduct a detailed review, analysis and update of the budget prior to implementation of the CWMP.

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 CWMP.

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 indicates 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 Coulibistrie watershed management council (CWMC) is therefore necessary to bring all related entities together to establish common goals through a shared vision for the community. It is recommended that MERMKU takes responsibility for the establishment and functioning of such a 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 set-up 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 out 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 CWMC, FWPD and Ministry of Agriculture and DOWASCO. Generally, the CWMC 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, a monitoring 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 CWMC 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 the way forward.

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 CWMC based on the monitoring and evaluation reports and in consultation with the communities and implementing agencies. A summary of the CW monitoring plan is detailed in Table 10.

Table 10: Monitoring plan for the CW

Objective	Desired output	Suggested evaluation tools/indicators	Measurement frequency	Responsibility	Target	Reporting frequency
To changes in water quality	Improvement in stream and river water quality	Measure of turbidity	Quarterly	CWMC	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	CWMC		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 recolonization of native species and stream bank vegetation for diminishing flash flood risks	Decrease in landslide and erosion Improve stability of riparian zone	Species diversity and evenness increase	Annually	MOA, DBOS	75 % of watershed vegetation gaps closed by yr 2	Annually
		Vegetation patchiness decrease				
		Stream/river stability				
		Stream/river turbidity				
To reduce the impact of natural hazards on the watershed	Watershed and ecosystem resiliency increases	Forest structure and composition	Annually	FWPD, MOA	Native species restored	Annually
		Extent of buffer protection				
To establish a watershed watchdog group or similar entity for championing watershed concerns locally and nationally	Formation and functioning of CWMC	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 12. In order to acquire enough funding such as from the national budget, trust funds, donor agencies or contributions from the relevant stakeholders, the CWMC 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 CWMC, 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 Coulibistrie watershed has been in a state of transition from a once actively farmed area to one where natural regrowth in promoted. The cessation of active farming in recent years due to severe loss of topsoil and farmlands, overburden of farm sites from debris-flow deposits, the collapse of the only farm feeder road and the potential for the occurrence of flash flooding after short intense rainfall, makes the watershed highly vulnerable and not practical for agricultural development. Focus should be towards promoting natural regeneration of native species to restore the watershed hydrology and flow regiments. However, enrichment planting is still a necessity to fill major gaps with the desired species that can provide vegetative cover and stability along the riverbanks and other areas prone to erosion. The full restoration of the watershed is dependent on building a coordinating framework to support decision making and a mechanism to leverage wider national support for implementing key actions. The framework should also provide the scope for community-led monitoring activities and the empowerment of local actors to strengthen implementation. The following recommendations will rail guard the plan and broaden the scope for long term sustainable watershed management of Coulibistrie.

6.1 Recommendations

Improvement of institutional arrangements for BWMP Implementation:
It is inevitable to strengthen the institutional arrangements among the key stakeholders agencies and local interest groups in the watershed. Improved cooperation will enhance strategic planning, allow for shared responsibility, and cost sharing ensuring that no one agency carries the full cost of implementation. In light of this, a co-management approach is recommended, and this can be formalized with a MoU.

River/stream bank conservation measures
The CW is prone to landslide and mass movement owing to its fragile shallow soils and high elevation rainfall. Erosion and sediment deposition have raised the riverbed significantly in the lower regions of the watershed increasing the risk for the development of flash floods during short high intense rainfall events. While conditions are generally unsuitable for any form of commercial agriculture, accordingly, the risk for further erosion and slides must be reduced. This can best be achieved by promoting natural regeneration and where necessary enrichment planting, in landslide prone areas and along the river course for stabilizing the stream banks. A mix of native species and tree crops should be utilized.

Monitoring of key watershed parameters
A watershed monitoring plan with a focus on selected parameters is recommended to gauge the effectiveness of specific interventions over time. Water quality monitoring, streamflow measurements and sediment loading rates should be considered as part of this overall effort to better gauge progress and trends. Recommended Actions:

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

(ii) The annual preparation of a Water watershed health report card is recommended. The report card will provide a transparent, timely, and geographically detailed assessment and results of implemented actions 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 CWMC'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 CWMC 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 CW

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: DOWASCO's activities and plans for the CW

Table 11 DOWASCO's ongoing activities and future plans for the CW

Activities/Plans	Coulibistrie Watershed
Ongoing Activities	• Present abstraction source for Coulibistrie, Morne Rachette, and Grand Savanne • Regular intake visits by system caretaker • Periodic visits by Area Supervisor and Operations Crews • Regular visits by water treatment officer • Periodic visits by lab technicians for checking source water quality • Occasional visits by Engineering Staff to undertake stream flow measurements
Future Development Plans	• Plans under Water Sector Strategic Development Plan (WSSDP) to construct new permanent intake structure in lower CW and new transmission pipeline along the riverbank, through the village and to new water treatment plant (WTP) and storage tank to be built near present Batali Pump Station.

Source: Magnus Williams, Chief Engineer, DOWASCO