THE VALUE OF HYDROMETRY IN REDUCING FLUVIAL FLOODING FOOTPRINTS ACROSS THE CARIBBEAN - A CASE STUDY IN DENNERY, SAINT LUCIA

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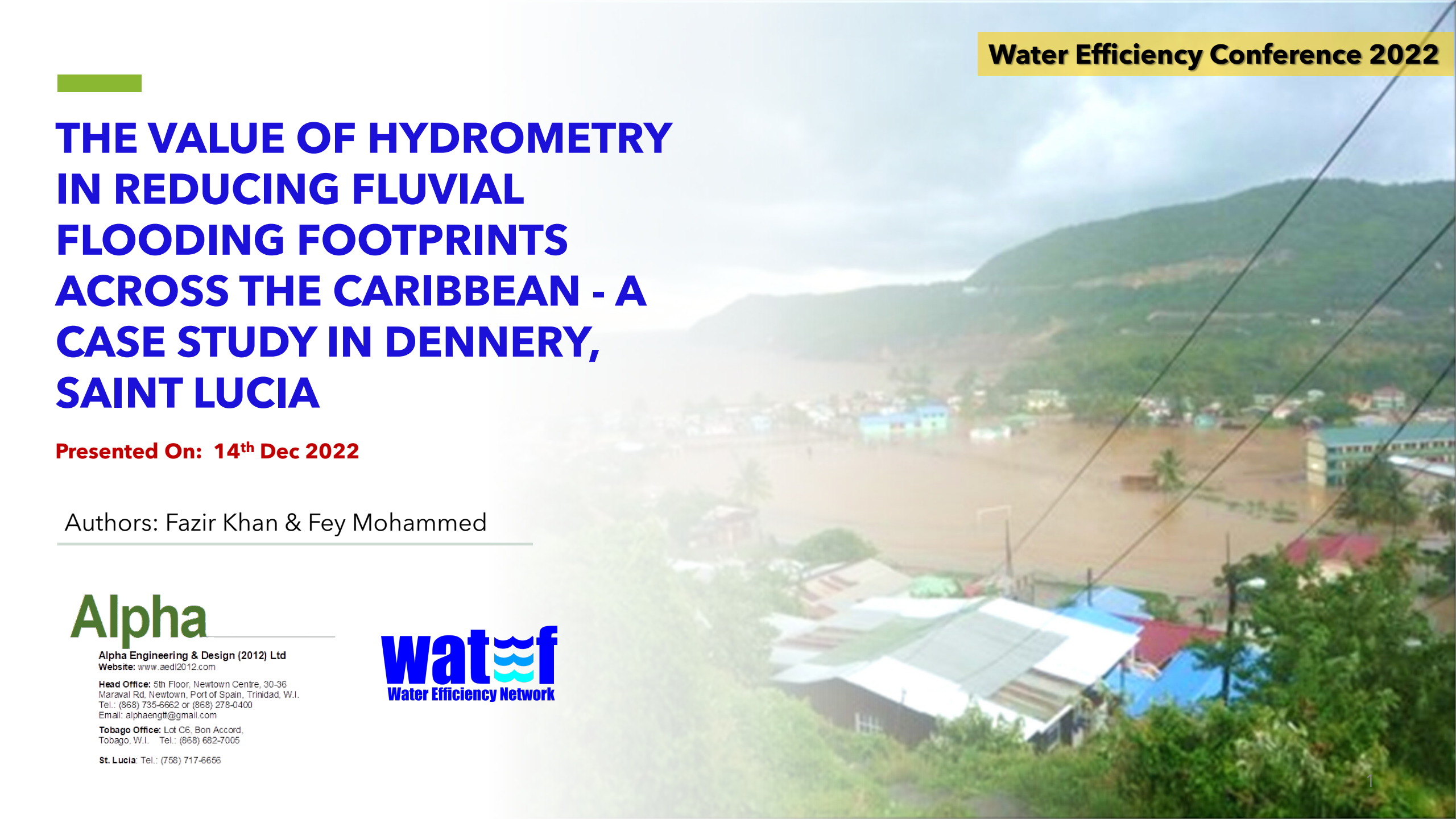
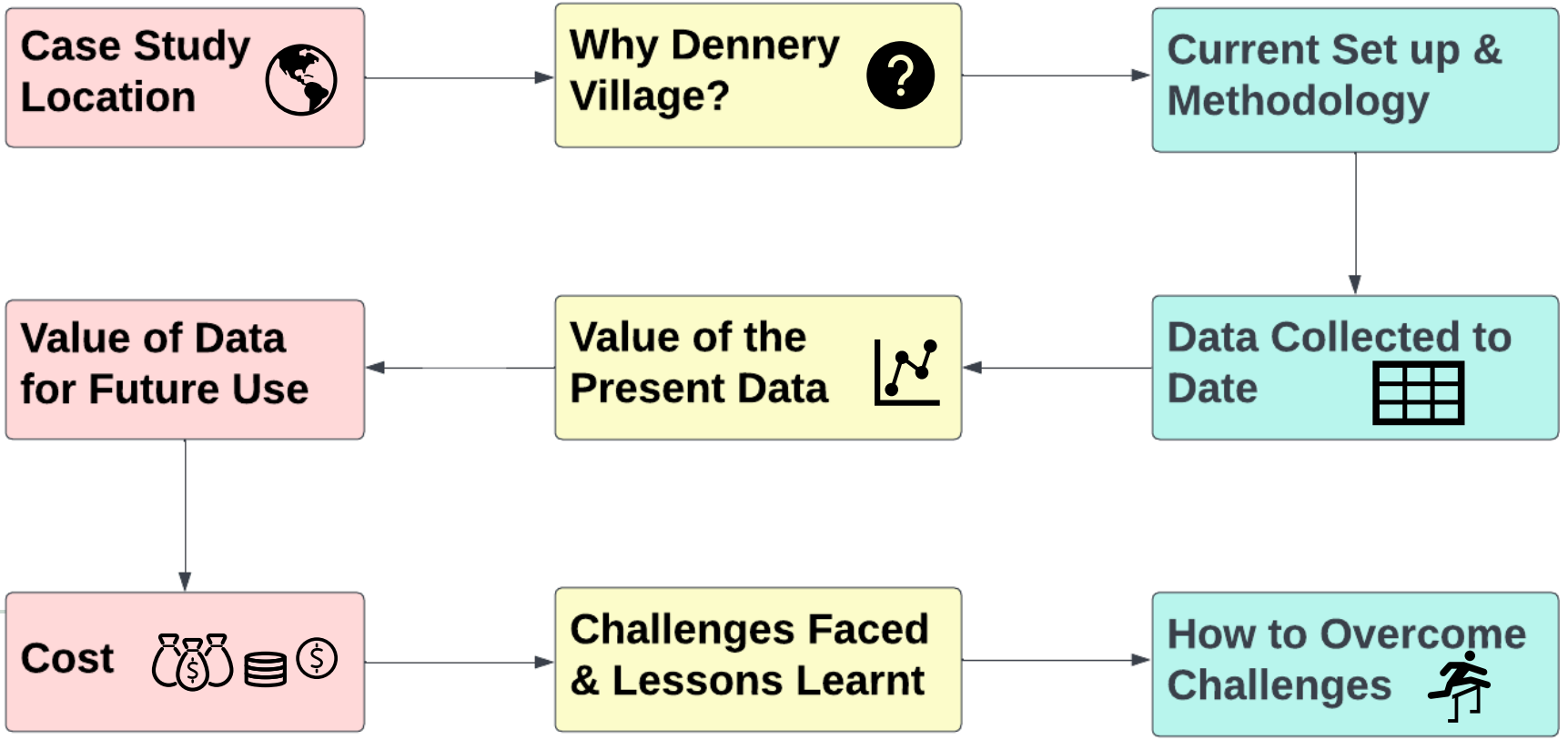
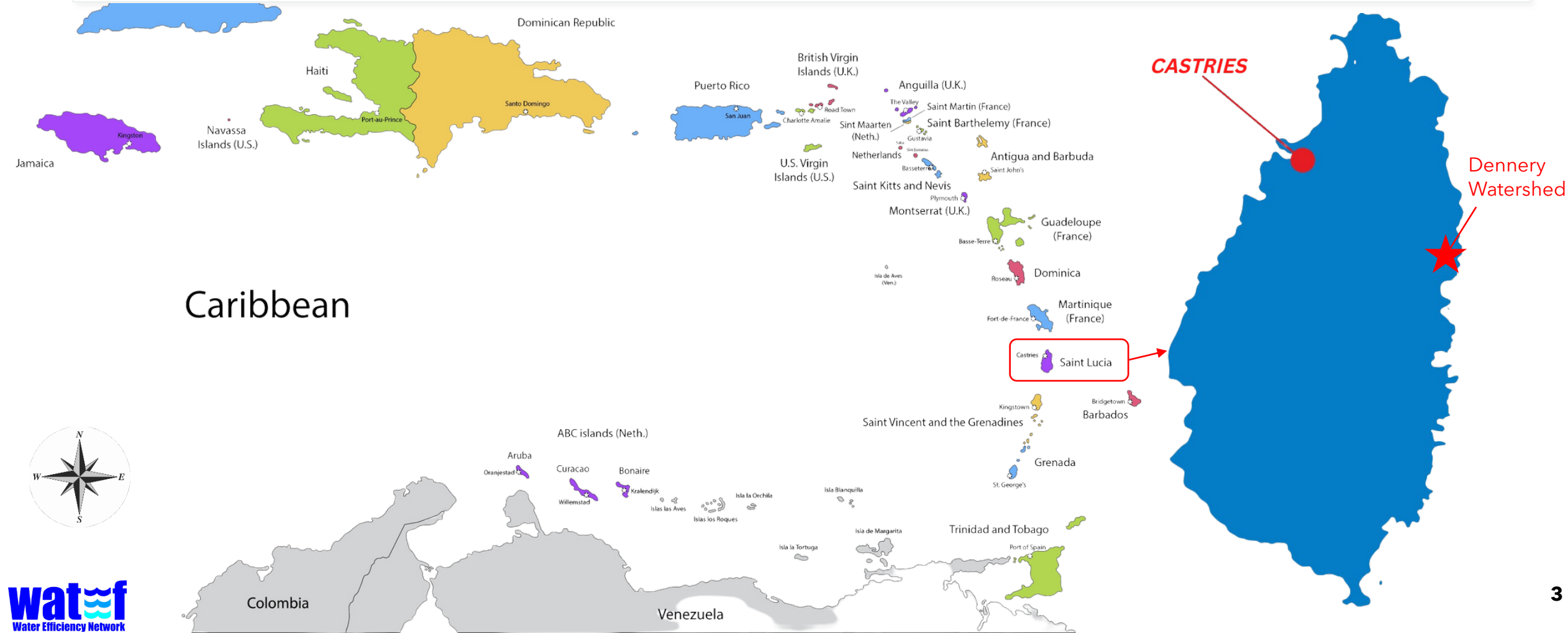


Outline of Presentation

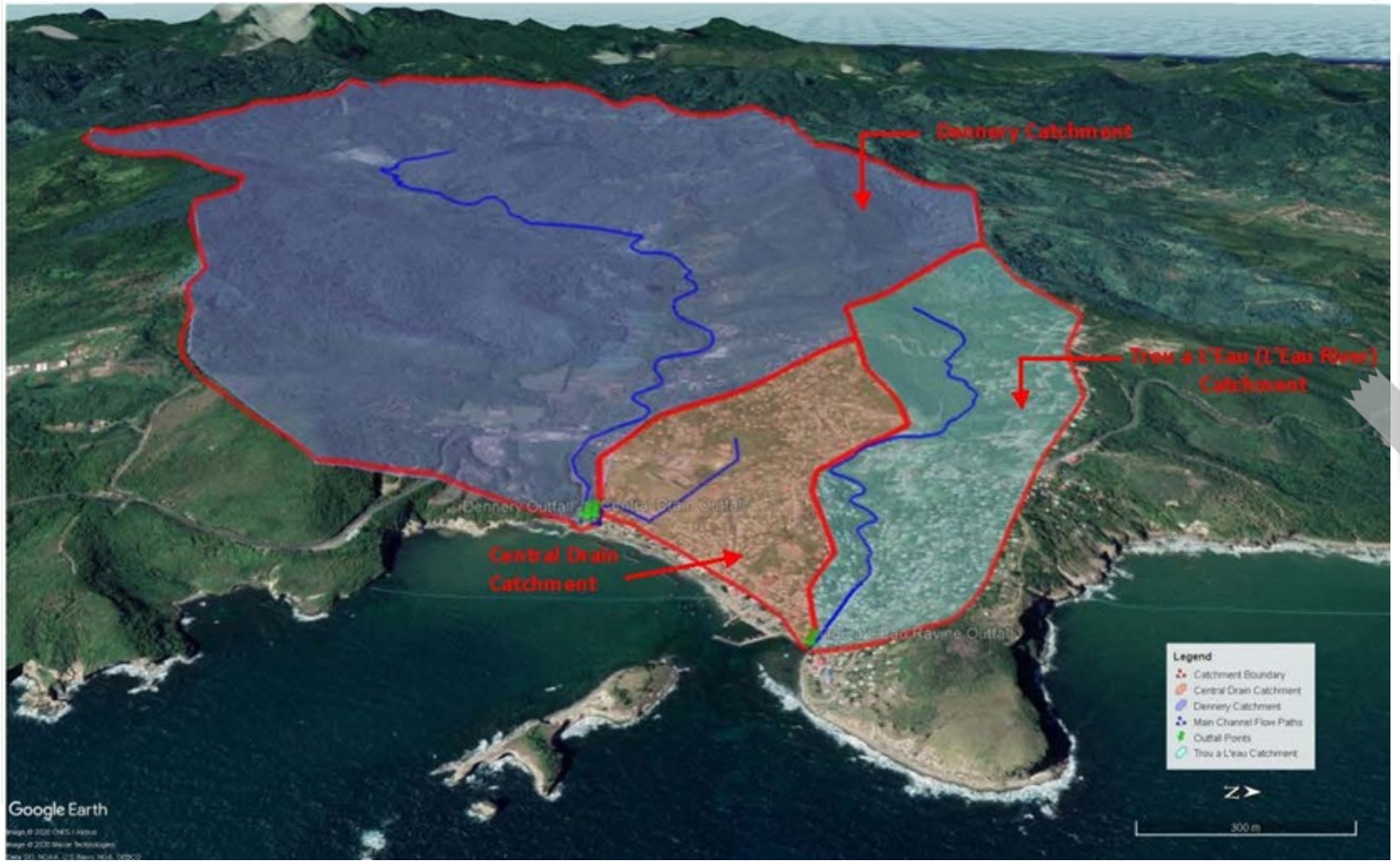


Case Study Location: Dennery Watershed in the Eastern Caribbean

Island of Saint Lucia



Dennery Watershed is Located on the Northeast Coast of Saint Lucia and has Three (3) Main Catchments



The Eastern Caribbean Island of Saint Lucia is frequently exposed to significant meteorological events that lead to flooding and landslides

suffered severe repeated flooding from extreme storm events

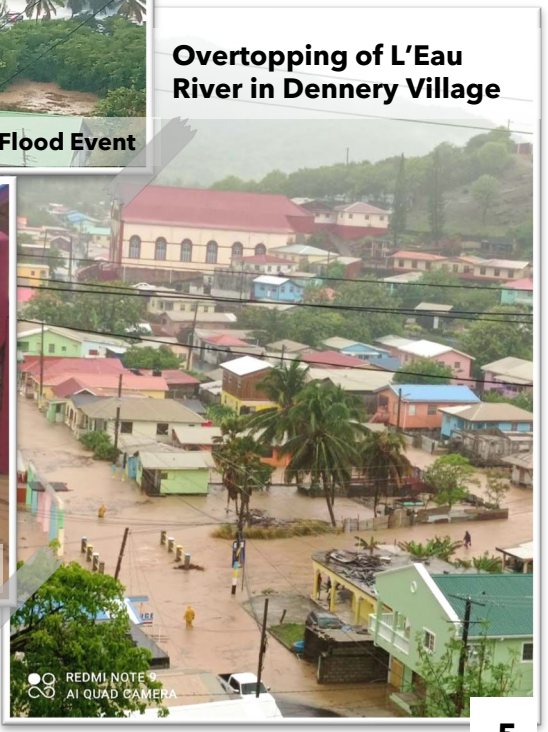
e.g., Hurricane Tomas (2010) with 563mm of rain in 23 hours

Major damage to coastal and low-lying areas where most of the population and main commercial activities are situated

Why Dennery Village?

Climate change-related impacts are expected to intensify precipitation patterns

development and implementation of flood mitigation solutions including early warning systems required



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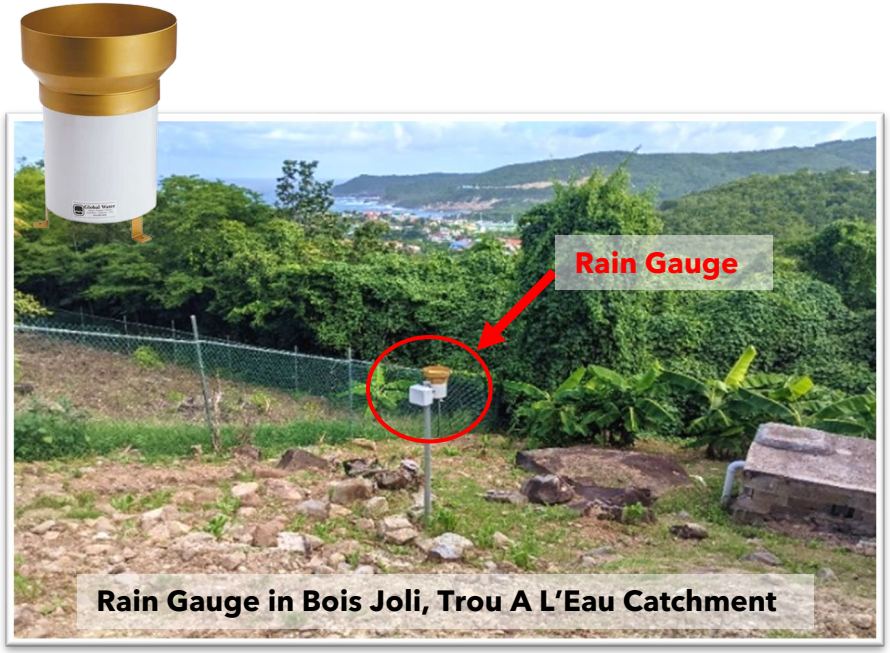
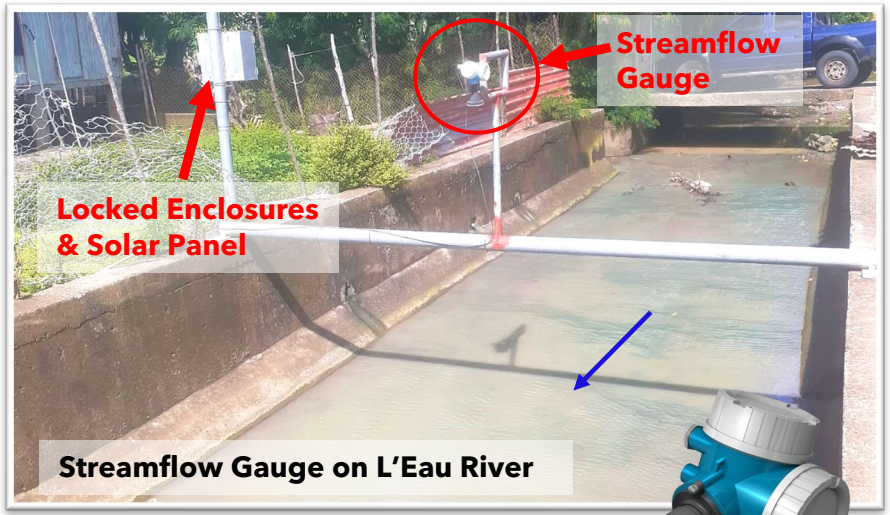
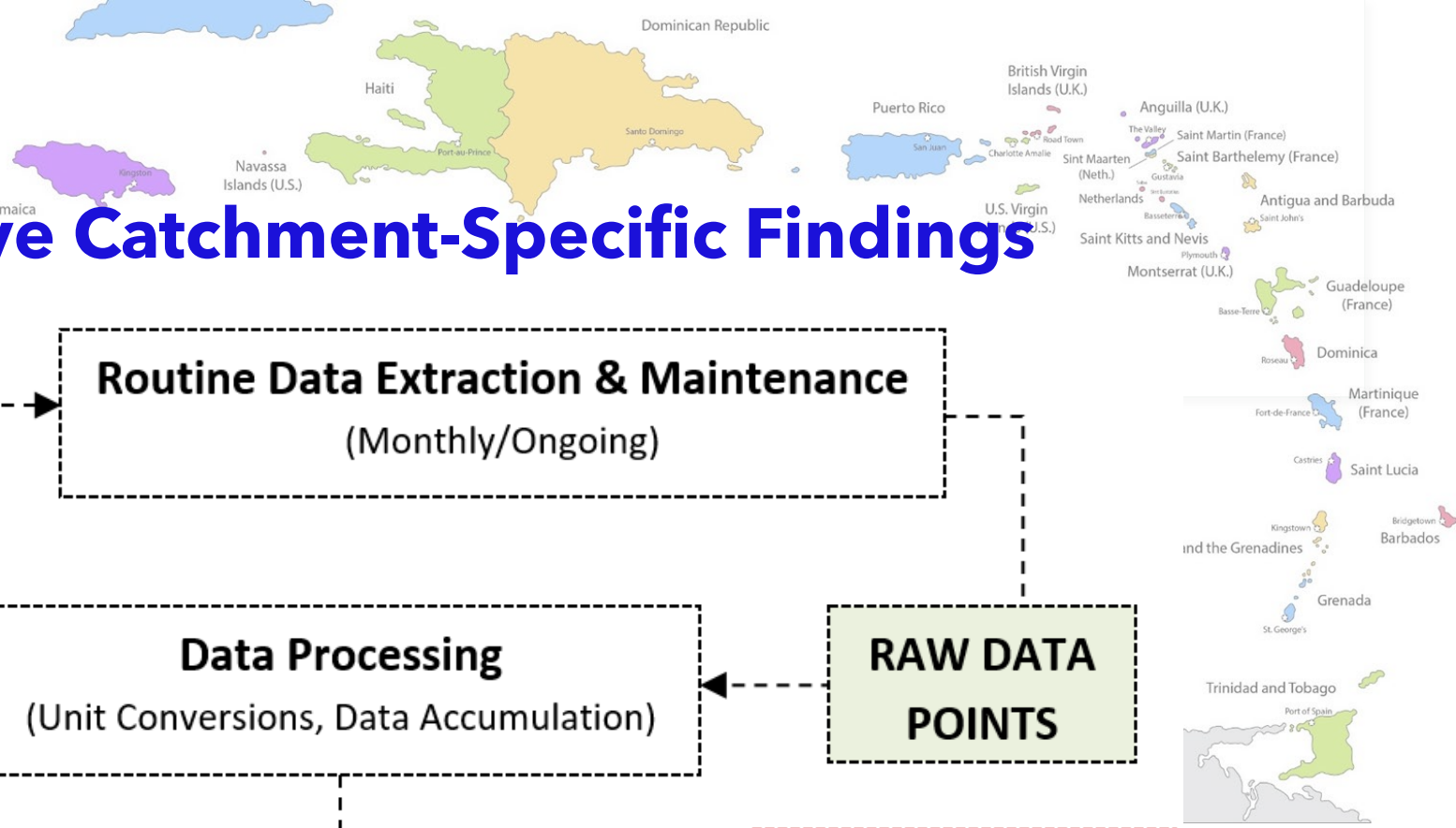
Alpha currently monitors rainfall depth and river stage in the Dennery River & Trou a L'Eau Ravine Catchments

- **Global Water RG600 8" Tipping Bucket Rain Gauge for Rainfall Depth**
  - accuracy of ± 1% at 25mm per hour
  - hourly time-step
  - **75m AMSL in Errard Estate in Dennery River Catchment**
  - **100m AMSL in Bois Joli in L'Eau River Catchment.**
- **Nile 502 Pulse Radar Water Level Sensor for River Stage/Streamflow**
  - ± 0.2mm accuracy
  - measuring range of 20m - distance from instrument to water surface used to determine river stage
  - 15-minute time-step
  - **Highway Bridge crossing Mole River 5m AMSL**
  - **Trou a L'Eau River 4m AMSL**





Typical Process to Derive Catchment-Specific Findings



Installation of Gauging Stations
(Procurement, Setting Up, Calibration)

Routine Data Extraction & Maintenance
(Monthly/Ongoing)

RAW DATA POINTS

Data Processing
(Unit Conversions, Data Accumulation)

Data Analyses
(Extraction of Extremes, Event Analyses, Rainfall/Streamflow Relationships)

Flood Hydrographs
Baseflow Estimation
Measured Lag Time
AMC Estimation

Cumulative Rainfall Totals
Wet/Dry Season Graphs
Rating Curves

Catchment-Specific Findings for Rainfall-Runoff Modelling & Calibration of Models

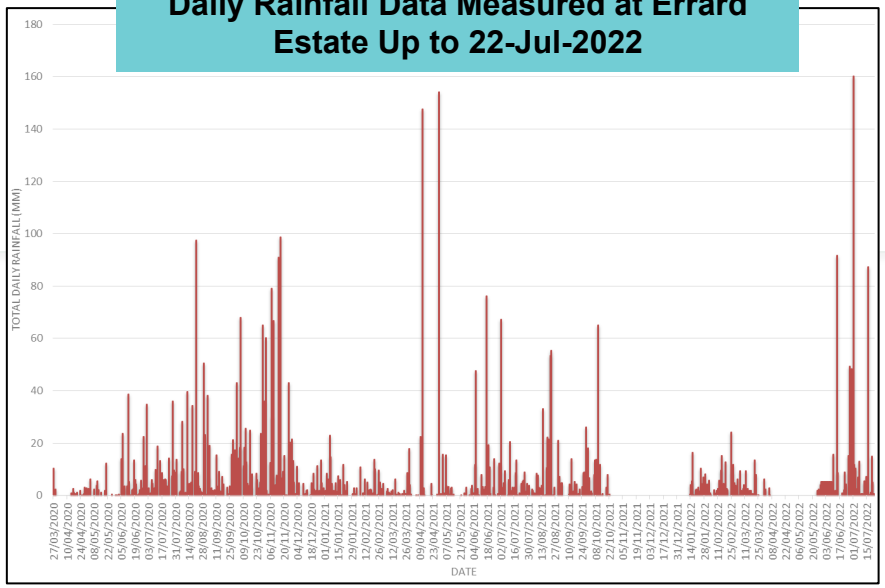
Ongoing Data Collection

Gauging Station	Observation Period		Data Resolution	Accumulated Period Presented
	From	To (*ongoing)		
Errard Estate Rain Gauge	27-Mar-2020	22-Jul-2022*	hourly	28 Months
Bois Joli Rain Gauge	4-Mar-2020			29 Months
Dennery/Mole River Streamflow Gauge	27-Mar-2020	9-Jul-2020	15-min intervals	3.5 Months
Trou a L'Eau Streamflow Gauge	27-May-2020	22-Mar 2022*		28 Months

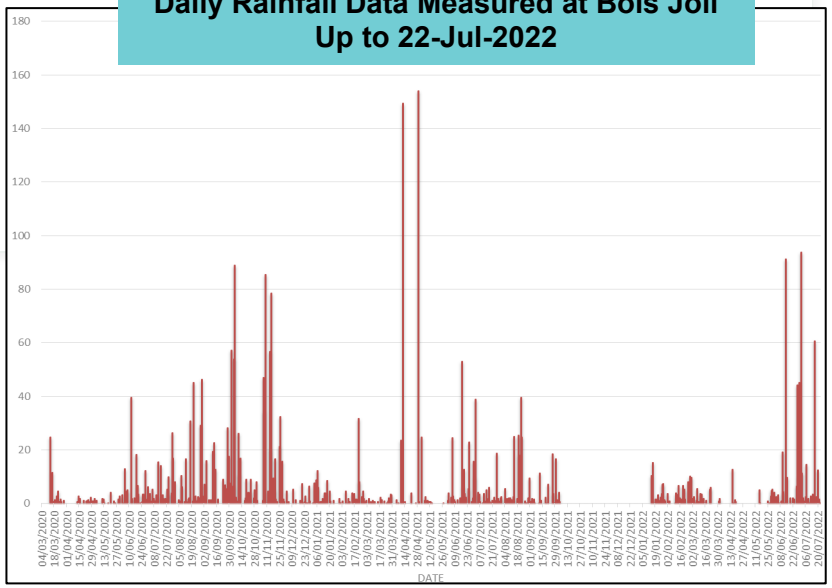
Graphed Raw Data from March 2020 to July 2022

- Site-specific temporal variation of rainfall and streamflow;
- Easy Identification of storm events and dry periods;
- Baseflow determination;
- Identification of anomalies in data.

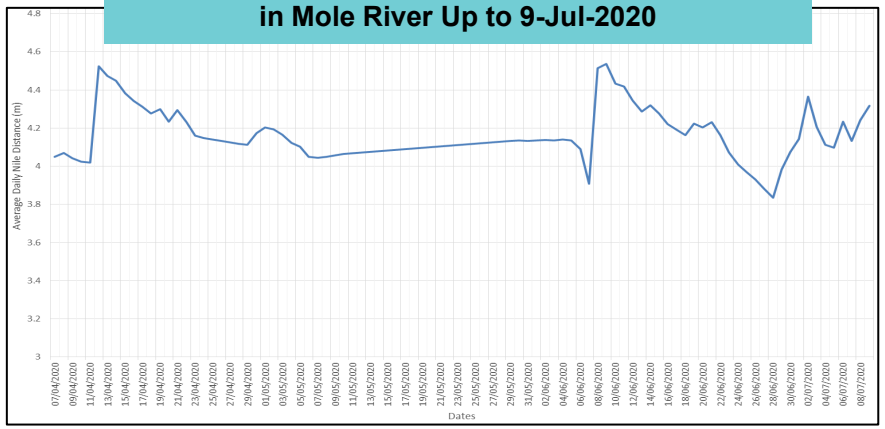
Daily Rainfall Data Measured at Errard Estate Up to 22-Jul-2022



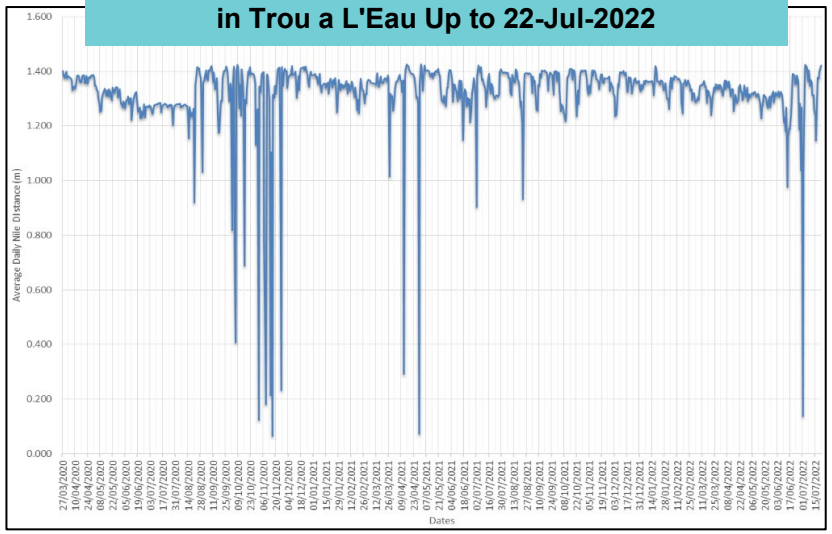
Daily Rainfall Data Measured at Bois Joli Up to 22-Jul-2022



Instrument to Water Surface Distance Recorded in Mole River Up to 9-Jul-2020



Instrument to Water Surface Distance Recorded in Trou a L'Eau Up to 22-Jul-2022



Note: Rainfall Daily Totals Presented for the purpose of graphing.

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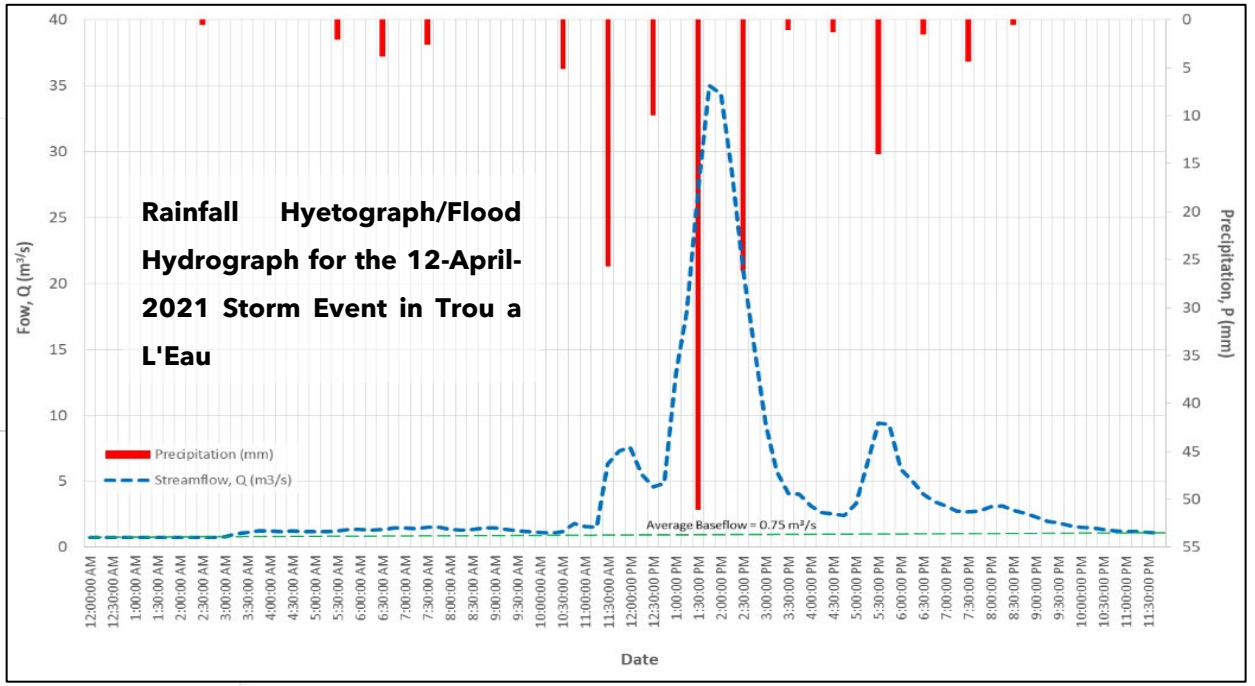
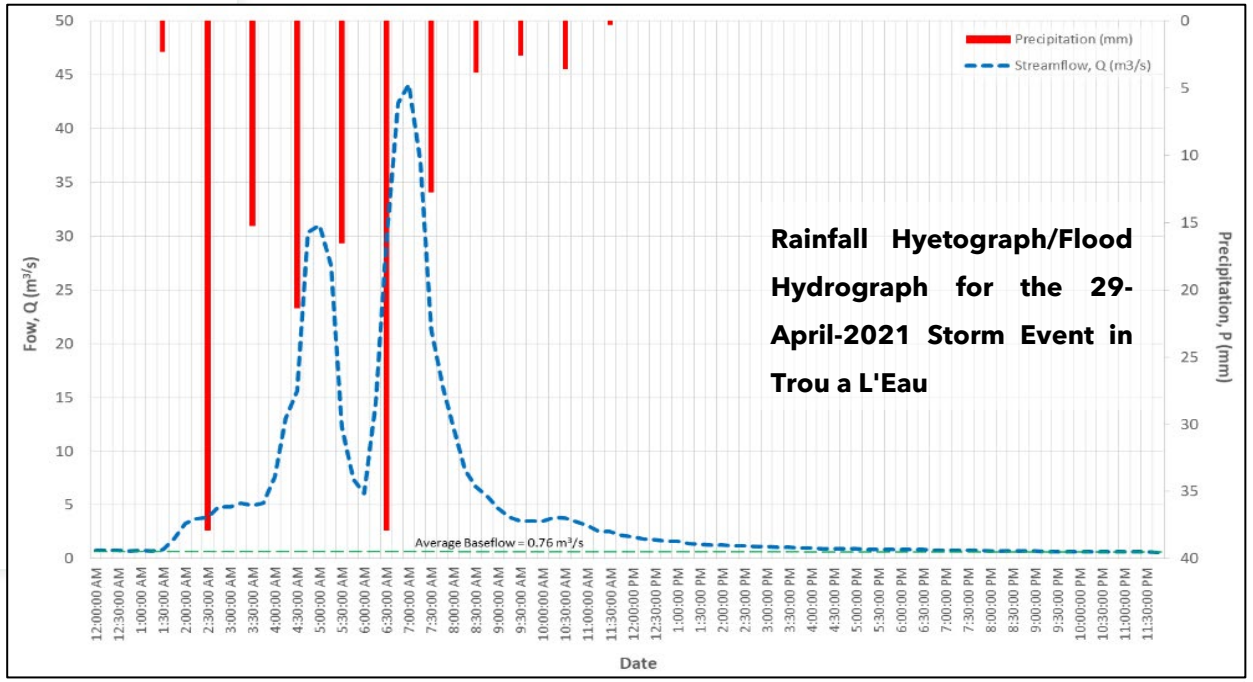
Value in the Short Datasets Collected

A) Two high-intensity rainfall events produced widespread flooding captured in Trou a L'Eau Ravine Catchment:

Event	12-April-2021	29-April-2021	
Avg. Rainfall Duration, D	10 hours	10 hours	
Total Rainfall, P	150mm	150mm	
Average Rainfall Intensity, I	15 mm/hr	15 mm/hr	
Storm Classification	10 Yr. R.I.	10 Yr. R.I.	
Rainfall Peak Time	0.7D	0.1D	0.5D
Peak Runoff, Q_p	35 m^3/s	31m^3/s	44m^3/s
Lag Time	15 mins	2.5hrs	30 mins
Prior Baseflow, Q_b	0.75m^3/s	0.7m^3/s	





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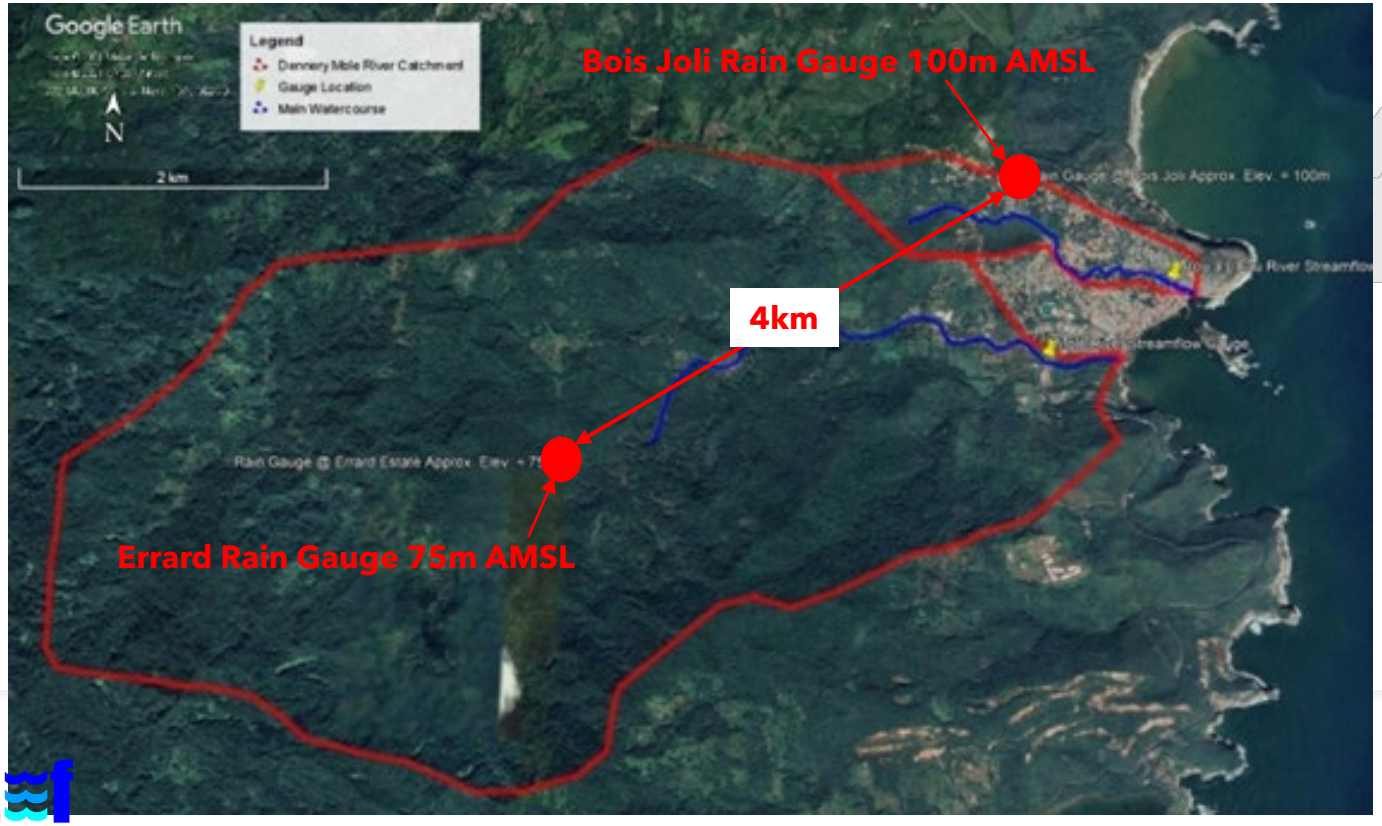
B) Spatial Correlation of Rainfall between Neighboring Catchments Errard & Bois Joli

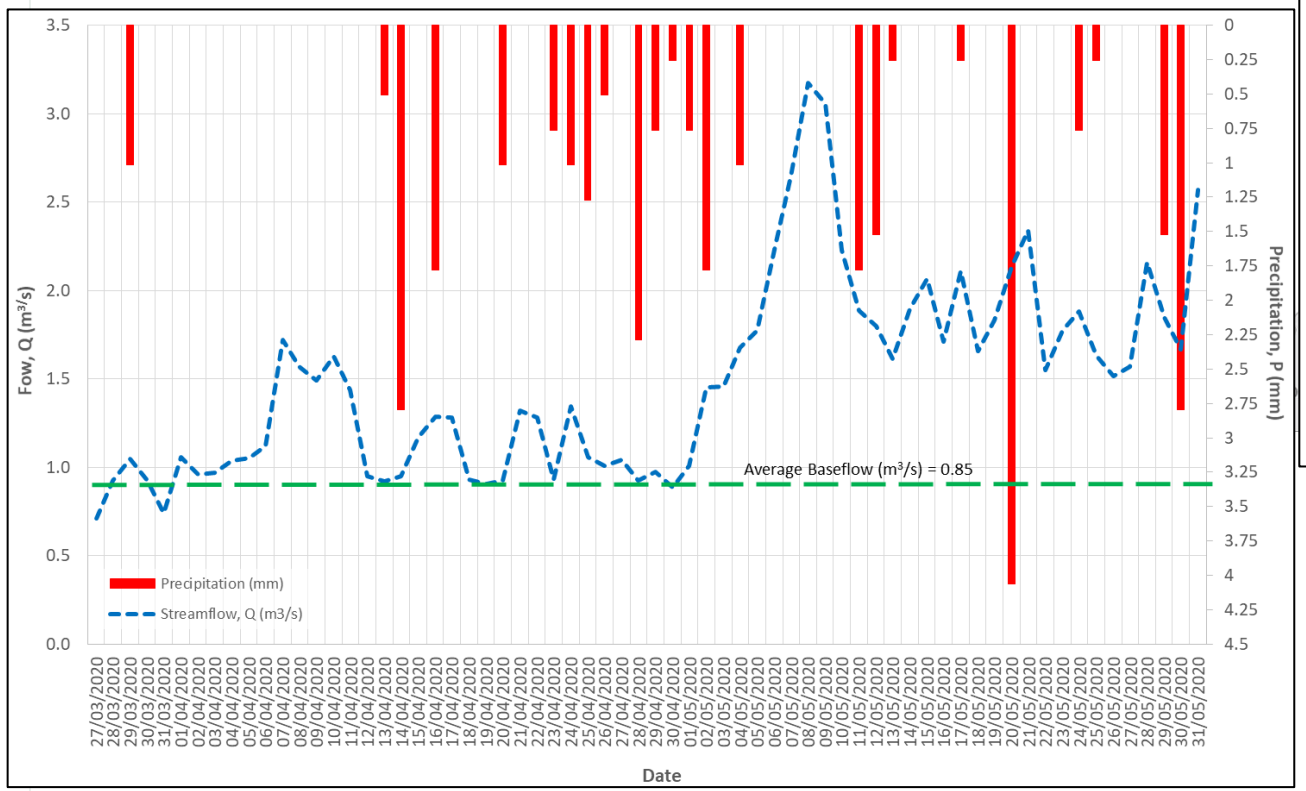
- There is a **69% difference** in the Total Rainfall recorded between Errard (4668mm) and Bois Joli (3200mm) for the observation period **27-Mar-2020 to 22-Jul- 2022 (28 months).**
- But when it comes to major rainstorm events, the measurements are **invariably the same** for the two days in April 2021.



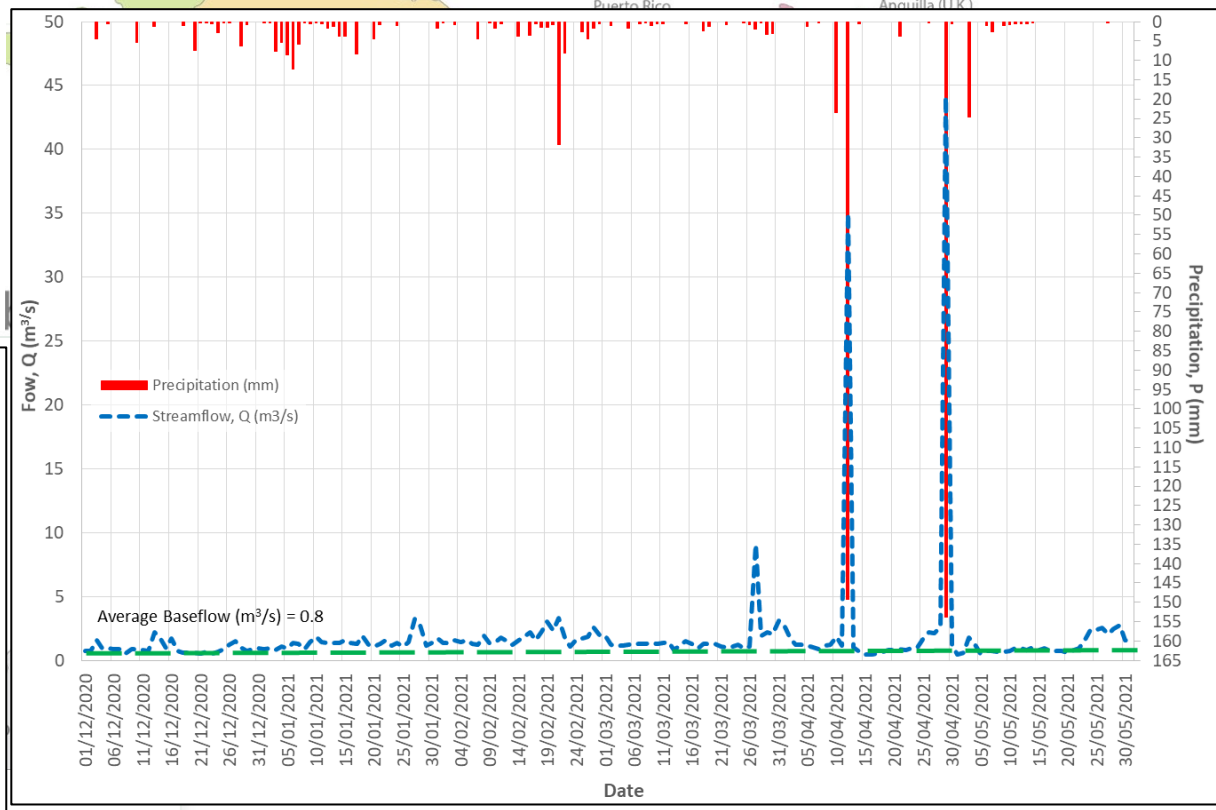
Date	% Diff	Errard (75m AMSL)	Bois Jolie (100m AMSL)
12/04/2021	1.2%	147.574mm	149.35mm
29/04/2021	0.2%	154.178mm	153.92mm

C) Dry Season Graphs / Estimation of Baseflow

- Wet Season: June – November
- Dry Season: December – May



2020 Dry Season Graph (Bois Joli / Trou a L'Eau River)



2021 Dry Season Graph (Bois Joli / Trou a L'Eau River)

2020 Dry Season Baseflow = 0.85 m³/s

2021 Dry Season Baseflow = 0.80 m³/s

Value of the Recorded Data in Future Hydrologic and Hydraulic Determinations

Parameter	Typically, these are:	Utility of the Recorded Data Facilitates:
Rainfall Distribution	Selected from pre-determined SCS 24-Hr rainfall distributions and disaggregation factors.	Development of disaggregation factors from location of peak rainfall and distribution.
Design Storm Selection	Selected storm characteristics (in terms of rainfall depth/intensity and duration) based on a specified level of flood risk.	Assessment of the flood levels experienced for a quantity of rainfall in a known amount of time.
Time of Concentration/ Watershed Lag Time	Determined from pre-developed models by estimating watershed slope and roughness.	Utilization Lag Time from the flood response to corroborate values derived in mathematical models.
Antecedent Moisture Content	Selected from predetermined conditions by NRCS.	Establishment of catchment-specific Antecedent Precipitation Index (API) from previous 3 – 6 days of a recorded storm event to select Runoff Curve Numbers
Selection of Runoff Coefficients **(CN – Curve Number / C – Runoff Coefficient)**	Based on visual inspection, land use maps and available soil surveys.	**Calibration of rainfall-runoff models by:** • back-calculating the "measured" CN or C value for measured peak flow from rainfall depth measured in the same catchment; • applying the Two-CN System Approach to reduce runoff prediction errors when using single composite CN values.
Baseflow Determination	Usually determined by anecdotal evidence and/or a one-time measurement on site in the dry season.	• Using catchment response times to execute "**baseflow separation**" from a flood hydrograph; • Using dry season data to extrapolate flow in channels during periods of no rainfall.

MAIN GOAL: To narrow the uncertainty margin in hydrological modelling & obtain closer orders of magnitude in the output.

The Data is Useful to Various Groups

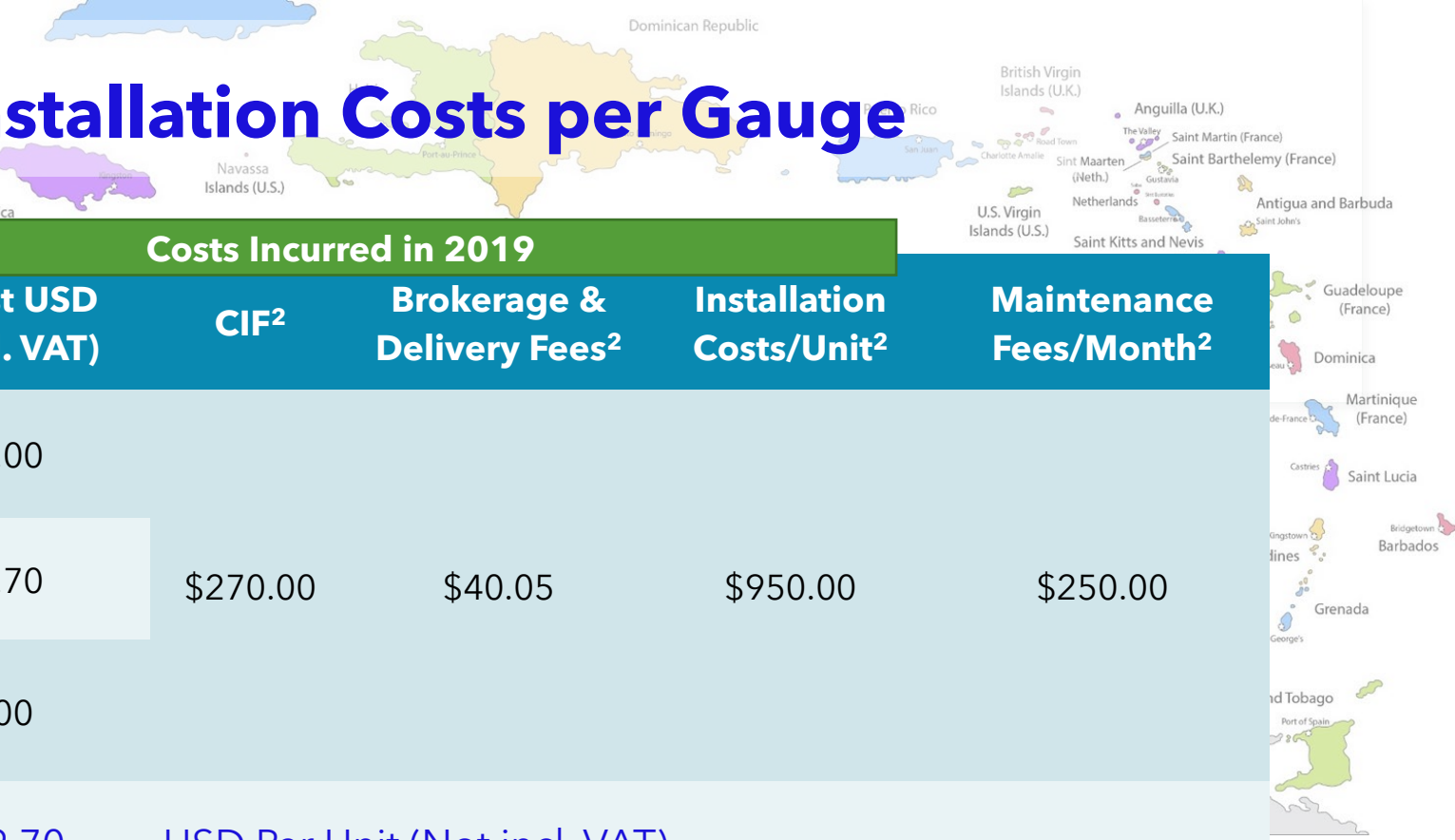
Engineers/Hydrologists	• To inform modelling applications for flood mitigation
State Agencies	• For Planning Response Strategies
Farmers	• Climate-Smart Agriculture • Managing / optimizing the use of resources
Community Members	• To prepare for flood events and increase awareness to reduce flood risk

Contributing to Increased Resilience to Climate Change

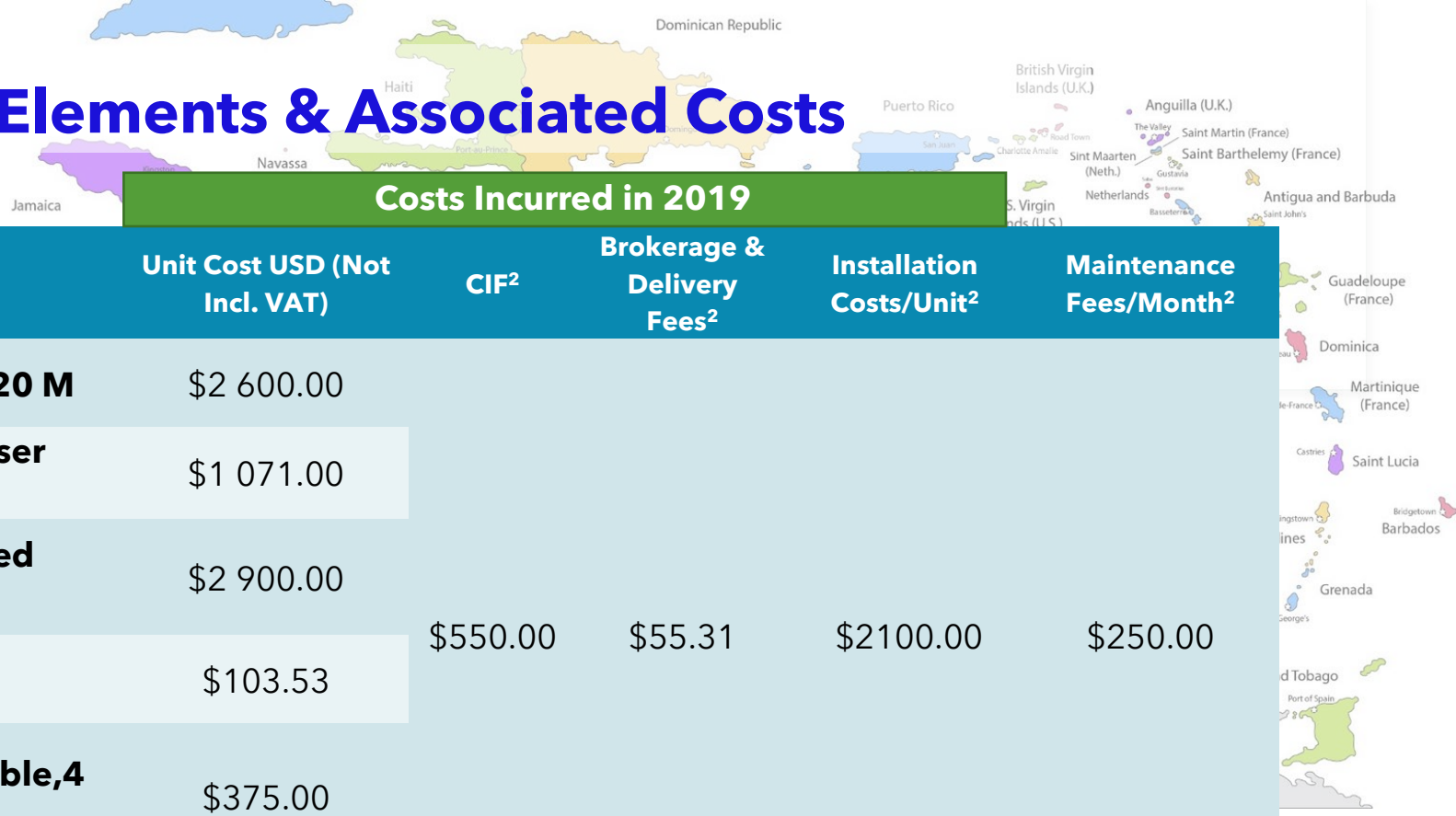
Rain Gauge: Supply & Installation Costs per Gauge

Component[1&]	Unit Cost USD (Not Incl. VAT)	Costs Incurred in 2019 CIF[2]	Brokerage & Delivery Fees[2]	Installation Costs/Unit[2]	Maintenance Fees/Month[2]
Global Water Rg600 8" Tipping Bucket Rain Gauge	$621.00				
Gl500 Data Logger	$441.70	$270.00	$40.05	$950.00	$250.00
K-114a Dcx Usb Communication Cable	347.00				
Total Cost of Rain Gauge =	$1409.70	USD Per Unit (Not incl. VAT)			
Supply & Installation Total Cost =	$2669.75	USD Per Unit (Not incl. VAT)			
Cost per Year =	**$267.00**	**USD Per Unit (Not incl. VAT / Annual Maintenance) Assuming a 10 Yr. Lifespan**			

[1]Supplier – Global Water; Caribbean Distributor – Rose Environmental Ltd.
[2]Costs Incurred Not Included in Total Cost of Gauge



Streamflow Gauge: Main Elements & Associated Costs



Costs Incurred in 2019

Component[1]	Unit Cost USD (Not Incl. VAT)	CIF[2]	Brokerage & Delivery Fees[2]	Installation Costs/Unit[2]	Maintenance Fees/Month[2]
Nile 502 - Pulse Radar Water Level Sensor - 0 To 20 M	$2 600.00				
Storm3-00 - Storm3-00 Data Logger With Web User Interface	$1 071.00				
Turnkey Integrated Enclosure,14x12, User Defined Data logger And Telemetry	$2 900.00				
Grounding Rod Kit, Light Duty For Tk Enclosures	$103.53	$550.00	$55.31	$2100.00	$250.00
H-Sdi-Cable-15 Weather/Sun Resistant Sdi-12 Cable,4 Conductor,22 Awg,15 Meters	$375.00				
Nile Mb – Mounting Bracket Kit, Nile Radar	$113.00				
Total Cost Of Streamflow Gauge =	$7162.53	USD Per Unit (Not incl. VAT)			
Supply & Installation Total Cost =	$9867.84	USD Per Unit (Not incl. VAT)			
Cost per Year =	**$987.00**	**USD Per Unit (Not incl. VAT / Annual Maintenance) Assuming a 10 Yr. Lifespan**			

[1]Supplier – Xylem; [2]Costs Incurred by Alpha Not Included in Total Cost of Gauge

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Continuous Gauging in the Caribbean - Typical Challenges

- Trapped Debris/Physical Cleaning
- Accessing Gauges in Remote Locations
- Continuous Analysis with new data is time-intensive

- Accessing the gauges for data collection mainly after flood events
- Securing the facilities in public spaces
- Difficult to identify anomalies
- Continuous Analysis with new data is time-intensive

A Worthwhile Undertaking

THE VALUE OF HYDROMETRY IN REDUCING FLUVIAL FLOODING FOOTPRINTS

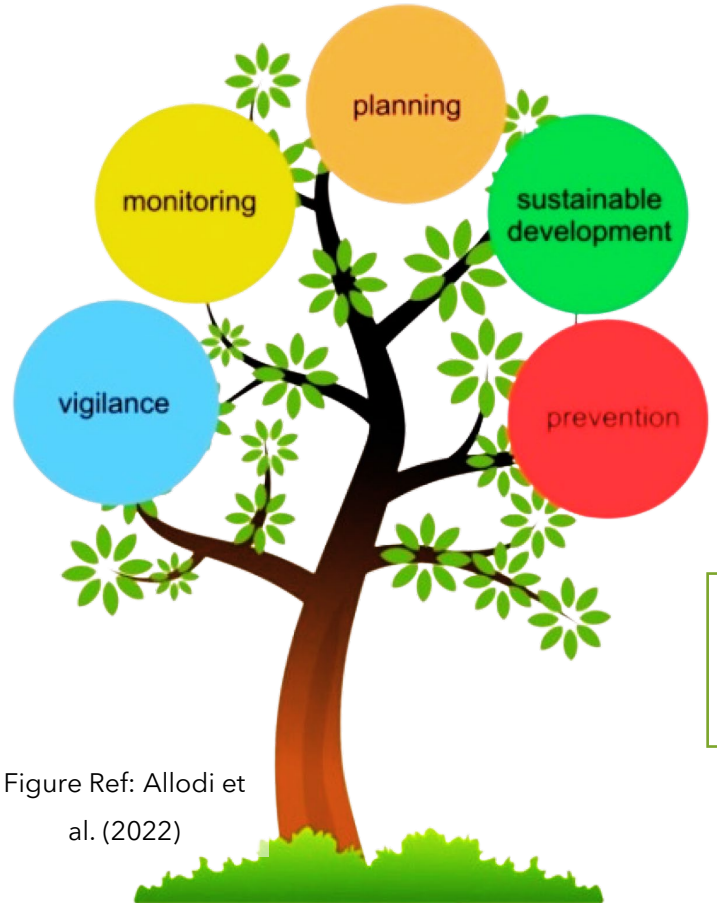

Figure Ref: Allodi et al. (2022)

- **Benefits Outweighed Annual Cost**
- **Several Site-Specific Findings Improved Accuracy in Modelling Process**
- **Reduced Epistemic Uncertainty in Engineering Output**

Q.E.D.: FEASIBLE TO MAINTAIN GAUGING IN THE FLOOD-PRONE WATERSHED

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Evolving Long-Term Technologies for Hydrometric Monitoring

Available Options[1]	Use/Application	Costs per Site[1]	Additional Requirements
<u>Option 1:</u> Xylem HydroSphere Cloud Based Data Hosting Platform (compatible with the existing Storm 3 Data Logger)	• Customizable graphs tables, and dashboards; • Data-driven alarms and customizable escalation; • Building networks of monitoring sites; • Creating public websites for visualization of curated data; • Cloud based design allowing access to data from any web-enabled device at any time.	USD $132/Yr.	• Sierra Wireless RV50X Modem ($1,200 USD); • Mast Antenna Kit, 10 FT ($520 USD).
<u>Option 2:</u> Campbell Scientific LoggerNet Data Logger Software Base Station Connect and Scheduling Software.	Suite of applications for: • datalogger programming; • data collection; • network monitoring and troubleshooting; • data display – real time graphs.	Potentially higher than Option 1: • Existing data loggers to be replaced with a compatible version; • Needs a Wireless Modem & Antenna Kit.	

[1]Information provided by ROSE Environmental Limited of Trinidad & Tobago.

THANK YOU

QUESTIONS?

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