Field Data Collection to Support Numerical Modelling of Mangrove Contributions to Compound Flood Mitigation

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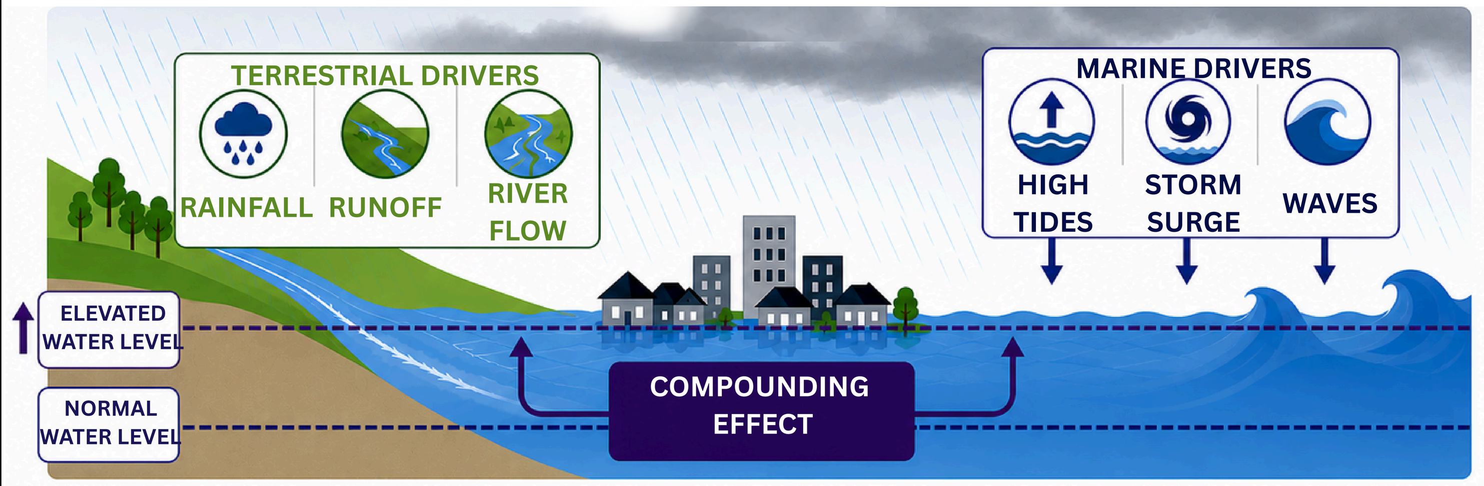
European Geosciences Union

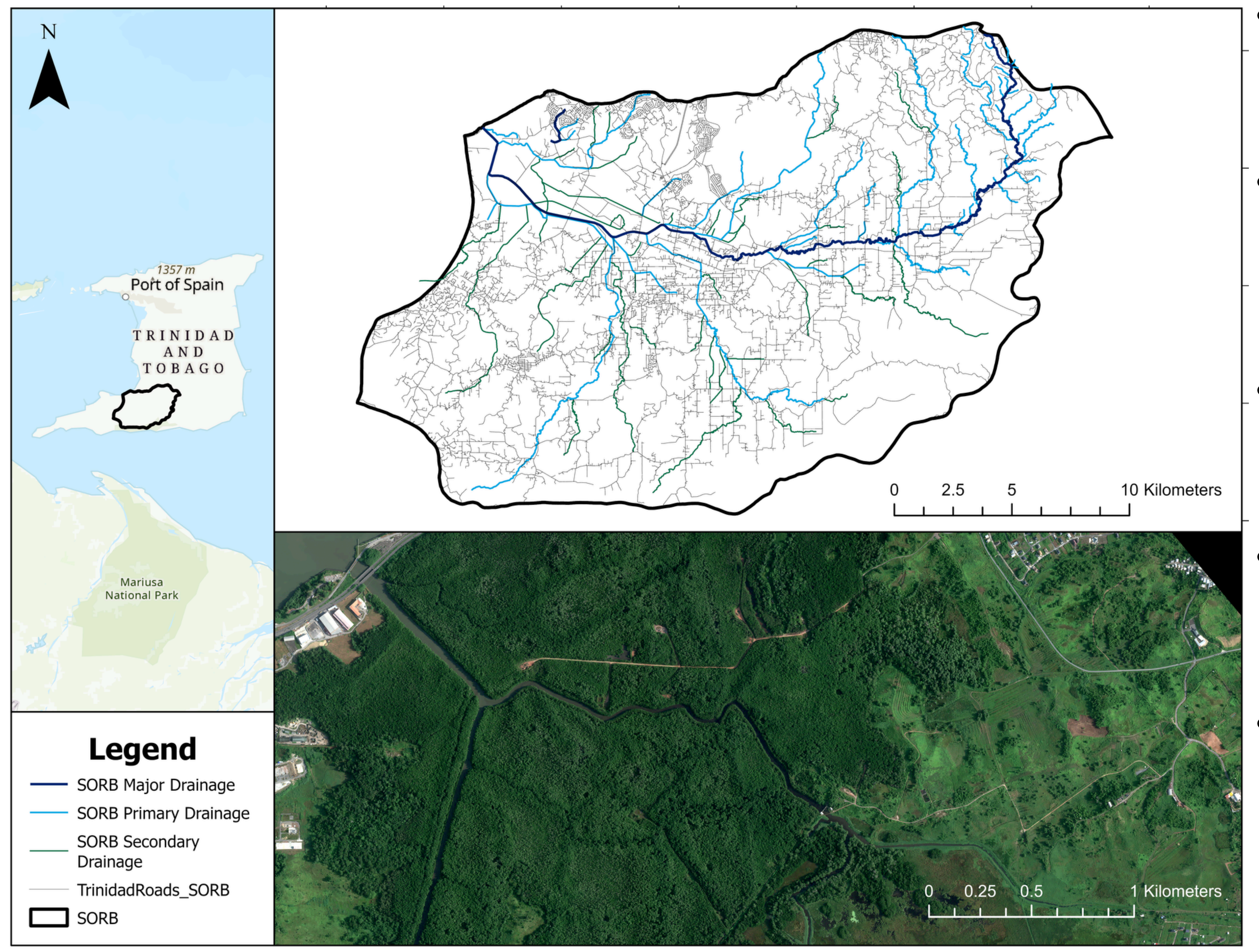
1. Introduction

COMPOUND COASTAL FLOODING



Small Island Developing States (SIDS) are highly vulnerable to compound coastal flooding resulting from the interaction of heavy rainfall, river discharge, tides, storm surge and waves. Climate change is expected to further intensify these hazards through sea level rise and changing storm and rainfall patterns. Nature based solutions (NBS), such as mangrove ecosystems, are increasingly recognized for their potential to reduce flood impacts while providing additional environmental and social benefits. However, modelling compound flooding and NBS performance in SIDS remains challenging due to limited long term observations and data scarcity. This study therefore focuses on field data collection and monitoring techniques to support the development, calibration and validation of a compound flood model.

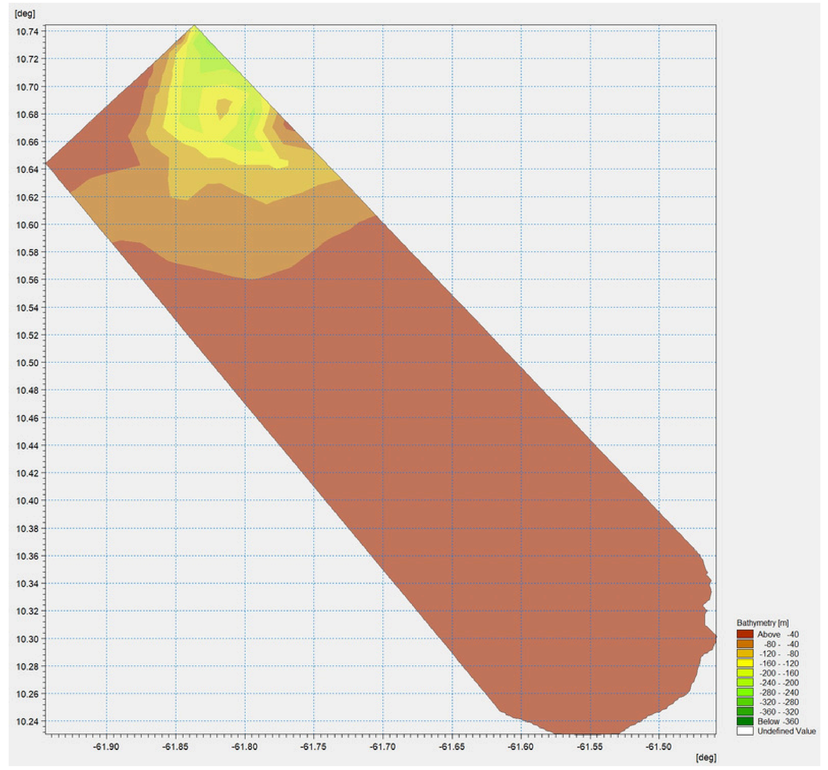
2. Study Site: South Oropouche River Basin



- Located along the southwest coast of Trinidad, the basin covers approximately 450 km² and drains into the Godineau Swamp (3,171 ha) before discharging into the Gulf of Paria.
- The basin is predominantly flat, with average slopes of approximately 0.3% and a longest flow path of nearly 30 km, contributing to slow drainage and a high susceptibility to prolonged flooding.
- Hydrodynamics within the lower basin are influenced by tidal forcing and saline intrusion, which extend several kilometers inland and interact with the surrounding estuarine systems.
- Approximately 740 ha of mangrove forest fringe the Godineau Swamp, providing important ecosystem services including wave attenuation, storm surge buffering, and sediment stabilization.
- Nearly 200,000 residents live within the basin, where recurrent flooding impacts agriculture, fishing, commerce, and energy related activities, with estimated annual damages ranging between USD 19–36 million annually.

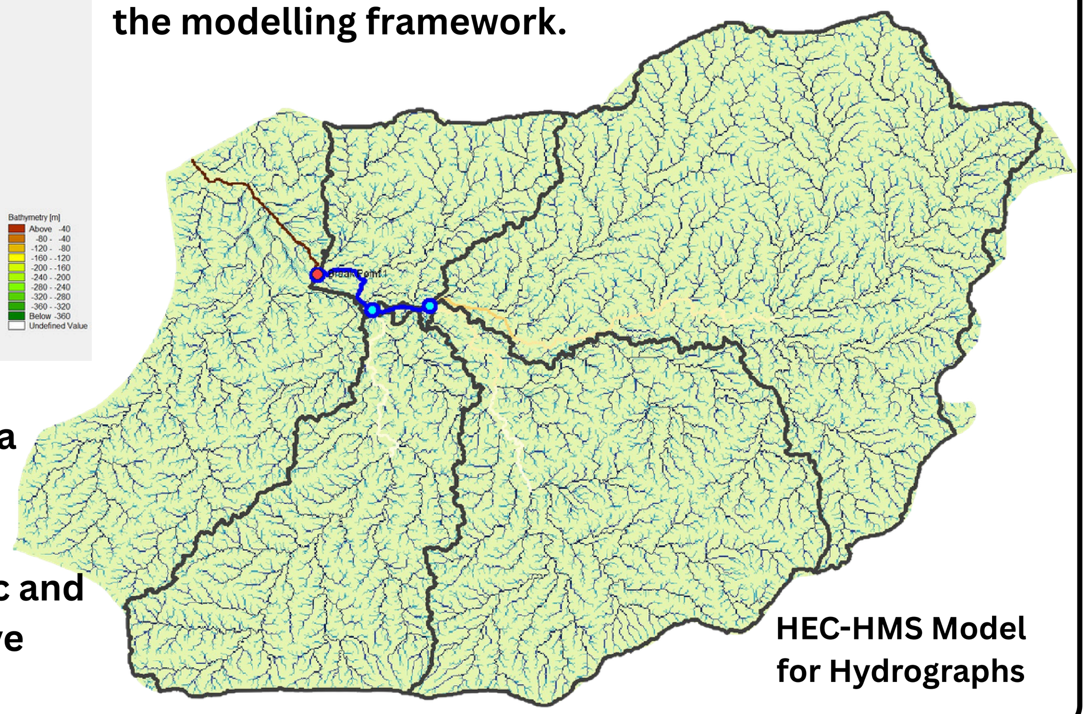
3. Modelling & Data Requirements

MIKE 21 Domain for Hydrodynamic Modelling



While global and open source datasets can support model development, these datasets are often uncalibrated for SIDS and may not have the spatial and temporal resolution to adequately represent the hydrologic and coastal processes within these regions. As a result, field observations are required to calibrate and validate model performance, improve boundary conditions, and support the representation of mangrove related processes within the modelling framework.

Compound flood modelling requires data from both the terrestrial and marine environments, including terrain and bathymetry, hydrological, hydrodynamic and meteorological conditions, and mangrove characteristics.



HEC-HMS Model for Hydrographs

4. Meteorological Data

Vantage Vue Weather Station

Trinidad Radar Rainfall

Weather stations measuring rainfall, wind speed and direction, barometric pressure, temperature and humidity will be deployed throughout the basin to capture the spatial and temporal variability of hydrometeorological conditions. Rain gauge observations will also be compared with radar rainfall estimates to develop bias corrected rainfall relationships.

5. Flood Data

Obscape Timelapse Camera

Water Level Logger

Water level loggers will be deployed throughout rivers, floodplains and mangrove areas to monitor hydrological conditions, flood depth and flood extent across the basin. At a coastal location influenced by multiple flood drivers, a paired camera and water level logger system will capture flooding depth and extent at high temporal resolution to support model calibration and validation.

6. Hydrological Data - River Discharge

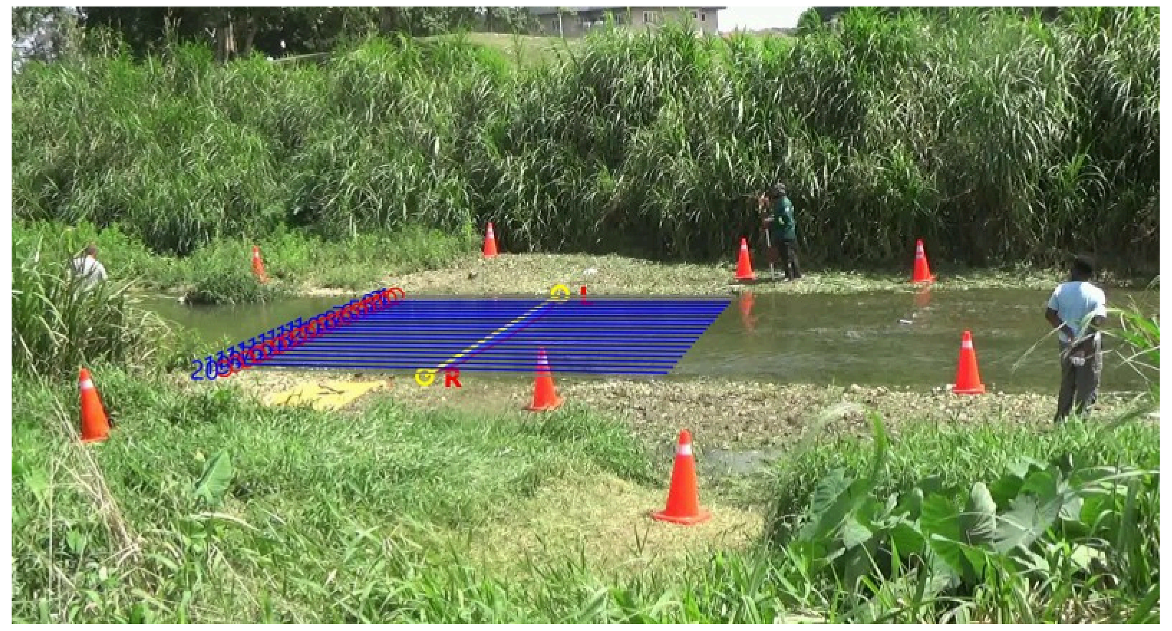
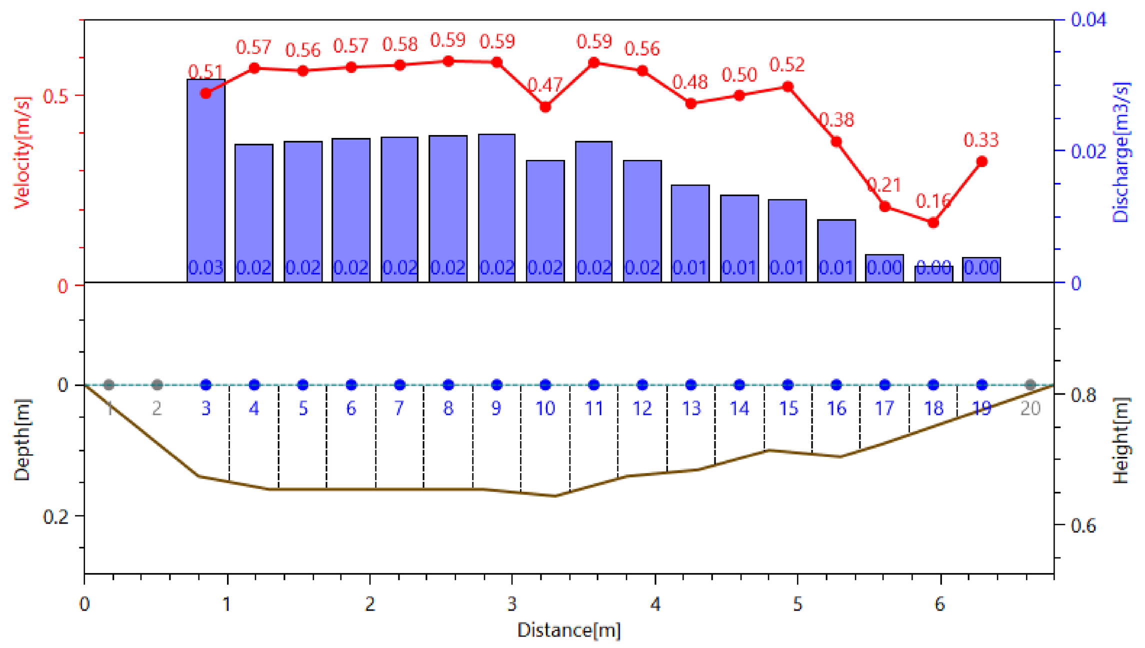
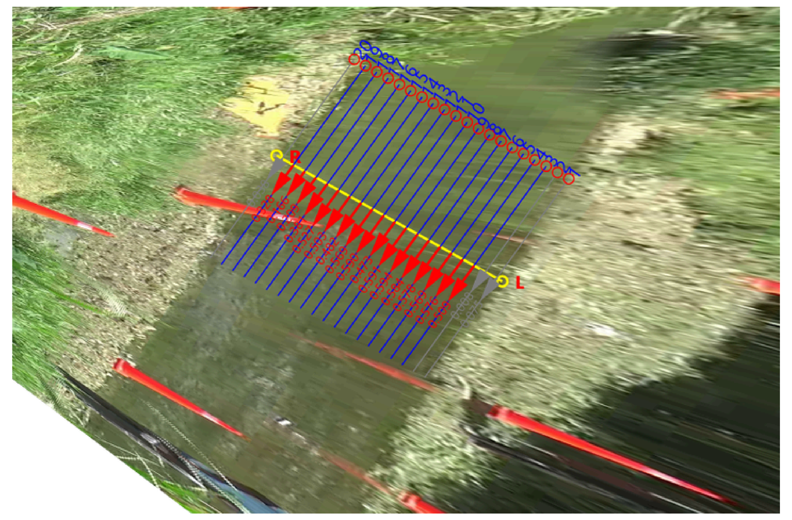


Image Velocimetry Analysis using Hydro-STIV



River Discharge Output

Image velocimetry techniques, including STIV and LSPIV approaches, will be explored to estimate river flow conditions from video imagery collected at selected locations. Surface velocities are measured at one or multiple points across the channel and transformed into representative mean flow velocities using formulas or correction coefficients commonly referred to as the surface alpha. These velocities can then be combined with channel cross sectional information to estimate river discharge, providing a non-contact approach for monitoring flows during flooding events.

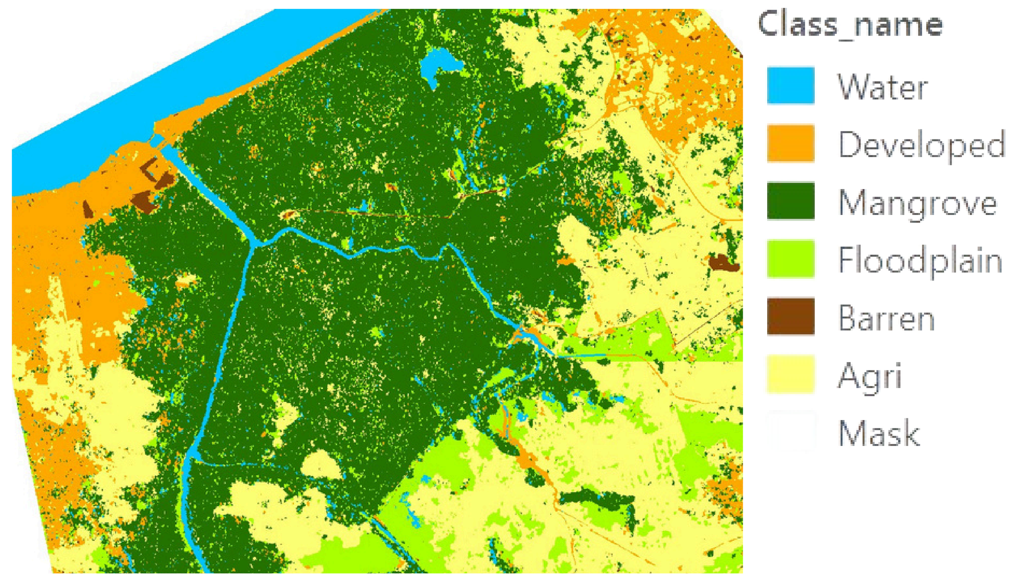


Geometric Correction Image)

7. Mangrove Characteristics - TLS and Satelolite Data

Leica Blk360 Laser Scanner

Terrestrial Laser Scanning (TLS) will be used to capture high resolution three dimensional representations of mangrove structure and vegetation characteristics. These datasets can support the assessment of parameters such as root density, root and trunk thickness, canopy structure and overall vegetation complexity for mangrove related parameterization within the numerical modelling framework.



Mangrove Classification

Satellite imagery and land use classification techniques will be used to map vegetation and surface characteristics across the basin. Variations in spectral signatures across different image bands can also support the identification and mapping of mangrove species distributions. These datasets will provide spatial information for assigning roughness and vegetation related parameters within the numerical model.

8. Future Work

- Full deployment of monitoring systems throughout the basin.
- Investigation of compound flood driver interactions.
- Assessment of flood thresholds and trigger conditions.
- Integrate mangrove characteristics within the numerical model.
- Calibration and validation of the numerical model.
- Scenario simulations under future climate and sea level rise conditions.

9. Conclusion

Field monitoring within the South Oropouche River Basin is expected to improve understanding of how multiple flood drivers interact to generate inundation under varying conditions. Together, the field data collection and modelling approaches will help quantify the degree to which mangroves mitigate flooding while providing a practical approach for improving compound flood assessment in data sparse regions including Small Island Developing States. This would help inform mitigative solutions and management strategies.