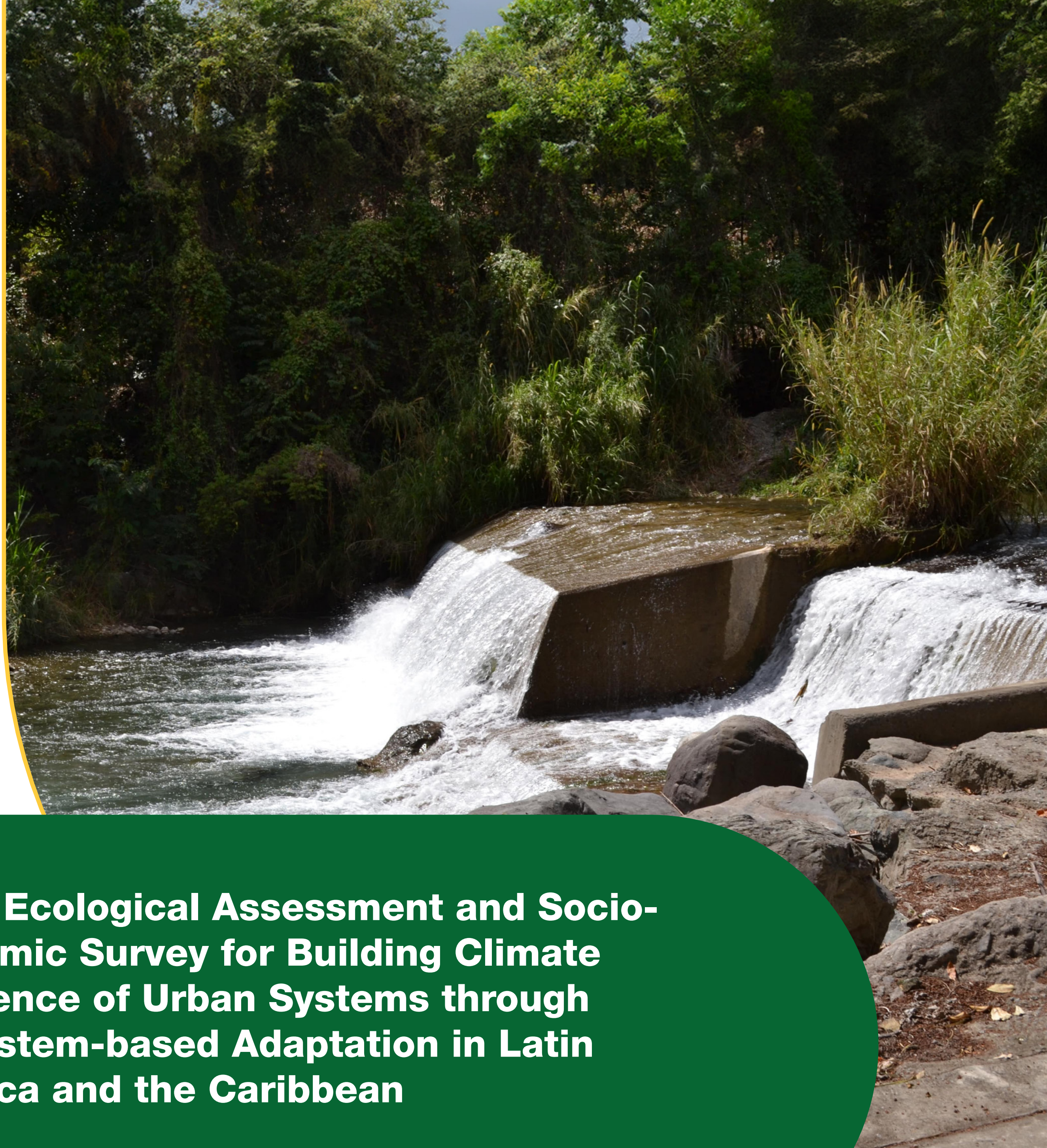


Rapid Ecological Assessment and Socio-economic Survey for Building Climate Resilience of Urban Systems through Ecosystem-based Adaptation in Latin America and the Caribbean

HOPE RIVER WATERSHED, JAMAICA

CityAdapt
RECONNECTING CITIES WITH NATURE
LATINAMERICA AND THE CARIBBEAN

UN environment programme

gef

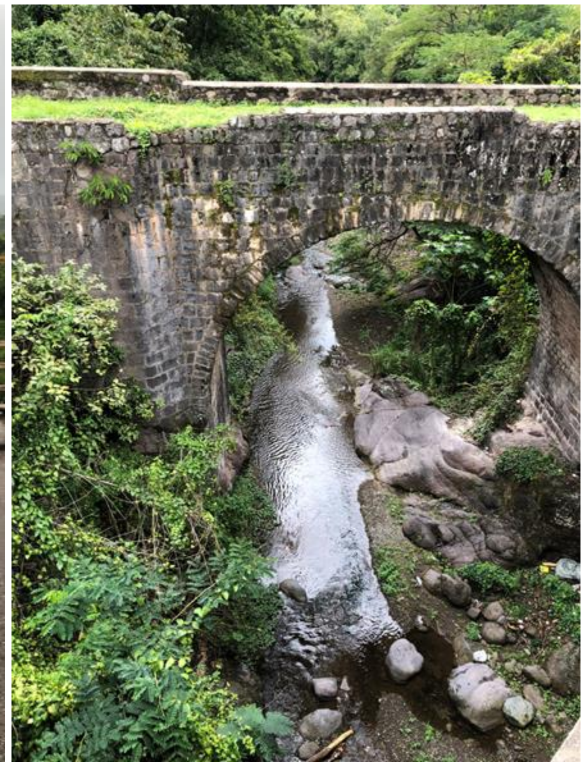
The Nature Conservancy

Rapid Ecological Assessment and

Socio-economic Survey for Building Climate Resilience of

Urban Systems through Ecosystem-Based Adaptation in Latin America and the Caribbean

(HOPE RIVER WATERSHED, JAMAICA)



PREPARED FOR:

The Nature Conservancy

PREPARED BY:

TEM network | TECHNOLOGICAL & ENVIRONMENTAL MANAGEMENT NETWORK LIMITED

190 Mountain View Avenue

Kingston 6, Jamaica W.I.

Contact: Paul M. Carroll

July 24, 2023

Document No.: **TEMN/TNC -2022-03**

REVISION RECORD

Originated by: Paul Carroll Revised by: Date: Approved by: Date: Revision #: 1 Revised by: Paul Carroll Date: Nov 18, 2022 Approved by: Date: Revision #: 2 Revised by: Bernadette Charpentier Date: November 18, 2022 Approved by: Date: Revision #: 3 Revised by: Brian Richardson Date: November 21, 2022 Approved by: Date: Revision #: 4 Revised by: Paul Carroll Date: November 23, 2022 Approved by: Date: Revision #: 5 Revised by: Bernadette Charpentier Date: Approved by: Date: 12/12/22 Revision #: 6 Revised by: Allison Richards Date: April 18, 2023 Approved by: Date:	Revision #: 7 Revised by: Bernadette Charpentier Date: April 21, 2023 Approved by: Date: Revision #: 8 Revised by: Paul Carroll Date: April 24, 2023 Approved by: Date: Revision #: 9 Revised by: Bernadette Charpentier Date: July 21, 2023 Approved by: Date: Revision #:10 Revised by: Paul Carroll Date: July 22, 2023 Approved by: Date: Revision #:11 Revised by: Allison Richards Date: July 22, 2023 Approved by: Date: Revision #:12 Revised by: Samira Bowden Date: August 31, 2023 Approved by: Date: Revision #:13 Revised by: Paul Carroll Date: September 4, 2023 Approved by: Date:

Table of Contents

LIST OF FIGURES

LIST OF TABLES

LIST OF ACRONYMS/TERMS

Acronym/Term	Meaning
4H	4 H Club
AMJ	April-May-June
AMO	Atlantic Multidecadal Oscillation
ASON	August-September-October-November
Bioswales	Channeled depression or trench that receives rainwater runoff
BOD	Biological Oxygen Demand
CC	Climate Change
CDD	Consecutive dry days
CLLJ	Caribbean Low-Level Jet
CMIP5	Coupled Model Intercomparison Project 5
CRU	Climatic Research Unit
CSGM	Climate Studies Group Mona
DAFOR	scale used to provide a quick estimate of the relative abundance of species (generally plants). D - Dominant (>75%); A - Abundant (51 - 75%); F - Frequent (26 - 50%); O - Occasional (11 - 25%); R- Rare (11 - 25%).
DJFM	December-January-February-March
EbA	Ecosystem-based adaptation
ENSO	El Niño Southern Oscillation
FD	Forestry Department
GCM	Global Climate Model
GHG	Greenhouse Gas
Graben	An elongated block of the earth's crust lying between two faults and displaced downward relative to the blocks on either side, as in a rift valley.
GT	Greenwich Town
GTC	Greenwich Town Community
GTFV	Greenwich Town Fishing Village
HEART Trust/NSTA	Human Employment and Resource Training Trust/National Service and Training Agency
HH	Household
HRW	Hope River watershed
HR	Hope River
IPCC	Intergovernmental Panel on Climate Change

Acronym/Term	Meaning
J	July
JAS	Jamaica Agricultural Society
JCF	Jamaica Constabulary Force
JDF	Jamaica Defence Force
JPSCo	Jamaica Public Service Company
KSMA	Kingston & St. Andrew Metropolitan Area
LICJ	Land Information Council of Jamaica
MLG	Ministry of Local Government and Community Development
NAO	North Atlantic Oscillation
NEPA	National Environment and Planning Agency
NGO	Non-Governmental Organisations
NO^3	Nitrate
NRCA	Natural Resources Conservation Authority
NSWMA	National Solid Waste Management Authority
NWA	National Works Agency
NWC	National Water Commission
PIOJ	Planning Institute of Jamaica
o-PO_4^{--}	Ortho Phosphate/reactive phosphate
R10mm	Annual (seasonal) count of days when rainfall is greater than or equal to 10 mm
R95p	Annual total when rainfall is above the 95th percentile
R99p	Annual total when rainfall is above the 99th percentile
RADA	Rural Agricultural Development Authority
RCM	Regional Climate Model
RCP	Representative Concentration Pathways
RegCM4.3.5	Regional Climate Model developed at the International Centre for Theoretical Physics
REA	Rapid Ecological Assessment
RiVAMP	Risk and Vulnerability Assessment Methodology Development Project
RX1	Annual (Seasonal) maximum daily rainfall
RX5	Annual (Seasonal) maximum consecutive 5-day rainfall
SDC	Social Development Commission
Shale	Soft, finely stratified sedimentary rock that formed from consolidated mud or clay and can be split easily into fragile slabs.

Acronym/Term	Meaning
SDII	Simple Daily Intensity Index
SLR	Sea Level Rise
SSP	Shared socio-economic pathways
SST	Sea surface temperature
STATIN	Statistical Institute of Jamaica
TNC	The Nature Conservancy
UTECH	University of Technology
UNEP	United Nations Environment Programme
VA	Vulnerability Assessment
UWI	University of West Indies
WMU	Watershed Management Unit
WRA	Water Resources Authority

1 EXECUTIVE SUMMARY

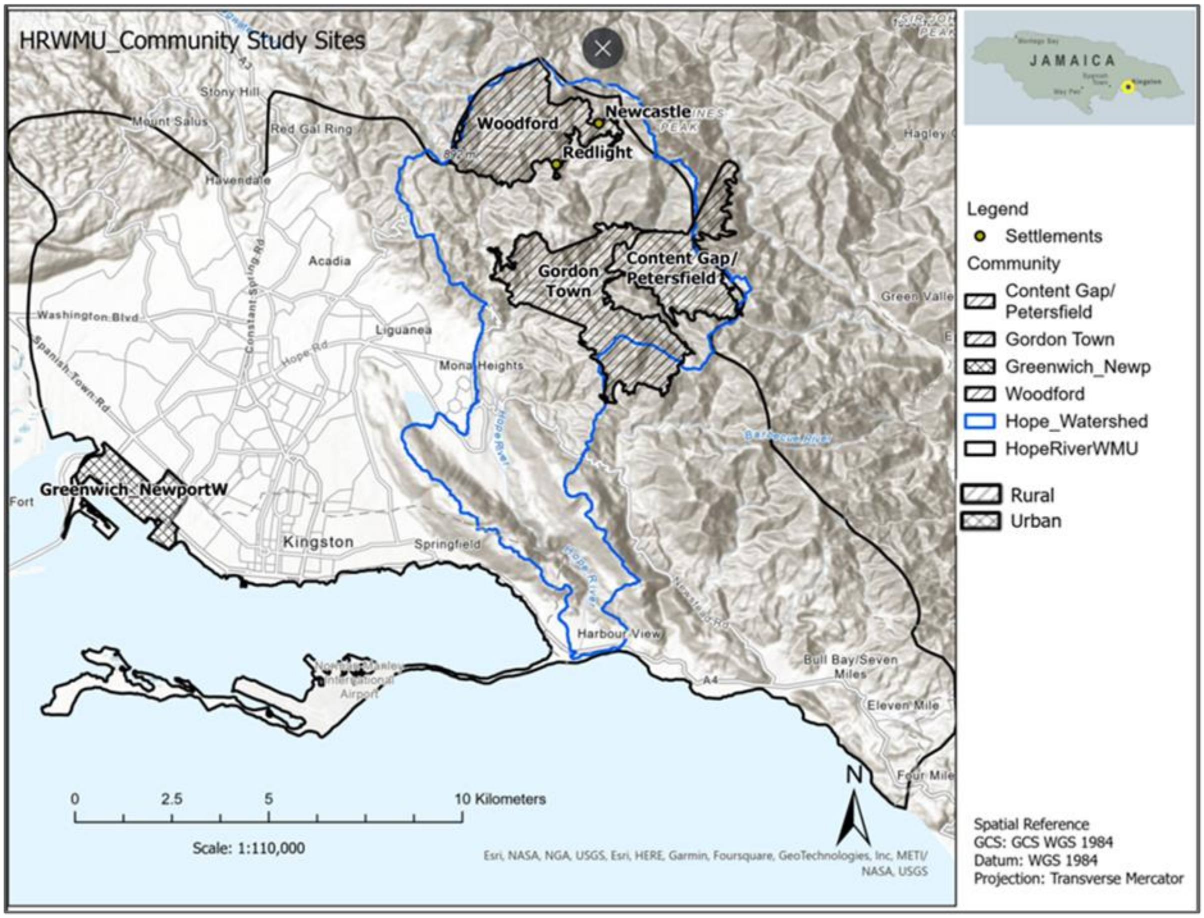
1.1 Introduction

The United Nations Environment Program (UNEP) is leading the CityAdapt initiative, which focuses on climate change adaptation projects for cities in Latin America and the Caribbean. Climate adaptation involves adapting natural and human systems in response to actual or expected climate change. Cities in this region are particularly vulnerable to climate impacts like rising sea level, heatwaves and other extreme weather events. To enhance their resilience, cities are implementing strategies such as green infrastructure, ecosystem-based adaptation, emergency preparedness, and sustainable land use planning.

One of the projects under CityAdapt is taking place in Kingston, Jamaica. Its primary objective is to reduce the vulnerability of urban and peri-urban communities, to present and future climate effects through Ecosystem-based Adaptation (EbA). Vulnerability is determined by how well a system can cope with negative climate effects, considering the character, magnitude, and rate of climate variation it faces, as well as its sensitivity and adaptive capacity.

A pilot study was conducted in Kingston, Jamaica, focusing on land use changes, urban/industrial sprawl, and associated concerns, with proposed EbA interventions including tree planting in Greenwich Town and in the Petersfield Forest Reserve in the Hope River watershed.

The current study builds on the CityAdapt Pilot Study by conducting a risk assessment in additional communities from the Hope River Watershed Management Unit. A Rapid Ecological Assessment (REA), and Socio-economic Assessment of the Hope Watershed were carried out in communities from the upper (Woodford, Newcastle, and Redlight), middle (Gordon Town, Petersfield, and Content Gap) and lower (Greenwich Town) reaches of the watershed management unit. The lower watershed community (Greenwich Town) is located within the boundaries of Kingston Metropolitan Area (KMA).



Community study sites in the upper, middle and lower reaches of the in the Hope River WMU.

1.2 Literature and Data Review

A comprehensive literature review and data analysis was conducted, including existing studies and historical data from relevant government agencies. Recent reports and studies on climate change for Jamaica and the Caribbean region were reviewed. The hazards study referenced various data sources, including satellite imagery, geological sheets, and hydrological simulations. Stakeholder consultation helped fill gaps in understanding specific local contexts for hazards in the study area.

1.3 Physical Environment Surveys

The field survey instrument was designed to address data gaps and assess community perception regarding watershed management and risk assessment vulnerability. For natural hazards, the field surveys focused on three main and recurrent geohazards: landslides/rock falls, extreme precipitation/flooding and earthquakes.

Hydrogeology

A detailed description of the physical environment included a review of historical hydrological data from WRA and geological hazards assessments from published sources. Specifically, this work covers the physical and hydrological aspects of the selected settlements located within the upper, middle and lower sections of the Hope River WMU.

Surface Water Resources

The main named surface watercourse is the Hope River, which runs through the centre of the watershed catchment. The main channel is wide and flat with steep-sided banks and some terraces at the seaward end. The watershed is adjacent the Kingston Metropolitan Area and lies along the southern slopes of the Blue Mountains. Tributaries to the Hope River in the upper and middle reaches of the catchment include, the Flora River, Hog Hole River, Mammee River and Salt River. In the lower catchment immediately adjacent Greenwich Town, there is the Shoemaker Gully. Several other gullies drain the lower reaches of the catchment within the Alluvial Plains. Most of these discharge to the Kinston Harbour.

The WRA stream flow data at the Gordon Town stream gauge station has recorded a maximum flow of 99.3 m^3/sec in September 2004 and a minimum flow of 0.05 m3/sec in December 2020. Catchment modelling research however, has shown modelled flows of 1,035 m3/sec in the vicinity of the Harbour View Community for extreme rainfall events (Mandal et al 2016).

Groundwater Resources

The hydrogeological units in the catchment are divided into two main categories: aquicludes and aquifers. The upper, middle, and lower reaches of the HRW are defined by aquicludes, with the upper reaches having a basal aquiclude from volcanic formations and the coastal aquiclude consisting of non-porous limestone. Aquifers, which are geologic formations holding usable groundwater, include alluvium aquifers below Greenwich Town. Groundwater springs, such as Craig Hill and St. Georges, are found in the middle reaches, but they are physically separated from the larger alluvial aquifer to the west and may intermittently cease during extended periods of low rainfall. Other unnamed springs, serve as water sources for certain communities lacking piped water in the upper and middle reaches.

Geology and Soils

The upper and middle areas of the watershed are volcanic based sedimentary deposits, with some igneous intrusions derived from the older Wagwater Belt Graben, which received large volumes of sediment in the geologic past. The soils of the lower watershed vary in texture from sands and loams to clayey loams and are generally the most fertile soils in Jamaica. They are deep soils with good to rapid internal drainage and poor surface runoff. Soils within the Hope River Watershed are classified under the USDA Hydrologic Soil Group as "A", "C" and "D" soils which are characterised as having high rainfall runoff potential.

The upper and middle reaches of the watershed are known for flash floods which are commonly coupled with landslides and debris flows. Thresholds for landslides induced by the intensity of rainfall have been determined and policymakers should consider undertaking localised hazard mapping that incorporates these thresholds within the risk mapping process.

Given the frequent exposure to significant hazards in the watershed, there is a crucial need for continuous public awareness about the disaster risk in communities located on steep slopes and near geologically active faults. Local planners must base community planning on scientific evidence, translating it into easily understandable action plans for the communities to follow. Climate change adaptation is essential, given unprecedented challenges that require early warning initiatives and annual public education on climate change impacts. Furthermore, promoting public awareness of climate change link to ecosystem services and their management is necessary to mitigate long-term economic and societal losses.

WATER CHEMISTRY

Five sites were selected for the baseline water quality assessment in the study. These included a control site in the upper watershed and four others in the middle and lower reaches of the watershed.

To assess impact of agriculture, waste disposal and deforestation the following indicator were selected:

- Dissolved oxygen – indicator of organic pollutants
- Turbidity – indicator of erosion
- Temperature – a main indicator of climate change
- pH – control is essential to aquatic organisms
- Faecal Coliform – indicator of sewage pollution/mammalian waste
- Nitrate - indicator of sewage/mammalian pollution
- phosphates - indicator of pollution from agriculture
- BOD – indicator of sewage/organic pollution
- Total suspended solids – indicator of erosion

The water quality at the time of sampling indicated good, dissolved oxygen levels, but elevated nitrate and faecal coliform downstream of the background site suggested significant impact from faecal matter, likely due to the absence of central sewerage and reliance on soak-away sewage systems. The high dissolved oxygen levels encountered were likely due to high flow conditions and could decrease during low flow conditions, leading to potential anoxic conditions particularly at night. The low turbidity and total suspended solids indicated no flood conditions during sampling, but the watershed is prone to soil erosion, causing temporary deterioration in water quality, property loss and communication disruptions. As the Hope River is a major water source for the Mona Reservoir, this is a matter of concern. Sediment load from erosion can make the water unusable for public supply by the National Water Commission, leading to water lock-offs during heavy rains. Erosion remains a constant threat to the ecosystem and livelihoods in the area.

1.4 ECOLOGY (REA)

A rapid Ecological Assessment (REA) was conducted at sites chosen from the upper, middle, and lower reaches of the Hope Watershed. The REA aimed to characterise the biophysical conditions, vegetation type, biodiversity, and taxa distribution, providing a general assessment of the three study sites. To prioritise areas for field surveys, historical maps, aerial and satellite imagery, and the latest land cover GIS data from the Forestry Department were reviewed and used.

Field-based surveys were conducted to verify habitat types and gather detailed data on habitat structure, flora, biodiversity, community structure, conservation value, threats, and non-biological information (e.g., infrastructure location). The surveys were conducted in Woodford, Gordon Town, and Greenwich Town, with transects and data collected along tributaries and waterways. The species list was analysed, showing differences in composition and anthropogenic influences among the regions, including the impact of exotic species and human activities like farming and forest plantations.

The Hope River Watershed Management Unit is characterised by different forest types across its elevation gradient. These include montane rainforests in high elevations, mesophytic forests in middle elevations, and dry forests, coastal thorn scrub, and mangrove forests in lower elevations, as documented by Asprey and Robbins (1953). The vegetation has been subject to changes caused by both human activities and natural events, resulting in impacts on watershed ecosystems and the ecosystem services they provide. To address these issues, interventions have been implemented, including the protection and management of certain areas within the watershed (i.e., forest reserves), and educating stakeholders about best practices.

The data gathered was collated and checklists were generated for each zone. These were analysed, and summary charts produced to illustrate the outcomes of the sampling and analyses. In summary there was an increase in anthropogenic influences leading to changes in the vegetation and ecosystems as one moves from higher to lower elevations. The impact of certain human activities, when combined with natural factors, was amplified. These activities include farming, planned and unplanned settlements, habitat degradation, the introduction of invasive species, hurricanes, landslides, and fires. The recommendations to tackle the negative impacts on ecosystems and their services in the Hope River Watershed Management Unit are of a preventative, rehabilitative, or restorative nature. These cross-cutting recommendations apply to various sectors and stakeholders and have the potential to positively influence the conditions and services of the ecosystems within the watershed.

1.5 Socioeconomic Assessment

The socio-economic assessment (SA) was undertaken to examine the socio-economic setting and the factors that will most likely affect well-being of local communities, including livelihood characteristics, population growth, planned economic activities, disaster risk, and land-use change within the broader boundaries of the Hope River watershed management unit and selected communities identified from the upper, middle, and lower regions of the watershed.

Community selection was done collaboratively with participants from the TNC/UNEP team and the various specialisations on the TEM team. The criteria used to select communities were identified through review of existing literature. They are: (1) ecosystem health; (2) dependency of the ecosystem; (3) main ecosystem services available; (4) hazard history (5) population; (6) vulnerable population; (7) sex ratio (male to female); (8) housing vulnerability (% wood construction); and (9) actively unemployed population. The selected communities capture a varied view of ecological (ecosystem/habitat), population, and risk gradients from the upper to lower reaches of the HRWMU. The communities selected were:

- Lower watershed region - Greenwich Town
- Middle watershed region - Gordon Town in (in addition to Content Gap and Petersfield)
- Upper watershed region – Woodford (including Redlight and New Castle, which were included as they are located within the same enumeration district and poverty map community boundaries)

A socioeconomic survey was conducted to collect primary data within the selected communities. Information collected included household activities and practices that affect the ecosystem, non-household development and practices that affect the ecosystem, perceived value/importance of the ecosystem, vulnerability to climate-related risk, coping mechanisms, climate adaptation needs and governance of the ecosystem (existing/perceived system). Information was collected by means of a questionnaire consisting of 61 questions, administered in face-to-face interviews targeting heads of households or a representative 18 years and older. Target participants were identified from various stakeholders' groups including community residents and business operators. Sample size was determined based on a combination of population data using a plus or minus 5-7 margin of error and a confidence level of 95%. Simple convenience sampling was used to select participants, based on availability and willingness to participate in the full interview. While personal interviews are noted to be associated with high costs and tend to be time intensive, they have the advantage of a high response rate and tend to be more favourable for open-ended questions. The interviews also facilitated building awareness of key concepts watershed and ecosystem concepts amongst participants who indicated lack of knowledge. The instrument used to collect the information is included in the Appendix. A total of 184 interviews (99 in the lower watershed; 31 in the middle watershed; and 54 in the upper watershed) were conducted across all regions in October 2022. The sample size represents 3.6% of households across all communities in the study. Data gathered was processed and analysed using statistical software (SPSS, Excel) and other software for spatial analysis (ArcGIS Pro).

The study communities have a total population of approximately 14,984 persons, 5,105 housing units with average household size of 3.1 persons per household. The population of the study communities represents 2.3% of the total population of the KSA. The lower watershed has the largest population and number of housing units with declining population as you go from lower to upper watershed region. Almost 70% of the total population belong to the working age-group (15-64 years), 24.5% are under 15 years and 6.2% 65 years and older. Survey participants represented a range of social and economic circumstances. Seventy percent (70.4%) were males and 29.7% females. The average age of participants is 52 years ranging from 23 years to 93 years.

The socioeconomic variables were examined to determine exposure, vulnerability, sensitivity and the adaptive capacity of the communities to climate-related events. The key findings of the assessment show that a large proportion of the population of communities within the HRWMU are exposed and vulnerable to climate-related hazards. The high levels of dependence on the ecosystems and the Regulating, Supporting, Cultural and Provisioning services they provide, is an indicator that nature-based solutions (NbS) and ecosystems-based solutions (EbA) for building climate resilience of these communities are appropriate. Actions to protect the ecosystem recommended by survey participants included:

- Monitoring, enforcement, regulations that protect ecosystems, penalties for polluters (22.4%)
- Sanitation and waste management (20.8%)
- Education/Training/Community outreach and sensitisation to build capacity in the communities for sound environmental practice and management (15.8%)
- Conservation/reforestation/Plant more trees/Create and enforce riparian buffer around riverbanks to prohibit construction of houses along riverbanks (11.5%)
- Improve drainage system; more frequent cleaning of drains and gullies (7.7%)
- Better land use and farming practices (zoning for specific use, conservation) (4.9%)
- Community action and partnerships (2.7%)

The key findings of the socioeconomic assessment were aggregated with other study components and integrated into the vulnerability assessment model to identify potential climate impacts and EbA strategies to build climate resilience in the communities.

1.6 *Climate Analysis*

The impact of climate change was assessed by analysing key variables, including rainfall, temperature, tropical cyclone activity, and sea level rise. This assessment was based on several important reports, such as Near-Term Climate Scenarios for Jamaica (CSGM 2014), the 2015 State of the Jamaican Climate Report (CSGM 2017), the State of the Caribbean Climate (CSGM 2020), the State of the Jamaican Climate Volume III (CSGM 2022), the Working Group I contribution to the Intergovernmental Panel on Climate Change (IPCC) Sixth Assessment Report (IPCC 2021), and the IPCC's Special Report on Global Warming of 1.5°C (Hoegh-Guldberg et al. 2018). These reports highlight the trends in climate variability for the overall Caribbean region, with a special focus on Jamaica.

Historical Trends

Analysis of historical trends spanning 1981 through to 2021 used accessible station data from Jamaica's Meteorological Service The impact of climate change was assessed by analysing key variables, including rainfall, temperature, tropical cyclone activity, and sea level rise.

Future Near to Long-Term Climate Projection

To assess climate change impacts on the Hope River watershed management unit, dynamical downscaling using the International Centre for Theoretical Physics (ICTP) Regional Climate Model (RegCM) version 4.3.5 was employed, providing climate projections at a 20km resolution. The model was driven by representative concentration pathways (RCPs) data from Global Climate Models (GCMs) to produce historical climate data from 1971 to 2005 and future projections from 2021 to 2100, divided into near term (2030s), medium term (2050s), and end of the century (2080-2097) time slices for three RCPs (RCP2.6, RCP4.5, and RCP8.5) relative to a 1980-2003 baseline. The variables studied include rainfall, temperature, and relative humidity for annual and seasonal changes, as well as rainfall extremes like Consecutive Dry Days (CDD), Maximum 1-Day Precipitation (Rx1), and annual count of days with daily precipitation over 10mm (R10) for specific seasons. Projections regarding sea level rise and tropical cyclones were obtained from literature and online sources.

On a large scale, future rainfall and temperature estimates are generated from the Coupled Model Intercomparison Project 5 (CMIP5) ensemble of general circulation models (GCMs) run under three Representative Concentration Pathways (RCPs).

Rainfall

Climate change significantly impacts rainfall variability in the Caribbean, influencing both its frequency and intensity. Jamaica falls within rainfall zone 3, characterised by a bi-modal pattern with a peak in May and a mid-summer drought in May-June, followed by increased rainfall in September to November. Long-term historical data reveals four distinct geographical areas based on similarities in rainfall amounts and patterns in Jamaica.

From 1881 to 2019, Jamaica's average annual rainfall anomalies do not show a statistically significant trend, being dominated by year-to-year fluctuations with near-zero and insignificant trends. Seasonal anomalies during the same period also lack statistical significance. However, between 1940 and 2010, there has been an increase in extreme rainfall events. Positive trends are observed in annual total rainfall on the wettest days, monthly maximum one and five-day precipitation, and the proportion of rainfall intensity to occurrence. Additionally, there has been a decrease in consecutive dry days based on average indices.

TEMPERATURE

Globally, both near-surface air temperature and sea surface temperature (SST) have experienced significant changes due to global warming and human-induced climate change. The global mean temperature has increased, with a rise of 1.09°C from 2011-2020 compared to 1850-1900. The Caribbean region, including Jamaica, also reflects this warming trend, with linear increases in both near-surface air temperature and SST. Jamaica has experienced a warming of 0.20 - 0.31°C per decade, with minimum temperatures increasing at a higher rate than maximum temperatures. The warming has led to more warm-days and warm-nights and fewer cold days and nights. Additionally, the increasing SST may contribute to the formation and rapid growth of tropical cyclones.

HURRICANES

Hurricanes are a frequent and destructive natural occurrence in the Caribbean, including Jamaica. The southern coast of Jamaica is particularly vulnerable to their impact. Recent years have witnessed an increase in storm intensity, affecting sea level extremes in the region.

SEA LEVELS

The Caribbean region is highly vulnerable to sea level rise due to low elevation, dense population, and significant economic and infrastructural resources in coastal areas. Global mean sea level has risen by 0.20m between 1901 and 2018, with an accelerating rate in the late 20th and 21st centuries. Caribbean Sea levels have increased at a rate similar to the global average, rising at approximately 1.8 mm/year between 1950 and 2009. Increased storm intensity will further drive higher extreme sea levels through storm surges.

Storms and Hurricanes

The maximum is *recorded* in September where 30-49 named storms may be experienced per 100 years. For hurricanes, 5-19 events may be evident per 100 years for each month (August – October). In September the band of 20-34 hurricanes per 100 years is just north of the island.

Projections - Future Near to Long-Term Climate Projections

Annual Change

RegCM4.3.5 projections for Hope River WMU under RCP4.5 show variable rainfall changes, a slight increase in wind speed, and temperature rise throughout the region in the near-term, medium-term, and end of the century. Minimum temperature is forecasted to increase by 1.2°C in the northern region and up to 1.1°C in the coastal region during this period. In the medium-term, minimum temperatures may rise up to 1.5°C, and maximum temperatures up to 1.6°C. By the end of the century, both minimum and maximum temperatures are predicted to increase above 1.9°C.

Seasonal Changes

Projections indicate drier conditions, slightly higher wind speeds, and temperature increases for the WMU. However, seasonal impacts may differ, with some periods showing increasing rainfall despite overall drying trends in the future under intermediate and extreme emissions scenarios.

Extremes

The extreme rainfall indices, like consecutive dry days (CDD) and maximum 1-day rainfall (RX1), provide insight into projected rainfall changes. The results show slight changes in

CDDs and an increase in maximum 1-day rainfall in the southern section of the WMU by 2030-39. In the mid-century (2050-59), the WMU experiences a decrease in CDD and maximum 1-day rainfall, except for some areas in the east. Under the extreme RCP8.5 scenario, there is significant seasonal variability in CDD and RX1, with some areas experiencing decreases in RX1 during the wet season. Overall, the projections indicate increased rainfall intensity in the southern area but decreasing rainfall in other parts of the WMU.

Impact Assessment for Three Climate Change Projections

RCP2.6

Under RCP2.6 scenario, the Hope River WMU shows moderate increases in annual total precipitation at the end of the century, with higher values on the coast and lower values inland. Seasonally, the April-May-June period sees the highest increases in precipitation. Minimum and maximum temperatures are projected to rise, with medium-term increases up to 1.40C and 1.60C, respectively, and higher values by the end of the century.

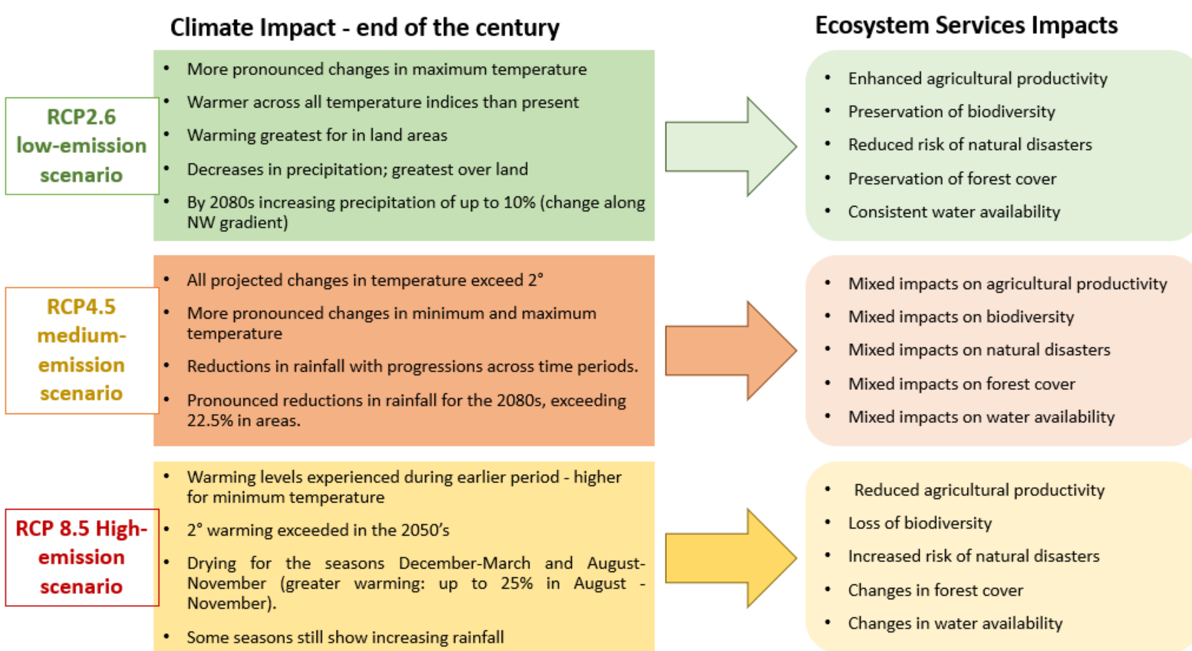
RCP4.5

Under RCP4.5 scenario, the Hope River WMU shows variable rainfall patterns in the near-term, with the southeastern portion receiving up to 10% more rainfall and the northern section remaining similar to the baseline. In the medium term, the southeastern region's wetter conditions decrease to less than 5% more rainfall, while the northern section experiences drier conditions with -5% less rainfall. By the end of the century, the entire WMU shifts to drier conditions. Maximum annual surface wind speeds show slight strengthening over time, while temperature projections indicate increasing trends in both minimum and maximum temperatures throughout the coming decades.

RCP8.5

Under RCP8.5, the Hope River WMU shows an overall drying trend in the mid-term. However, the April-June period becomes wetter by up to 25% throughout the entire WMU. The late rainfall season (August-November) is projected to see a decline of up to 20% in the northern region, while the dry season (December-March) may see decreases of up to 10% in most of the WMU. This indicates that while annual changes lean towards drier conditions in the future, some seasons may still experience increasing rainfall.

The present climate assessment of the Hope River Water Management Unit reveals variability in the present and future projections. Temperature increases of up to 2°C by the end of the century will have negative impacts on ecosystems and services they provide. Near-term rainfall will increase up to 15%, but by the end of the century, a drying trend of 22.5% is projected. Changes in rainfall patterns will affect freshwater supply and stream flow, impacting downstream users and habitat conditions. The WMU may face increased risk from intense winds and rains due to tropical cyclones. Global mean sea level rise projections range from 0.44 to 1.01 meters by 2100, with local projections indicating a rise of 0.64 to 0.85 meters on the north coast of Jamaica.



1.7 Vulnerability to Climate Change

The Vulnerability Assessment (VA) in select communities within the Hope River WMU was carried out to evaluate susceptibility to climate-related events and identify Ecosystem-based-Adaptation measures at the community level. It involved assessing exposure, sensitivity, impact, and adaptive capacity. Site-specific vulnerability analysis using baseline data was used to identify areas exposed to multiple risks and hazards, informing the selection of appropriate solutions.

This study focused on the upper and middle reaches of the Hope River watershed and the Greenwich-Newport sub-basins located in the lower reaches of the Kingston/Liguanea basin within the greater Hope River WMU.

Field survey results are used to identify and map major anthropogenic and natural hazards and risk factors that are damaging to the ecosystem and biodiversity within the three selected communities. Socio-economic and natural resource data from primary and secondary sources were compiled in a GIS database and provide the basis for climate-related risk analysis of the sites in the Hope WMU.

LAND COVER

Land cover data, obtained from Jamaica's Forestry Department, was utilised to characterise the land cover in the Hope River Watershed Management Unit and track changes over time (2000-2020). The data includes information from Landsat imagery with a 30 m pixel resolution. **Table 11-1** summarises the land cover types in different areas of the watershed, encompassing various categories such as forest types, cropland, settlements, and other land uses. Further details on the methodology and validation of the land cover classification can be found in the work by Bowers and Ryan (2021) titled "Land Cover Change in Jamaica". The land-cover types include dense moist forest, secondary moist forest, dry forest, mangrove forest, cultivated cropland, settlement, seasonally inundated land, permanent water, mining, and other bare areas:

- In Woodford, Redlight, and Newcastle communities, dense moist forest covers approximately 40% of the land, with secondary moist forest, making up an additional 25%. Farming is significant, occupying around 29% of the land, and settlements cover about 6% of the area.

- Content Gap and Petersfield are primarily covered by forest, with secondary moist forest at 31% and dense moist forest at 20%. Cultivated cropland represents 28.1% of the area and settlements account for 9.1%.
- In Gordon Town and surrounding areas, secondary moist forest dominates, covering about 50% of the land, while moist dense forest covers around 17%. Cultivated land represents 15% of the area, and settlements cover 10%.
- Greenwich Town is predominantly urban, with 95.9% of the land covered by settlements. Cultivated cropland represents 3% of the area, and other land cover types, such as dry forest and mangrove forest, are negligible.

The results of the analysis indicate that farming plays a significant role in the livelihoods of communities in Woodford, Redlight, and Newcastle, with around 29% of the land used for cultivation. Common crops grown include coffee, cocoa, banana, plantain, yam, and dasheen. Agroforestry practices are also employed to promote biodiversity and sustainability.

Content Gap and Petersfield are also largely dependent on farming with cultivated cropland representing 28.1% of the area.

Similarly, Gordon Town and surrounding areas are dominated by secondary moist forest (about 50% of the land cover) and moist dense forest (around 17%). Approximately 15% of the area is cultivated, and settlements account for 10%.

In contrast, the lower reaches of the Hope River watershed, including Greenwich Town, are mainly urban and suburban areas. Settlements (built-up impervious surfaces) cover 95.9% of the area, while cultivated cropland represents 3%. Dry forest, mangrove forest, seasonally inundated land, and permanent water have negligible coverage in this urban landscape.

Forest Lands and Forest Reserves

The Blue and John-Crow Mountains National Park in Jamaica is protected by various Acts, including the Watershed Protection Act (1963), Natural Resources Conservation Authority

Act (1991), and the Forest Act 1996, aimed at watershed protection, conserving biodiversity and managing forest resources. These acts play a crucial role in protecting forests, watersheds, and wildlife. The Hope River watershed includes forest reserves and protected areas, highlighting the importance of forest conservation and sustainable use for ecosystem health and community livelihoods.

Deforestation

In the upper reaches of the Hope River watershed (Woodford, Redlight, and Newcastle), dense moist forest cover declined at a rate of -0.013% per year, while secondary moist forest cover increased at a rate of 0.04% per year between 2000 and 2020. In the middle reaches (Gordon Town, Content Gap, Petersfield), dense moist forest cover decreased at a rate of -0.03% per year, and secondary forest cover increased at a rate of 0.03% per year during the same period. In the lower reaches (Greenwich - Newport), mangrove stands were lost at a rate of -0.05% per year, while dry forest cover increased at a rate of 0.03% per year between 2000 and 2020. Overall, the Hope River watershed experienced a decline in deforestation at a rate of -0.08% per year between 2000 and 2020, with exceptions in 2004, 2006, 2013, and 2014.

The Hope River watershed has experienced deforestation and land use changes due to agriculture and urbanisation, resulting in soil erosion, pollution, and reduced water quality. Conservation efforts are underway to protect and restore natural habitats and promote sustainable land use practices. Deforestation is defined as a change from forest land cover to any other type, while forest regrowth is the opposite and refers to succession from non-forest to secondary forest cover. Secondary forests are important for ecological and socio-economic benefits, but deforestation can have negative impacts on forest ecosystems, including fragmentation and habitat loss. Reforestation programs, such as the Forest Management and Conservation Project (FMCP) and the Watershed Management Project, have been implemented in Jamaica in the early 1990s to rehabilitate degraded forests, establish new plantations, and promote sustainable forest management practices.

Community-based reforestation initiatives involving local communities have also been implemented in Jamaica during that time.

Change Detection

An analysis of decadal land cover data from 2000 to 2020 in HRWMU, Jamaica, using Landsat data, revealed that approximately 470 hectares (4.7 km2) of forest land underwent changes from 2000 to 2010, with 64% attributed to natural or anthropogenic disturbances (forest to forest), 22% forest to agriculture, 11% forest to settlements, and 3% forest to other purposes such as mining and barren land. In contrast, from 2010 to 2020, there was a four-fold increase in forest land changes, with an estimated 1,918 hectares (19.18 km2) impacted, and the most notable changes were 32% forest for agriculture and 13.4% forest for settlements. Continued monitoring and management of land use are needed for sustainable forest management practices.

Hazard Assessment

The Hope River watershed Management Unit (WMU) is vulnerable to natural hazards, which can be classified into meteorological/hydrological hazards (such as landslides, floods, and droughts) and geological hazards (including earthquakes and earthquake-induced landslides). Floods are particularly common, occurring year-round and more frequently during heavy storms and hurricanes from June to November. The diverse natural hazard profile of the HRW underscores the importance of considering all potential hazards and their impacts when developing disaster risk reduction strategies. The natural hazard profile of the HRW is diverse (See 5.14.3.1 Physical Environment), and it is important to consider all potential hazards and their impacts when developing effective strategies to reduce disaster risk:

- Meteorological hazards – hurricanes, storms, droughts, extreme heat
- Landslides
- Flooding, flash floods
- Earthquakes

Landslides

The communities of Woodford, Redlight, and Newcastle in the Hope River watershed are at medium to high risk of landslides, with 34% of the terrain having a medium risk, 47% having a medium-to-high risk, and 11% at high risk. Similarly, Gordon Town and Content Gap communities have a similar landslide susceptibility, with 39% of the terrain at medium risk, 39% at medium-to-high risk, and 8% at high risk. Greenwich, on the other hand, shows no risk of landslides. Effective land management and climate change adaptation measures are crucial in these communities to mitigate landslide impacts.

Flooding

In the Kingston Metropolitan and surrounding areas, flooding has caused significant and widespread impacts, including property damage, infrastructure disruption, health concerns, economic losses, and environmental damage. The Hope River watershed is vulnerable to coastal, flash, and riverine flooding, with communities like Greenwich and Kintyre at high risk due to their low-lying elevation and proximity to the sea. Climate change is expected to increase the frequency and intensity of flooding events, posing further risks to communities in the watershed. Effective flood management and adaptation measures are essential to mitigate the impacts of these natural disasters.

Multiple Hazards

In Greenwich Town, residents perceive their community as vulnerable to natural disasters, with hurricanes being the primary concern, followed by flooding, earthquakes, storm surges, and freak storms. Air pollution and noise pollution are also significant hazards mentioned in the community.

In Gordon Town, 71.4% of households feel vulnerable to natural hazards, with hurricanes/storms and mudslides/landslides being the main concerns. Flooding and storm surges are also identified as potential risks in the community.

In Woodford, environmental concerns include inadequate watershed protection, soil erosion, reduced forest cover, poor solid waste management, groundwater pollution, and irregular water supply. The community expressed concerns about their susceptibility to hazards such as earthquakes, landslides, and hurricanes.

Exposure

Among the factors contributing to vulnerability, exposure stands out as the only one directly linked to climate parameters. This involves the characteristics, intensity, rate of change, and fluctuations of climate elements, including temperature, precipitation, and extreme events such as heavy rainfall and meteorological drought. Alterations in these parameters can notably escalate stress on systems, like intensified heavy rain events, temperature rises, or changes in peak rainfall occurrences.

Greenwich is highly vulnerable to climate-related factors such as precipitation and exposure to hazards due to its geographical location and high population density. The community faces direct risks from storm events like hurricanes, resulting in inundation and sea-level rise, posing significant threats to residents and infrastructure.

Gordon Town, Content Gap, Woodford, Redlight, and Newcastle communities are exposed to climate-related factors, with landslides being a primary hazard in the middle and upper reaches of the Hope River watershed. These communities also face adverse weather conditions such as drought, hurricanes, excessive rainfall, and earthquakes, which can negatively impact livelihoods, cultivated land, and the overall community well-being.

Sensitivity

Sensitivity in the Hope River watershed refers to how vulnerable communities are to the impacts of climate change, considering factors like demographics, resource access, and social and cultural values. Woodford, Redlight, and Newcastle are rural communities relying on agriculture, making them moderately susceptible to climate-related impacts. Content Gap depends heavily on agriculture, making them vulnerable to climate change effects on the local economy. Gordon Town faces challenges from improper farming practices and human encroachment, threatening the local ecosystems. Greenwich is densely populated, with high poverty rates, and is highly exposed to hazards like hurricanes and flooding, further threatening their livelihoods. Understanding sensitivity is crucial for developing strategies to build resilience in these vulnerable communities and protect their natural heritage.

Adaptive Capacity

Adaptive capacity refers to a community's ability to prepare for, respond to, and recover from the impacts of climate change. It involves developing emergency response plans, improving infrastructure, and building community resilience through ecosystem services. Ecosystem services play a crucial role in enhancing adaptive capacity by providing essential resources that support community well-being and help cope with climate change impacts. Forests, for instance, can mitigate flood impacts by absorbing and storing excess water and regulating temperatures. Ecosystems also supply food, water, and other vital resources necessary for human survival during crises like natural disasters and climate-related events.

1. *Ecosystem Services -* The Hope River Watershed Management Unit (WMU) is a diverse ecosystem that provides crucial ecosystem services, including provisioning, regulating, cultural, and supporting services, to local communities. The Blue and John Crow Mountains National Park, a UNESCO World Heritage Site located in the Blue Mountain area, plays a significant role in providing these ecosystem services, supporting local communities through agriculture and tourism, and offering recreational opportunities. The Blue Mountains are essential for water supply and regulation, biodiversity conservation, agriculture, soil conservation, climate regulation, recreation and tourism, and cultural values. They serve as a critical source of fresh water for the Kingston Metropolitan area, support biodiversity, provide fertile soils for agriculture, stabilise soil, regulate local climate and air quality, offer recreational opportunities, and hold cultural significance for local communities. Protecting and conserving the Blue Mountains and the surrounding areas, including Woodford, Redlight, Newcastle, and Gordon Town, Content and Petersfield is crucial

for maintaining the well-being of local communities including the KSMA and sustaining the ecosystem services they provide.

2. *Institutional Capacities/Regulatory framework* The Hope River Watershed Management Unit has established institutional capacities and regulatory frameworks to enhance adaptive capacity and resilience within the watershed. These capacities and frameworks are implemented through various agencies and policies, including the Forestry Department, Water Resources Authority, National Environment and Planning Agency/Natural Resources Conservation Authority, and Jamaica Conservation and Development Trust.. These agencies are responsible for forest management, conservation, water resource management, water quality monitoring, environmental regulation, and coordination of watershed management activities such as flood control measures, reforestation efforts, and sustainable land use practices. In addition, legislation and policies such as the National Climate Change Policy and Action Plan, Natural Resources Conservation Authority Act (1991), Jamaica National Heritage Trust Act (1985), and Forestry Act (1996) provide legal protection for the Hope River Watershed and its resources. These institutional capacities and regulatory frameworks are crucial for improving adaptive capacity and resilience in the face of climate change and other environmental challenges in the Hope River watershed.
3. *Community initiatives -* Woodford, Redlight, Newcastle, and Gordon Town communities have good adaptive capacity with proactive community organisations addressing environmental concerns. Content Gap and Petersfield communities have medium adaptive capacity but require institutional initiatives for training on agricultural practices. Greenwich Town has very low adaptive capacity and relies on government and NGO initiatives for dealing with hazards, with limited training for emergency preparedness.

POTENTIAL IMPACTS

The potential impacts of climate change on cities are influenced by both exposure and sensitivity. Exposure refers to the likelihood of being affected by physical climate change impacts, such as extreme weather events and sea-level rise. Sensitivity, on the other hand, relates to the vulnerability of a region, its populations, and infrastructure to these climate impacts.

In the Hope River WMU, exposure is determined by factors such as geographic location, elevation, and climate projections. The eastern part of the watershed is prone to landslides due to steep terrain, soil type and improper land use practices. The low-lying coastal area faces high risks of coastal inundation due to hurricanes, and flash floods.

Sensitivity in the Hope River WMU is influenced by social, economic, and health-related factors. Low-income communities and those with outdated critical infrastructure and services are more sensitive to climate change impacts. These communities are at higher risk of suffering adverse effects from climate-related hazards.

The eastern part of the Hope River WMU (i.e., Gordon Town, Content Gap, Petersfield Woodford, Redlight, Newcastle) is primarily at risk of landslides. The low-lying coastal area (i.e., Greenwich) faces multiple hazards, including coastal inundation and flash floods, with communities that are more sensitive to these impacts. Understanding the interplay between exposure and sensitivity is crucial for developing effective strategies to mitigate climate change risks in the area.

OUTCOME OF THE VULNERABILITY ASSESSMENT

Vulnerability encompasses the potential impacts (exposure and sensitivity) of climate change and the adaptive capacity of an area. It considers susceptibility to climate-related hazards and the ability to cope, adapt, and recover. Two aspects of vulnerability are socioeconomic vulnerability, reflecting the community's ability to respond to disasters, and biophysical vulnerability, identifying areas susceptible to specific hazards.

Coastal areas like Greenwich are highly vulnerable due to exposure to multiple hazards, including coastal inundation, hurricanes, and pollution. Content Gap is vulnerable to landslides and flash floods, with limited resources to cope with climate change risks.

Gordon Town, Woodford, Redlight, and Newcastle communities face complex topography and unregulated land use. Their resilience is strengthened by community organisations, but they are moderately vulnerable to climate change impacts, necessitating protective measures for ecosystems like unique forest lands.

Areas classified as highly vulnerable lack adequate infrastructure and services, requiring interventions to enhance resilience and reduce risks. Effective governance and urban planning are essential for climate change adaptation in all communities, and cities with limited capacity for comprehensive planning may be more vulnerable to climate change impacts.

ECOSYSTEM-BASED-ADAPTATION

Ecosystem-based adaptation (EbA) is a strategy that utilises ecosystem conservation, management, and restoration to enhance community resilience and adapt to climate change impacts. By leveraging the valuable services provided by ecosystems, such as coastal protection, water regulation, and food and income generation, EbA aims to reduce vulnerability and address climate change's effects on biodiversity, food security, and human welfare. Compared to traditional infrastructure-based approaches, investing in EbA measures can offer cost-effectiveness and sustainability (Secretariat of the Convention on Biological Diversity, 2016).

SOLUTIONS PROPOSED BY COMMUNITY MEMBERS DURING SURVEYS

In addition to EbAs, the survey participants from the lower, middle and upper reaches of the Hope River WMU provided a number of recommendations for protecting the watershed:

- As a priority, emphasis on sanitation and waste management (e.g., provision of skips), particularly more frequent and consistent garbage collection to prevent garbage from littering the communities and entering waterways and drains/gullies (this was a key proposal from all communities surveyed);

- Improving the drainage systems and conducting regular cleaning of drains and gullies to prevent flooding during heavy storm events;
- Special protection/status of riparian buffer zones along riverbanks to prevent the construction of houses and discourage squatting. Policies and enforcement of setbacks from the "100 year flood" water levels would protect houses, productive systems and infrastructure from future flood events;
- Adopting better land use and farming practices, such as zoning for specific purposes and promoting conservation;
- Encouraging community action and establishing partnerships to promote conservation, reforestation/afforestation;
- Education, training, and community outreach to enhance environmental practices and management in communities;
- Monitoring, enforcement, and regulations to safeguard ecosystems and impose penalties on polluters. Hiring rangers/wardens was put forth as an idea.

EbA for Lower Reaches of the Hope River watershed Greenwich Fishing Beach and Town

a. Clearing drainage ways and gullies
b. Mangrove restoration
c. Urban forestry
d. Vegetative buffer strips between GFB and Petrojam
e. Urban gardens
f. Green roofs
g. Rain harvesting
h. Replacing impervious surfaces with pervious surfaces
i. Outreach and capacity building

Proposed EbA for Middle and Upper Reaches of the Hope River watershed

a. Forest conservation - Forest Reserves and Crown Lands (declaring more protected or restricted areas)
b. Reforestation
c. Restoring riparian buffers
d. Agroecology
e. Agroforestry
f. Slope stabilisation – vegetation, vegetation and green infrastructure
g. Green infrastructure (gabion baskets, check dams)
h. Outreach and capacity building

2 INTRODUCTION

2.1 Background

The United Nations Environment Program (UNEP) is spearheading CityAdapt , an initiative consisting of multiple climate change adaptation projects targeted at cities in Latin America and the Caribbean. Climate adaptation refers to adjustments made to natural or human systems in response to actual or expected climatic changes or their effects. Climate adaptation strategies can be implemented at various scales, including local, regional, and national. Cities are particularly vulnerable to the impacts of climate change, such as sea level rise, heat waves, and extreme weather events, so many cities are implementing adaptation strategies to reduce their vulnerability and increase their resilience. These strategies can include building green infrastructure, ecosystem-based adaptation measures, enhancing emergency preparedness, and promoting sustainable land use planning.

The CityAdapt Project is being implemented in Kingston, Jamaica with the specific aim of reducing the vulnerability of urban and peri-urban communities to current and future effects of climate climate through Ecosystem-based Adaptation (EbA). In this context, vulnerability is defined as "the extent to which a system is able or unable to cope with the negative effects of climate change, including climate variability and extreme events. Vulnerability is a function of the character, magnitude, and rate of climate variation to which a system is exposed, its sensitivity and its adaptive capacity" (IPCC, 2007).

2.2 CityAdapt Pilot Study

A pilot study was conducted in Greenwich Town and in the Petersfield1 Forest Reserve in the Hope River Watershed Management Unit (Kingston, Jamaica). The baseline assessment examined changes in land use, urban / industrial sprawl, and associated concerns (e.g., floods, pollution/sewage and solid waste management). Proposed EbA interventions

---

[1] Henry, C. (2021, October 21). Kingston And St. Andrew to Benefit From CityAdapt Project. *Jamaica Information Service*. https://jis.gov.jm/kingston-and-st-andrew-to-benefit-from-cityadapt-project/

consisted of planting 1,400 trees to rehabilitate 2.3 hectares of land in lower income communities, planting 800 trees across communities (with 400 designated for schools in specific parishes), planting 3,000 drought-resistant trees in the forest reserves of the Hope River WMU, and rehabilitating two hectares of wetland in the Palisadoes Port Royal area. (**Figure 2-1**).

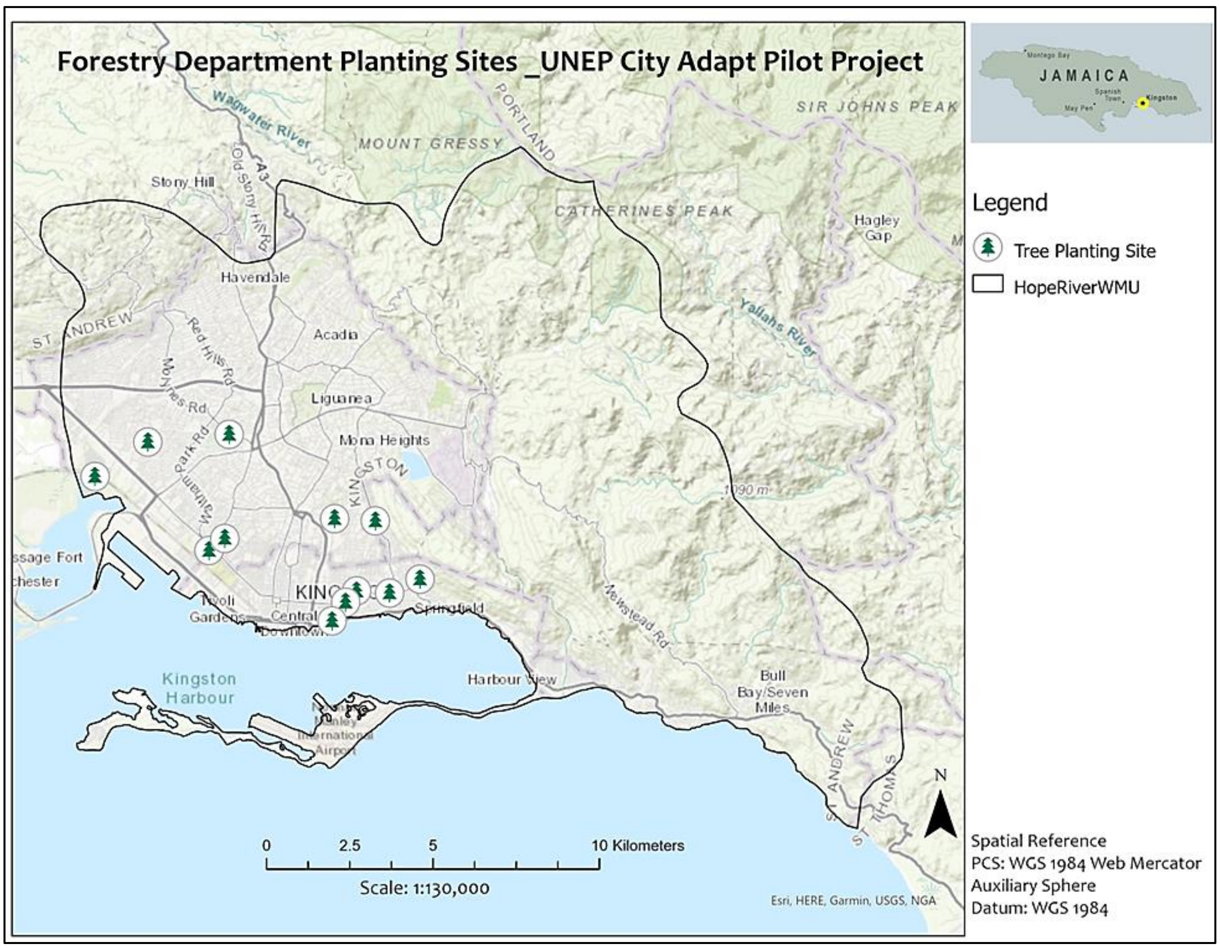


Figure 2-1. Select communities in the Hope River watershed Management Unit (WMU) where the vulnerability assessment was carried out for the current study. The map also indicates the location of sites where trees were planted as part of the CityAdapt *Pilot study.*

2.3 Hope River Watershed Study

The present study builds on the CityAdapt Pilot Study by expanding the risk assessment to other communities selected from the upper, middle and lower reaches of the Hope River Watershed Management Unit (WMU) (**Figure 2-2**). The chosen communities represent ecological (ecosystem/habitat), population, and risk gradients across the broader watershed management unit:

- Upper: Woodford, Newcastle, Redlight
- Middle: Gordon Town, Content Gap and Petersfield
- Lower: Greenwich Town Fishing Beach, Greenwich Town Community

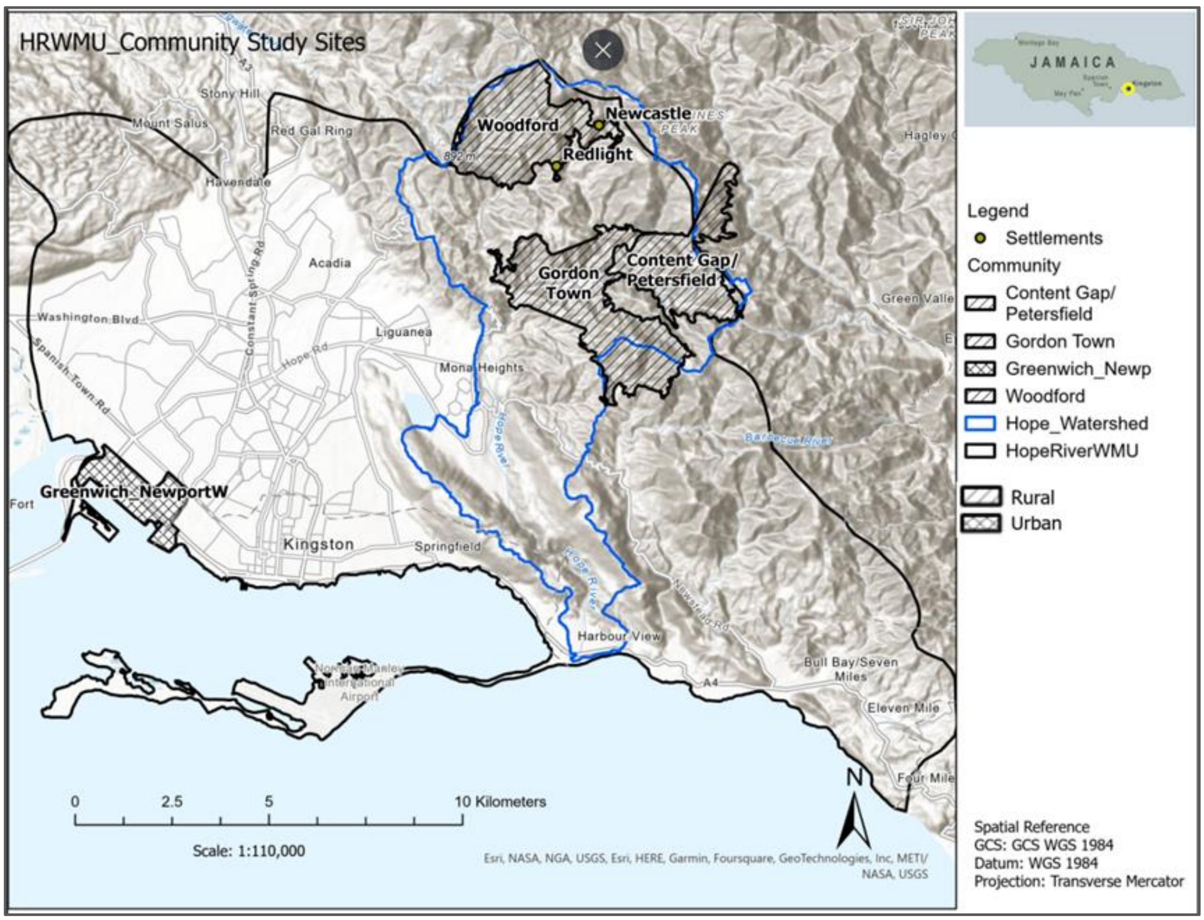


Figure 2-2. Community study sites in the Hope River Watershed Management Unit (WMU).

Field studies were conducted in the Hope River watershed to assess the physical environment, including hydrology and water quality. A Rapid Ecological Assessment (REA) was conducted to evaluate the ecological condition and health of the ecosystems in the study areas. The main objective of the REA assessment was to identify potential hazards and vulnerabilities threatening the ecosystems in the study area. The studies also examined the socio-environmental vulnerability of specific urban and rural communities within the Hope River WMU to the cumulative effects of weather-related events under future climate scenarios, with a focus on landslides, erosion, and flooding.

The Socio-economic Surveys carried out in the in the upper, middle and lower reaches of the Hope River WMU focused on determining:

- The perceptions of ecological conditions and the potential impacts of human (anthropogenic) and natural disturbances, including climate change, on ecosystems, ecosystem services, and environmental changes
- Local livelihoods and climate vulnerability
- Environmental governance
- Climate adaptation needs
- Identification of resource availability

The intended outcome of the surveys was to identify communities at greatest risk from climatic events, and to propose EbA measures that contribute to enhancing the resilience of these communities to future impacts of climate change through ecosystem restoration, conservation and sustainable use and development.

The project team worked with stakeholders from the government, the communities, non-governmental organisations (NGOs), the private sector, Conservancy (TNC) and the United Nations Environment Program (UNEP) (**Table 2-1**).

The aim of these interactions was to develop ecosystem-based adaptation (EbA) strategies, inform policy briefs and participate in a training workshop for capacity building at community and government partner levels. Proposed EbA measures and associated recommendations include solutions to improve the community's disaster management as well as increase investments in the protection of key ecosystems. The project identifies a selection of ecosystem-based adaptation solutions aimed at fostering sustainable development of the watershed by improving climate change resilience. The synthesis of the study findings will provide the basis for the overall mainstreaming of EbA and NbS measures as well as other projects addressing climate change adaptation.

Table 2-1: Stakeholder Groups

Stakeholder Group	**Acronym**
Church Groups	
Community Associations	
Forestry Department	FD
Human Employment and Resource Training Trust/National Service and Training Agency	HEART Trust/NSTA
Jamaica Constabulary Force	JCF
Jamaica Defense Force	JDF
Ministry of Local Government and Community Development	MLG
National Environment and Planning Agency	NEPA
National Solid Waste Management Authority	NSWMA
Land Information Council of Jamaica	LICJ
National Water Commission	NWC
National Works Agency	NWA
Planning Institute of Jamaica	PIOJ
Rural Agricultural Development Authority	RADA
Statistical Institute of Jamaica	STATIN
University of Technology	UTECH
Social Development Commission	SDC
4 H Club	4H
University of West Indies	UWI
Water Resources Authority	WRA

3 SCOPE

Assessments were carried out in select communities within the upper (Woodford, Newcastle, and Redlight) and middle (Gordon Town, Petersfield and Content Gap) regions of the HRW. Additionally, the assessment also included Greenwich Town, representative of the lower reaches of the greater Hope River WMU. The following activities were carried out:

i. Development of an inception report with a detailed methodology and work plan outlining the activities to be performed and a proposed timeline. This work plan was used to coordinate activities in the field, as well as activities and consultations with other experts and with TNC, including a workshop with the communities.

ii. Site selection with a focus on communities located within the broader boundaries of the Hope River WMU, taking into consideration the ecological characteristics, population, and risk gradients and vulnerabilities, from the upper, middle and lower reaches of the watershed.

iii. Field trips, expert interviews, and focus group discussions to gather and update (as applicable) the necessary information on habitats.

iv. Identification, location, and mapping of the major threats, vulnerabilities and pressures to the ecosystem and biodiversity by anthropogenic and natural phenomena (including climate change) within the selected communities.

v. The causes, sources, effects and impacts of these threats, vulnerabilities and pressures, as well as any related factors, were also identified and characterised (as applicable).

vi. A socio-economic survey (including a high-level gender analysis) to identify factors that will most likely affect the well-being of local communities, including population growth, planned economic activities, livelihood activities, urban development plans, disaster risk and land-use change.

vii. An analysis of climate trajectories at the city level and associated impacts on the urban communities located within the Hope Watershed, Kingston, Jamaica.

viii. An inventory of the socio-economic and natural resource data for the three target communities.

ix. An analysis to determine the best, middle and worst-case scenarios related to urban development, unplanned growth of the city, climate-related risks and resource availability under conditions of climate change.

x. Development of recommendations for protection, restoration, and conservation actions to increase the ecosystem services provided by the studied habitats and to abate threats, especially related to climate change adaptation, coastal protection, disaster risk reduction, and livelihood provision.

xi. An evaluation of the feasibility of different habitat restoration techniques to identify the most appropriate adaptation actions (within identified zones).

xii. Development of indicators and thresholds for triggering evaluation and adaptation actions so systems can be managed for ecosystem resilience.

xiii. Forecasts of future ecological health based on current management and an evaluation of alternative management options and their consequences (to improve community interactions with surrounding ecosystems).

xiv. Identification of 10 specific Ecosystem based Adaptation actions for Kingston, as well as solutions to promote socio-economic/behavioural changes, integrate hard or hybrid infrastructure, and foster change at the governance level.

xv. Development of this technical report which incorporates the items listed above.

xvi. Assisted TNC in the design of a workshop to present the results contained herein (REA and Socio-economic Analysis) to local experts and key community groups for review and feedback.

xvii. Collaborated with the Policy Strategist, Training Strategist, and Upscaling Strategist to review all developed products and participate in the workshop associated with those deliverables.

4 LITERATURE AND DATA REVIEW

The study was conducted through a mixed method approach that included literature review of existing data and technical reports, stakeholder consultation, field work, and data analysis. A detailed description of each study component is provided in the following sections.

A literature review of existing studies and historical data from relevant ministries, departments, and agencies was undertaken to summarise the study area's existing knowledge and identify any data gaps and additional research questions that would need to be addressed in the scope of the current study. The literature review also included a review of available historic/other data for documented changes in the spatial extent, health, condition, composition, and threats to the biological resources of the Hope River watershed.

These included:

- Reports and relevant data were sourced from various government agencies including:
- the Water Resources Authority (WRA)
- Office of Disaster Preparedness and Emergency Management (ODPEM)
- Rural Agricultural Development Authority (RADA)
- Forestry Department (FD)
- National Environment and Planning Agency (NEPA)
- Ministry of Local Government and Community Development
- Statistical Institute of Jamaica (STATIN)
- National Spatial Data Management and Services
- Integrated Management of the Yallahs and Hope River Watershed Management Areas Project
- University of West Indies (UWI), and others.

Recent studies on climate change and climate variability for Jamaica and the Caribbean region were reviewed to provide context for the analyses (discussed in Section 2) and provide information specific to the WMU. Documents included in the review are the Near-Term Climate Scenarios for Jamaica (CSGM 2014), the 2015 State of the Jamaican Climate Report (CSGM 2017), the State of the Caribbean Climate (CSGM 2020), the State of the Jamaican Climate Volume III (CSGM 2022), the Working Group I contribution to the Intergovernmental Panel on Climate Change (IPCC) Sixth Assessment Report (IPCC 2021) and the IPCC's Special Report on Global Warming of 1.5 Degrees (IPCC 2018).

The available data that were referenced for the hazards study are listed below:

- Satellite imagery of site taken from Google Earth, dated October 2022.
- 1: 50,000 Series Geological Sheet 13 & 18 (Metric Series) 1984, revised 2008
- WRA Geospatial Data
- The Effects of Land Use Practices on Water Quality and Quantity in the Hope River watershed, M.Sc. thesis, UWI, 1995
- An assessment of the impact of 1.5 versus 2 and 2.5°C global temperature increase on flooding in Jamaica, Mandal et.al, August 2021
- Simulations of hydrological extremes in Jamaica – Case Studies of Hope, Yallahs and Outram River Watersheds, Mandal et.al., undated
- Rainfall-runoff simulations using the CARWIG Simple Model for Advection of Storms and Hurricanes and HEC-HMS: Implications for Hurricane Ivan over Jamaica Hope River watershed, Mandal et al, 2016
- Caribbean Natural Disaster Archives

All natural hazards known to affect the study area, such as those associated with extreme rainfall, geology, and drainage/flooding which can affect critical facilities were reviewed within the upper, middle and lower watershed boundaries. Historically compiled hazard details were largely available only at the national and parish level which left gaps in understanding of specific local contexts for hazards. These gaps were partially filled through stakeholder consultation (see following section).

5 PHYSICAL ENVIRONMENT

5.1 Field Surveys

The field survey instrument was designed based on the existing literature and data review and stakeholder consultation to address data gaps and assess community perception regarding watershed management and risk assessment vulnerability. Collection of primary and secondary baseline data on natural habitats involved determining the spatial extent, biodiversity and threats (sources and attributing factors), and identifying relevant biodiversity indicators. For natural hazards, the field surveys focused on three main and recurrent geohazards: landslides/rock falls, extreme precipitation/flooding and earthquakes.

5.2 Hydrology - Surface and Groundwater Resources

A detailed description of the physical environment, based on site reconnaissance, collection of primary data and a desktop literature review, was developed with particular emphasis on hydrology/hydrogeology/geomorphology and geohazards, considering both the boundaries of the Hope River Watershed and adjacent/neighbouring areas that may contribute to pressures exerted on the watershed and the environmental services it provides. This included review of historical hydrological data from WRA and geological hazards assessments from published sources. The assessment investigated environmental impacts inclusive of cumulative impacts, analysis of spatial and temporal hydrology of the Hope River, and hazard duration within hydrological systems which may impact systems with limited water resources. Specifically, this part of the study covers the physical and hydrological aspects of the settlements located within the upper (Woodford, Newcastle, Redlight), middle (Gordon Town, Petersfield, Content Gap) and lower (Greenwich Town) reaches of the Hope River WMU and includes:

- A definition of the study area based on a desktop review of available topography maps, aerial photographs, and limited field reconnaissance along open and traversable roadways.

- Baseline data collection on the study area (hydrology, geology, hydrogeology, earthquakes, flooding, etc.) and review of existing reports and other information relevant to the study area.
- Review of the collected data to determine the physical pressures that may contribute to the pressures on the watershed when combined with human activities such as:
  - Geological and hydrological drivers that exacerbate environmental degradation within the upper, middle and lower watershed.
  - Known hazards within the upper, middle and lower watershed.
- Identification of potential environmental impacts relating to flooding, seismicity and heavy precipitation within the three sections of the watershed.

5.2.1 Surface Water Resources

The main named surface watercourse is the Hope River, which runs through the centre of the watershed catchment. The main channel is wide and flat with steep-sided banks and some terraces at the seaward end. The watershed is adjacent to the Kingston Metropolitan Area and lies along the southern slopes of the Blue Mountains. There are several tributaries to the Hope River watershed in the upper and middle reaches of the watershed catchment. These include, but are not limited to, the Flora River, Hog Hole River, Mammee River and Salt River. In the lower catchment immediately adjacent to Greenwich Town, there is the Shoemaker Gully. Several other gullies drain the lower reaches of the watershed within the alluvial plains. Most of these discharge to the Kingston Harbour.

The WRA stream flow data at the Gordon Town stream gauge station recorded a maximum flow of 99.3 m^3/sec in September 2004 and a minimum flow of 0.05 m^3/sec in December 2020. Catchment modeling research, however, has shown modeled flows of 1,035 m^3/sec in the vicinity of the Harbour View Community for extreme rainfall events (Mandal et al 2016).

Figure 5-1 outlines the drainage characteristics and the 100-yr return flood areas of the Hope River plains of Kingston. Climate change modeling suggests that there is likely to be an increase in rainfall under a 1.5°C scenario and a decrease at 2.0°C. Flood risk modeling projected that discharges from the Hope River were higher when compared to the historical record. Suggesting that these increased modeled flows may result in increased damage to the sections of the watershed compared to the historical levels due to increased flow area, flood depth and extent[2].

The 30-yr mean annual (1971-2000) rainfall for Kingston and St Andrew published by the Meteorological Office is reported at 1,447mm with the two highest averages occurring in September (206mm) and October (241mm). Consequently, precipitation and peak runoff within the HRW occur in a bimodal distribution.

Piped water is supplied by the National Water Commission for sanitary services across the Hope River WMU. It is likely that, in some remote communities in the upper and middle catchment, water is retrieved from the tributaries of the Hope River to meet every day needs if piped water is unavailable.

[2]An assessment of the impact of 1.5 versus 2 and 2.5°C global temperature increase on flooding in Jamaica: a case study for the Hope Watershed, Mandal *et. al*., 2021

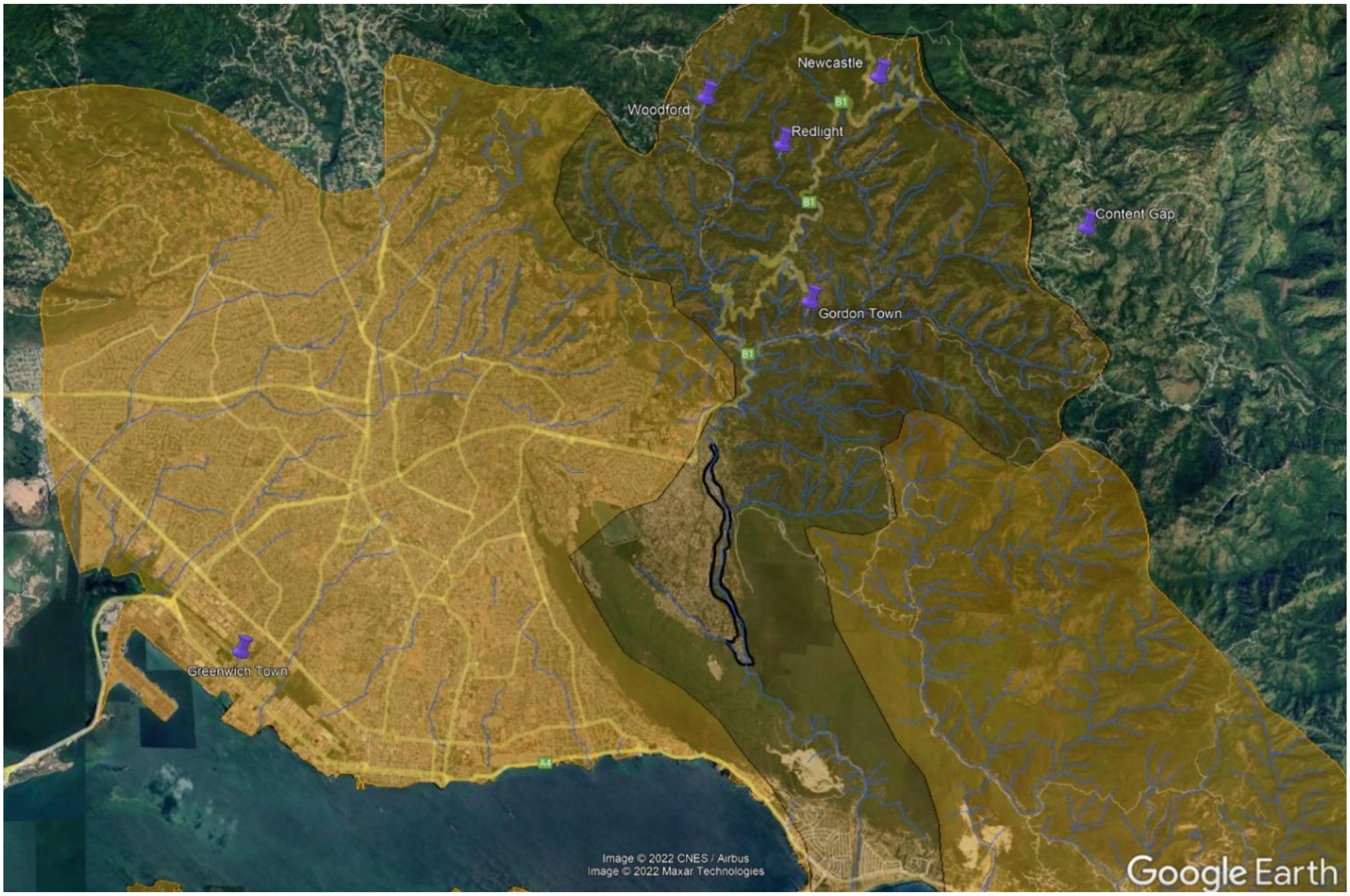


Figure 5-1: Drainage (blue polylines) within the Hope River watershed (black polygon) and alluvial plains to the West. HRW 100yr return flood (thick black polyline). The Yallahs River catchment is shown to the East

5.2.2 Groundwater Resources

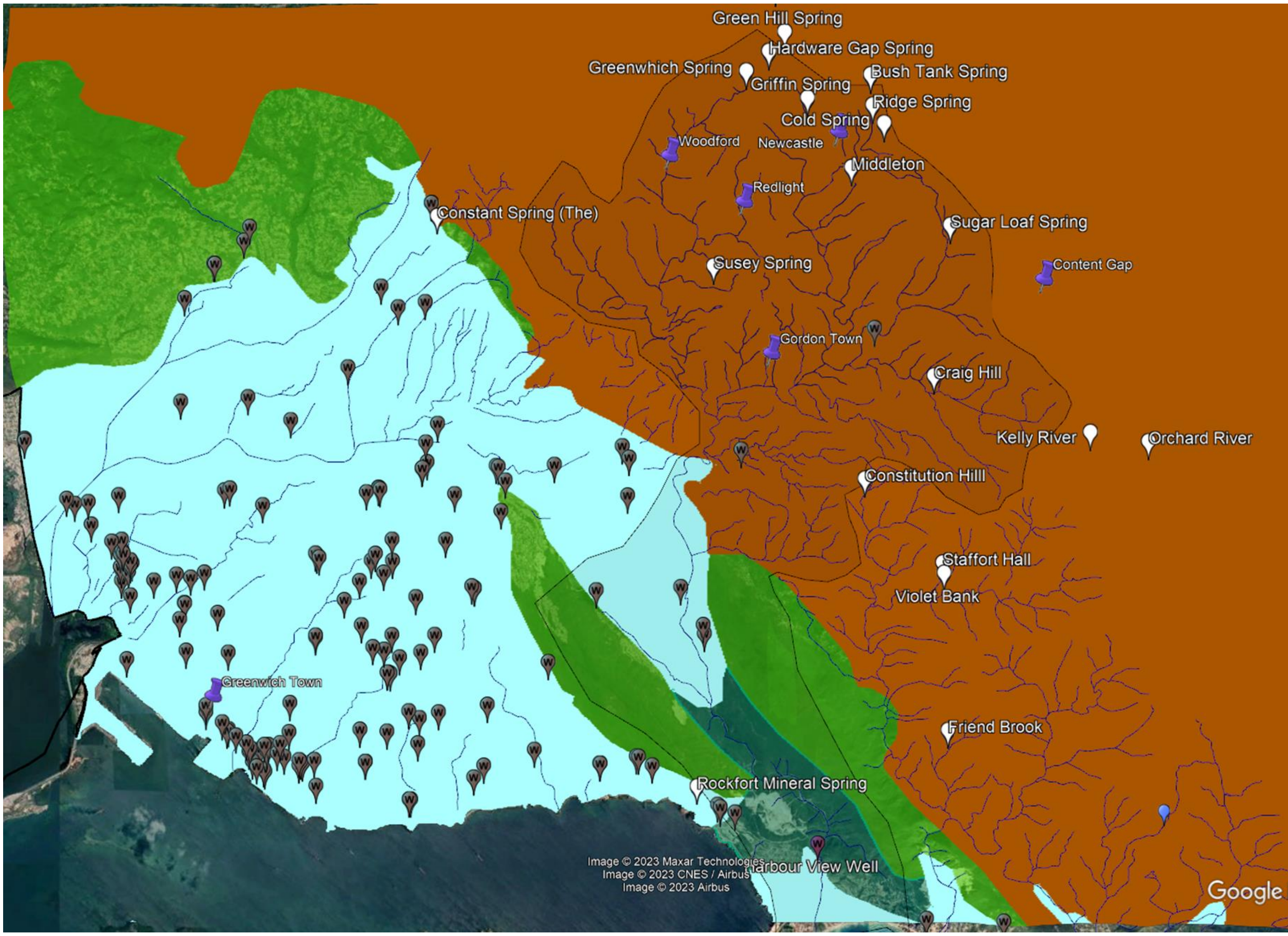


Figure 5-2 shows the hydrogeological classification of the subsurface geology within the Hope River watershed. The hydrogeological units within the catchment are broadly separated into two categories noted below:

- **Aquicludes**: These define the upper, middle and lower reaches of the HRW. The upper reaches are defined by basal aquiclude due to the volcanics of the Wagwater Group. While nestled between the Long and Dallas Mountains are the coastal aquiclude which comprise non-porous limestone.

- **Aquifers**: Aquifers are underground saturated geologic formations that yield usable groundwater. Alluvium aquifers define the majority of the catchment beneath Greenwich Town; while limestone aquifers lie beneath the Long and Dallas

Mountains only. Two groundwater springs (Craig Hill and St. Georges) are noted within the middle reaches of the catchment and these are usually due to thick overburden of weathered soils and near daily precipitation in the high elevations. They are physically disconnected from the larger alluvial aquifer to the west. These springs, along with other unnamed springs, can be intermittent and may cease during periods of extended low rainfall/drought. Similar unnamed springs are located within the upper and middle reaches of the catchment and are sources for some communities that lack piped water.

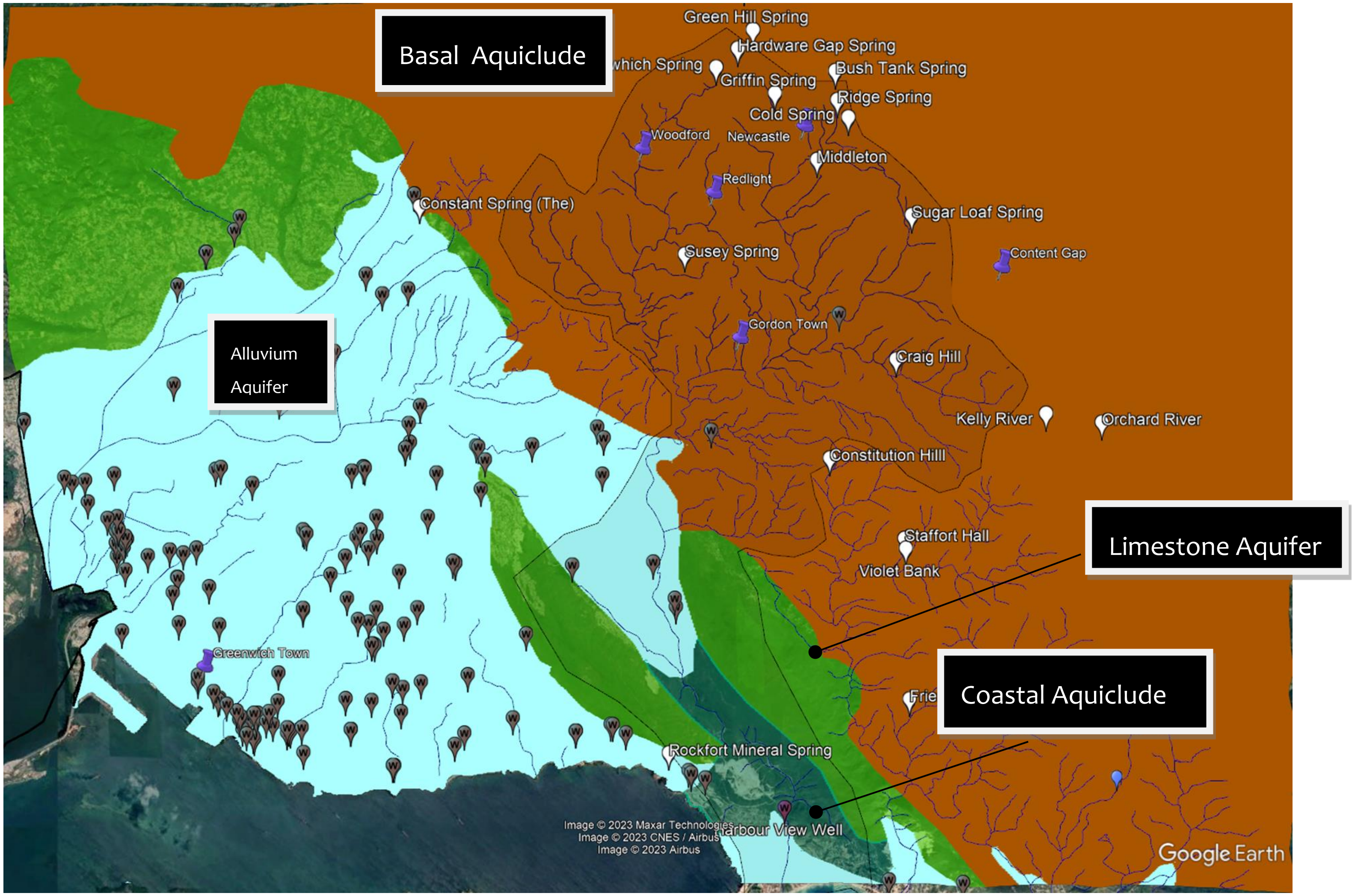


Figure 5-2: Hydro stratigraphy within the Hope River watershed. The light blue teardrops are groundwater and spring water abstraction locations within the Hope River watershed.

5.3 Geology and Soils

Published geological information (Geological Sheets 13 & 18, 1:50,000 Metric Series), extract shown in

Figure 5-3, indicates that the upper and middle settlements of the watershed are underlain by the Cretaceous aged volcaniclastics of the Wagwater Group. The upper and middle areas of the watershed are volcanic based sedimentary deposits, with some igneous intrusions derived from the older Wagwater Belt Graben, which received large volumes of sediment in the geologic past. The dominant Wagwater Group comprises conglomerates, sandstones and mudstones, while the Newcastle Volcanics comprise volcanic tuffs and lavas and are interbedded with Richmond shale beds. The lower settlements are underlain by more recent Alluvium deposits. While the lower alluvial material is derived largely from the hilly, volcaniclastic hinterland and comprises coarse and ill-sorted, brown to grey alluvial deposits, with finer grades and numerous boulders at depth.

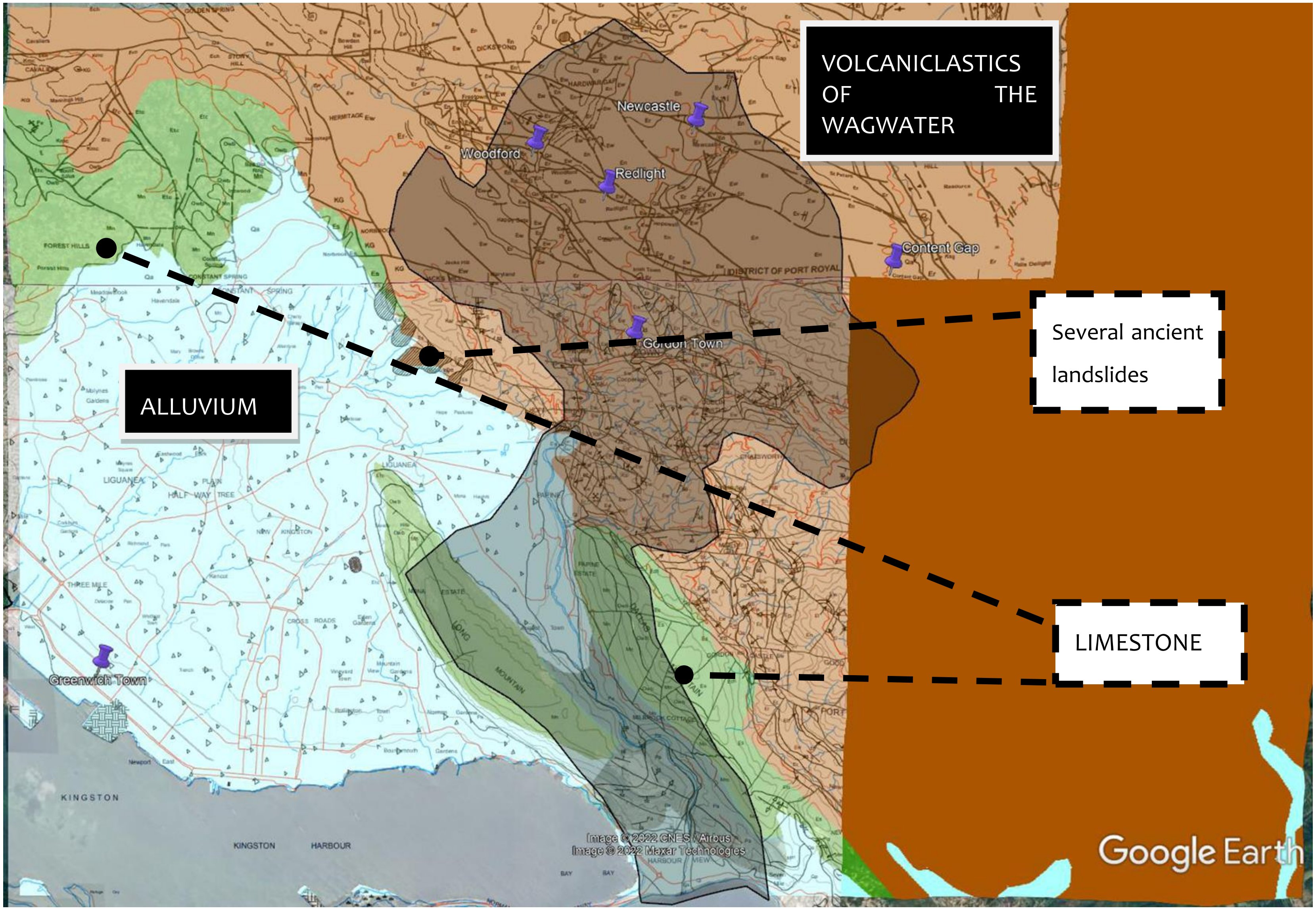


Figure 5-3: Excerpt Section of geological map Sheet 13 (top) & 18 (bottom) showing the settlement pushpins. The upper and middle segments of the watershed comprise volcaniclastics of the Cretaceous Wagwater Group and the low comprise recent Alluvium. Montpelier Limestone

Structurally, the watershed is littered with numerous faults and fractures indicating that the watershed resides in a very tectonically active zone. The slope stability of the upper and middle watershed is described as poor, particularly if the geological material contains discontinuities such as fractures and faults. Weathering of the basal geology also increases the slope stability risk. Where slopes have no weathered soil cover, these usually indicate zones of repeated soil slippages. Rotational landslides, debris flows and rock falls are common in such areas of the watershed and depend on slope, weathered soil depth, fracturing/faulting, soil moisture content and severity of precipitation.

The surficial soils are described as ranging from gravelly, sandy loams to clays in the upper and middle reaches of the watershed. These soils occur on steep slopes and are described as very "erodible". Internal drainage is described as "rapid" and is largely due to the high percentage of coarse sand within the soil profile. These soils are known to be moderately fertile soils which encourage subsistence farming on the slopes of the Hope River watershed.

The soils of the lower watershed are soils that vary in texture from sands and loams to clayey loams and are generally the most fertile soils in Jamaica. They are deep soils with good to rapid internal drainage and poor surface runoff.

Soils within the Hope River watershed are classified under the USDA Hydrologic Soil Group as "A", "C" and "D" soils (

Table 5-1) which are characterised as having high rainfall runoff potential (**Figure 5-4 (a**)).

Table 5-1: Criteria for assignment of hydrologic soil groups when a waster impermeable layer exits at a depth between 50 and 100 centimeters (20 and 40 inches)

Criteria for assignment of hydrologic soil groups when a water impermeable layer exists at a depth between 50 and 100 centimeters [20 and 40 inches]

Soil property	Hydrologic soil group A	Hydrologic soil group B	Hydrologic soil group C	Hydrologic soil group D
Saturated hydraulic conductivity of the least transmissive layer	>40.0 μm/s (>5.67 in/h)	≤40.0 to >10.0 μm/s (≤5.67 to >1.42 in/h)	≤10.0 to >1.0 μm/s (≤1.42 to >0.14 in/h)	≤1.0 μm/s (≤0.14 in/h)
	and	and	and	and/or
Depth to water impermeable layer	50 to 100 cm [20 to 40 in]	50 to 100 cm [20 to 40 in]	50 to 100 cm [20 to 40 in]	<50 cm [<20 in]
	and	and	and	and/or
Depth to high water table	60 to 100 cm [24 to 40 in]	60 to 100 cm [24 to 40 in]	60 to 100 cm [24 to 40 in]	<60 cm [<24 in]

The land use (**Figure 5-4(b)**) indicate that the watershed is moderately degraded in the middle and lower reaches with significant buildings and urban areas being located within it.

The upper reaches of the watershed are primarily composed of disturbed secondary forests and fields.

Due to high soil fertility, natural vegetative cover loss due to improper agricultural practices (such as "slash and burn" practices, felling and removal of native trees, farming on very steep slopes etc.) have led to accelerated soil erosion in the upper and middle regions that ultimately are reflected in a higher runoff coefficient. This results in larger flooding events during the rainy season and less retained water during the dry season.

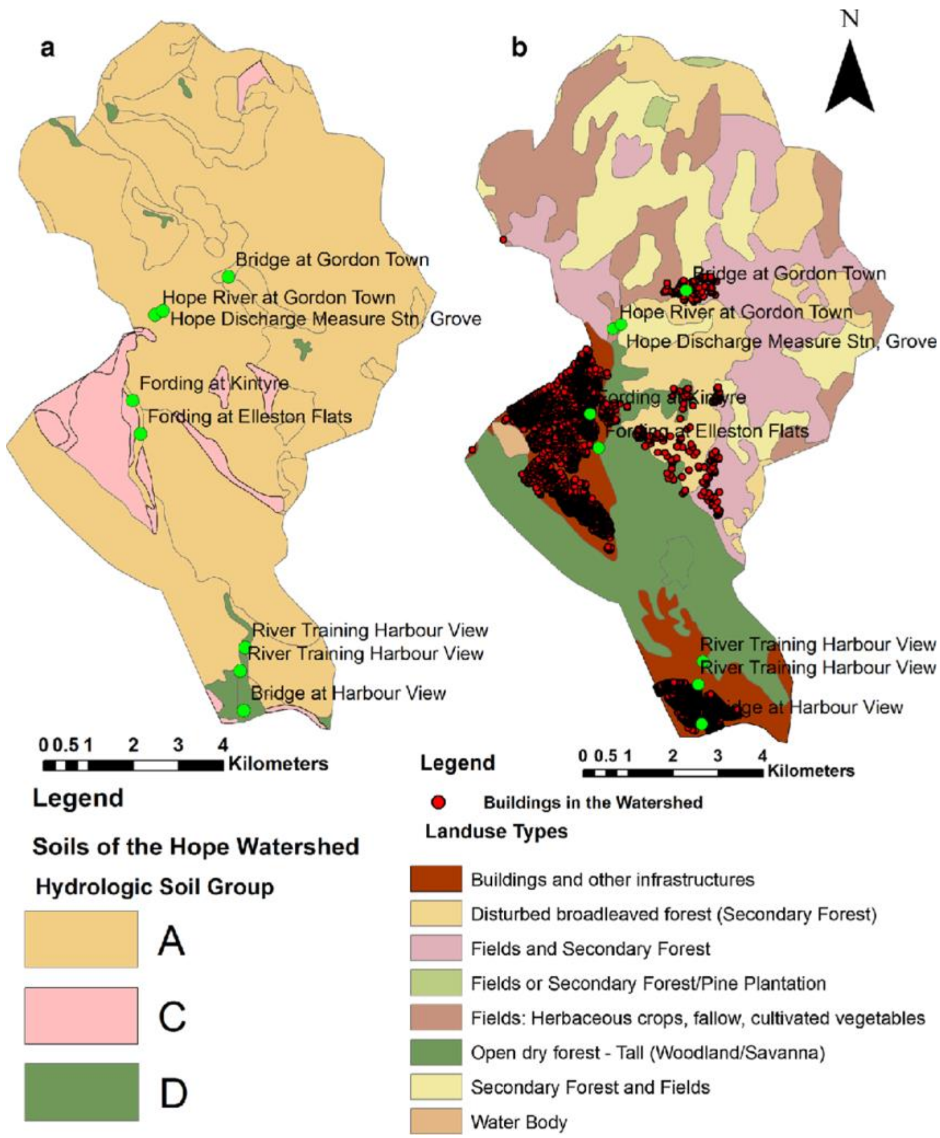


Figure 5-4 (a) & (b): Hydrologic soil grouping and land use of the Hope River watershed (reproduced from Mandal et. al., 2016)

5.4 Flooding Hydrology

The Hope River watershed is located in the most mountainous region of Jamaica, which experiences recurrent and intense rainfall events due to its elevation and the Blue Mountain's position within a hurricane belt.

Flooding within the watershed is an annual occurrence and occurs more frequently during the two known rainy seasons and the hurricane season. Historically, hurricanes such as hurricane Gilbert in 1988 triggered numerous landslides and eventual debris flows within the

HRW. The evidence suggests that in addition to underlying geology and natural events, these unprecedented landslides were exacerbated by the extensive land use changes and extensive deforestation on the steeper slopes of the watershed. The upper and middle reaches of the watershed are known for flash floods which are commonly coupled with landslides and debris flows. As outlined above, thresholds for landslides induced by the intensity of rainfall have been determined and policymakers should consider undertaking localised hazard mapping that incorporates these thresholds within the risk mapping process.

Human exposure to both geological and hydrological hazards are known to result in substantial losses which are likely to increase as climate change triggers increased, short duration intense rainfall events within a denuded watershed environment.

As the watershed is exposed to a number of significant hazards, most on an annual basis, there is need for continuous and widespread public awareness about the disaster risk potential of locating communities in zones that are cited on steep slopes and in close proximity to geologically active faults. It will be incumbent on local planners to ensure that community planning is based on scientific evidence that is appropriately translated into easy-to-understand action plans that can be easily adhered to by the communities.

Climate change adaptation will also need to be incorporated, as this emerging issue has no precedence and persons' recent experiences may not make them well suited for the more intense hazards that will accompany climate change. The municipal council will need to consider early warning initiatives along with public education on an annual basis with local communities. Additionally, further public awareness of climate change linkages with ecosystem services and their management will also need to be developed and promoted annually in order to reduce economic and societal loss over the long-term.

5.5 Water Quality

A baseline water quality assessment in the study area included a control site in the upper watershed. The sites were georeferenced and spatial comparison of the data done to assess impact of human activities. Five sites were selected in the upper and middle reaches of the HRW (**Figure 5-5**).

Of particular interest was the impact of agriculture, waste disposal and deforestation. Accordingly, focus was on the following water quality indicators:

- Dissolved oxygen – indicator of organic pollutants
- Turbidity – indicator of erosion
- Temperature – a main indicator of climate change
- pH – control is essential to aquatic organisms
- Faecal Coliform – indicator of sewage pollution/mammalian waste
- Nitrate - indicator of sewage/mammalian pollution
- Phosphates - indicator of pollution from agriculture
- BOD – indicator of sewage/organic pollution
- Total suspended solids – indicator of erosion

Results from the water quality sampling were compared to local and international water quality standards and informed the REA. Water quality methods are summarised in **Table 5-2**.

Table 5-2. Summary of Water Quality Methods

Parameter	Method
Field/In situ Analysis	
Dissolved Oxygen	YSI Model 86 S-C-T-DO meter
Turbidity	Horiba Model U-10 Water Quality Checker
Temperature	YSI Model 86 S-C-T-DO meter
pH	Oakton pH Testr10 Meter - Glass Electrode
Lab Analysis	
Faecal Coliform	Standard Method No 9222 D. Fecal Coliform Membrane Filter Procedure
Nitrates	Colourimetric Automated Cadmium Reduction Hach Method No. 353.2
Ortho-phosphate	Colourimetric Ascorbic Acid Method HACH Method No. 365.1
TSS	Standard Method No. 2540 D Total Suspended Solids Dried at 103-105°C
BOD	Standard Method No. 5210 B. 5-Day BOD test

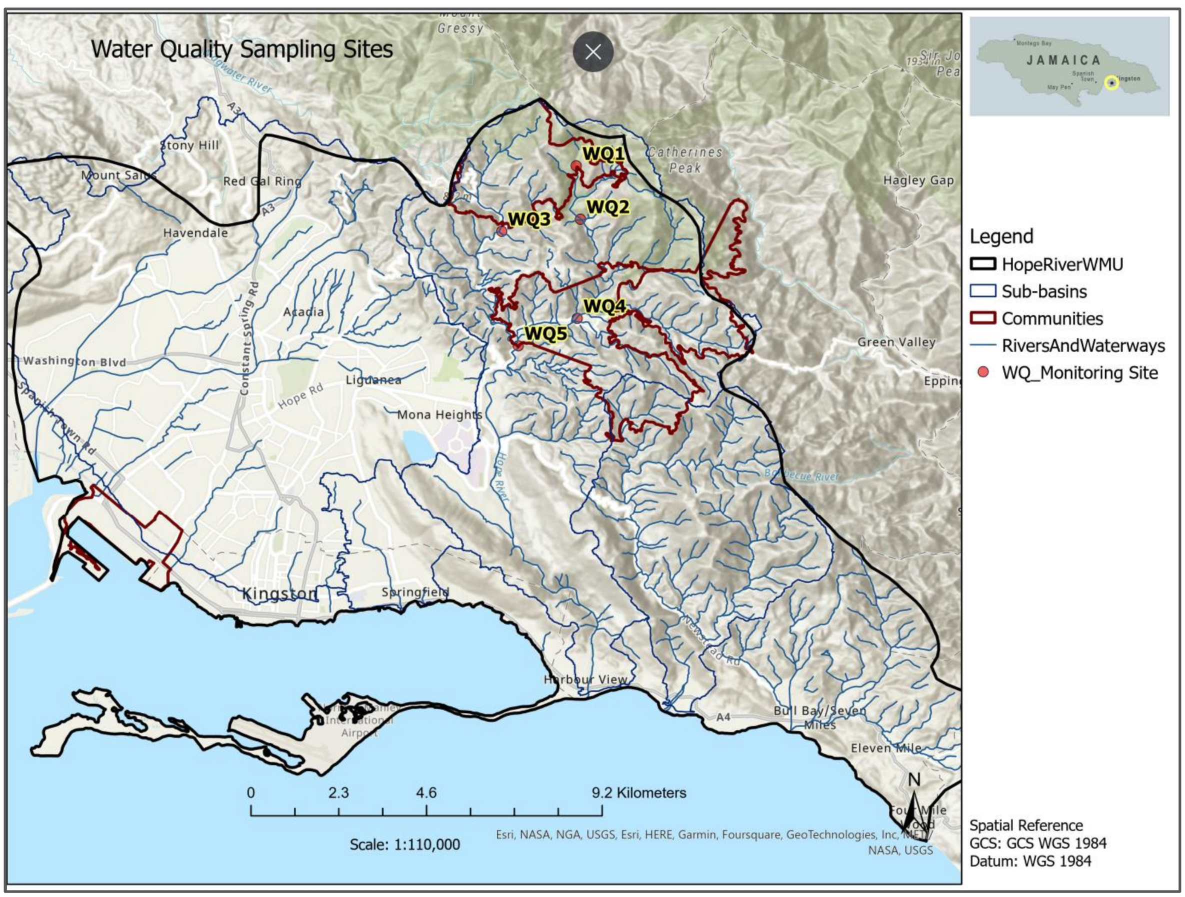


Figure 5-5: Hope River watershed - Water Quality Sampling Sites

There is a paucity of information regarding water quality on the Hope River. Hayman (2000) established a relation between land use Practices on Water Quality and Quantity in the Hope River and makes a case for improved management of the watershed to address the impact of these land use changes on water resources. These land use changes include agriculture expansion, settlements, and deforestation.

It is worth noting that while sections of the parishes of Kingston and St. Andrew are served by a central sewage treatment system the primary method of sewage disposal in the Hope Watershed remains the use of hand-dug soak-away pits which carry a risk of contamination of ground and surface water by high fecal coliform and nitrogen levels. In 2000, faecal coliform was determined to exceed the maximum allowable limits with the highest levels occurring during the high flow periods. Nitrate showed a trend that increased fourfold between 1989 and 2000 (Hayman, 2000).

The Hope River is the main source of water for the Mona Reservoir that serves Kingston. The National Water Commission has a big stake in the effective management of the watershed and have stated that:

> "The state of the watershed is very important in ensuring that there is good quantity and quality water available for our use. The watershed not only has serious implications for water supply services and water supply costs, but also affects a wide range of environment and health related issues" (NWC, 2015)

https://www.nwcjamaica.com/publication.phpPublished 2015.

5.5.1 Water Quality Monitoring Results

Results of Monitoring Exercise - Water quality data from the sampling exercise carried out on October 5 is presented in **Table 5-3**. Sampling commenced at 7:32 and ended at 12:15 hours. Laboratory Analysis Certificate is presented in **Appendix 2**. The weather during field sampling was fair and sunny. The flow at all sites was brisk and indicative of wet conditions. Depths at the sampling sites were between 0.5m and 1m.

Table 5-3: Water Quality Data, Hope River Watershed – October 5, 2022

Sample ID	Coordinates (DD)		Description	Elevation (/10^2m)	Time	Depth (m)	COND (µs/cm)	Turb (NTU)	TSS	TEMP (°C)	pH	DO (mg/L)	DO sat	%Sat	NO_3 (mg/l)	o-PO_4 (mg/l)	BOD (mg/l)	FC (MPN)/ 10 x 10^{-1}
	N	W																
HRW1	18.07163	-76.71845	Tank Near Newcastle ("Griffin")	8.9	732-742	1.0	162.0	1.4	<2.5	18.8	7.5	8.4	6.9	122	<.9	0.18	0.90	5
HRW2	18.05907	-76.71746	Fording at Red Light - Hope River Tributary (Upland)	6.48	817-828	1.0	274.0	1.1	<2.5	20.3	7.6	8.2	7.0	117	22	0.14	1.05	24
HRW3	18.05622	-76.73597	Maryland Bridge (Mammee River)	5.05	955-1023	0.5	400.0	5	<2.5	21.9	7.5	7.8	7.2	108	3.74	0.14	0.46	35
HRW4	18.03576	-76.71821	Hope River Gordon Town River (Bridge)	3.62	1058-1130	0.5	-	3	<2.5	23.6	7.5	8.4	7.3	115	3.64	0.14	0.51	24
HRW5	18.02931	-76.73209	Just Upstream Grove Bridge/Aqueduct take off	2.56	1138-1215	1.0	500.0	10	<2.5	25.1	7.9	8.1	7.4	110	4.4	0.19	0.25	54
STD/REF							150-600[1]	30[2]		29.4[3]	7.0-8.4(1	4.0[4]			0.1-7.5[1]	0.01 - 0.8[1]	0.8-1.7[1]	<126[3]

(1) – NRCA Draft Jamaica National Ambient Water Quality Standard – Freshwater, 2009.

(2) – Florida Surface Water Quality Standards Florida Dept. of Env. Protection 62-302.530, February 17, 2016.

(3) – USEPA Temperature, Water Quality Standards Criteria Summaries: A compilation of State/Federal Criteria, September 1988

(4) – USEPA Quality Criteria for Water, May 1, 1986

Conductivity levels were in the range 162µS and 500µS. Conductivity was lowest at the HRW1 (upper watershed background site – **Figure 5-6**) and increasing progressively to the site at the lowest elevation WQ5 (Just upstream of where the aqueduct begins. These levels were within the NEPA freshwater standard of 150µs/cm to 600150µs/cm.

Figure 5-6: Background Site HRW1 – Upper Watershed

Turbidity levels were in the range 2 – 10 NTU for all sites (**Figure 5-7**). Turbidity increased progressively from the upper to the lower watershed, At WQ1 (background site in the upper watershed) turbidity was 2 NTU. At the Red Light Fording (WQ2) turbidity was 4NTU while at

WQ3T (Mammee River/Bridge at Maryland), turbidity was 5 NTU. At WQ3T (Gordon Town River at Gordon Town Bridge) turbidity was 3 NTU. Turbidity was highest at WQ5 (Grove just upstream of where the aqueduct begins).

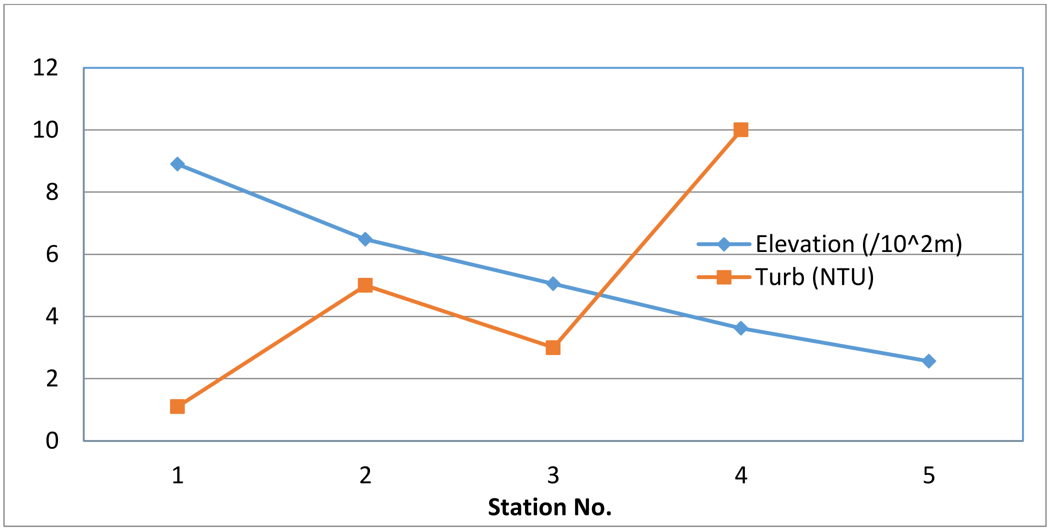


Figure 5-7: Hope River Watershed October 5, 2022, Elevation Vs. Turbidity

Water temperature was in the range 18.8oC to 25.1°C. The lowest temperature was recorded for the background site in the upper watershed (WQ1), with values increasing progressively with decreasing elevation to WQ5 where the highest temperature was recorded (**Figure 5-8**). These levels were within the Florida standard for fresh water.

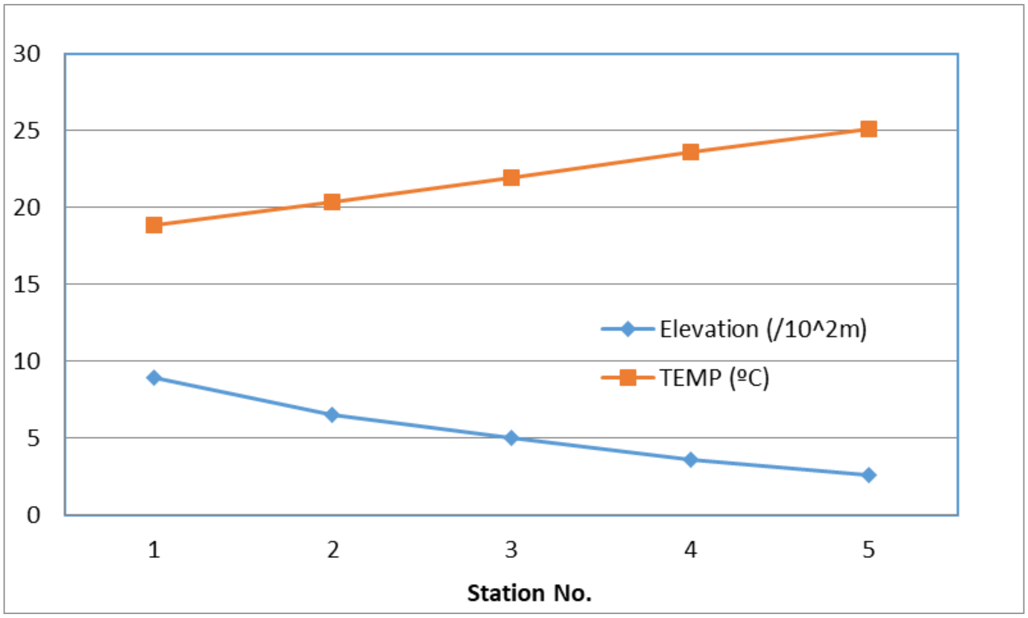


Figure 5-8: Hope River watershed October 5, 2022, Elevation Vs. Water Temperature

pH was in the range 7.5 to 7.9 for all sites. The lowest value was determined at the background site (WQ1) while the highest level was determined for WQ5 (site in the lower watershed). These levels are within the NEPA standard for fresh water.

Dissolved oxygen levels were in the range 7.8mg/l to 8.4mg/l. mg/l for all sites (**Figure 5-9**). The lowest reading was determined for the Mammee River at the Maryland Bridge where DO was 7.8mg/l. The highest level was determined at WQ1 and WQ4 (background site and Gordon Town Bridge respectively). At Red Light (WQ2) DO was 8.2mg/l, while at WQ5 (lower watershed) DO was 8.1mg/l. All levels indicated a saturation level of >100% and were better than the USEPA standard of 4.0mg/l for fresh water (Figure 5-8).

This is not surprising as the water flow was brisk at all sites, and the steep terrain over the generally rocky riverbed would favour oxygenation.

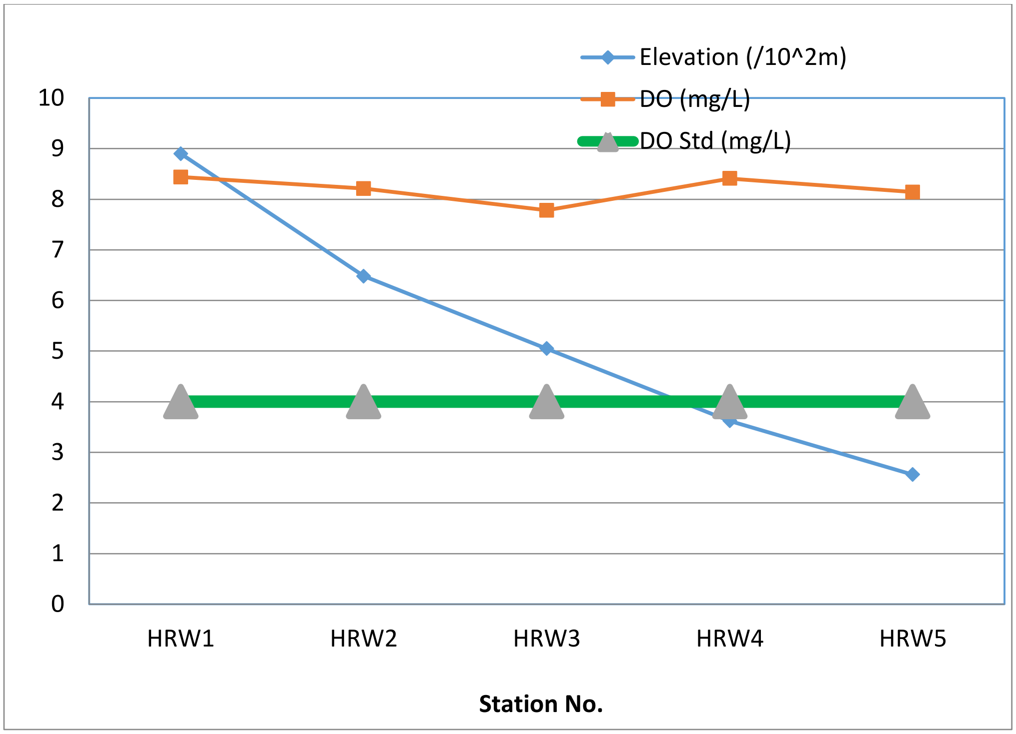


Figure 5-9: Hope River watershed October 5, 2022, Elevation Vs Dissolved Oxygen

Biological oxygen demand (BOD) was low at all sites being in the range 0.25mg/l to 1.05mg/l. These levels were within the NEPA interim standard for fresh water.

Nitrate levels were in the range <0.9mg/l to 22mg/l. The lowest reading was determined for the sample taken at HRW1 (background site upper watershed near New Castle) while the highest level was determined for the sample taken at HRW2 (Red Light). At all other sites in the mid and lower watershed, nitrate levels were in the relatively narrow range 3.74mg/l to 4.4mg/l. Though these levels are within the standard, they show a trend of increasing downstream of the background site as much as 20-fold at HRW2 (Red Light) (**Figure 5-10**).

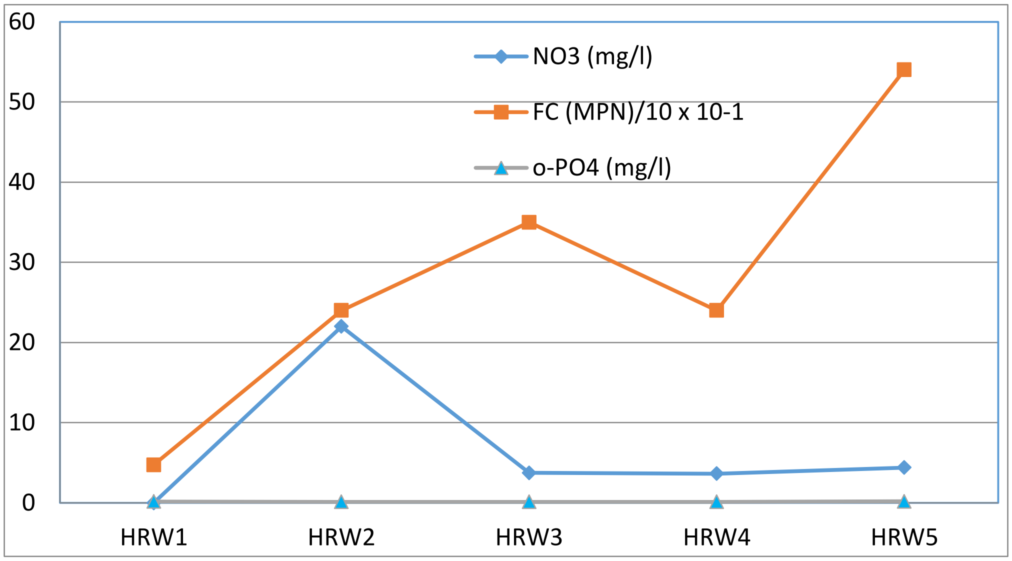


Figure 5-10: Hope River watershed October 5, 2022, Nitrate (NO_3), Faecal Coliform (FC), o-Phosphate o-PO_4)

Reactive phosphate (o-PO_4^{-}) levels were in the narrow range 0.14mg/l to .19mg/l for all sites (**Figure 5-10**). At the background site (HRW1) o-phosphate was 0.18mg/l while at HRW 2, HRW3 and HRW4, o-phosphate was 0.14mg/l. o-Phosphate was highest (0.19mg/l) at HRW5 (just upstream of where the aqueduct begins).

Faecal coliform levels were in the range 50MPN to 540MPN. Faecal coliform progressively increased from the upper to the lower watershed with the lowest level determined for the sample taken from the upper watershed site (HRW1) and the highest at HRW5 just upstream of where the aqueduct begins.

5.5.2 Discussion and Conclusions

Though the high dissolved oxygen suggests good water quality, at the time of sampling the elevated nitrate and faecal coliform downstream of the background site indicates a significant impact from faecal matter. This is consistent with the absence of central sewerage and thus the reliance of residents on soak-away sewage disposal systems. There is the possibility that the high DO levels area maintained at this time because of the relatively high flow conditions and could be lowered during low flow conditions when the faecal load would likely remain constant or even increase with a much reduced flow. This is of particular significance as the Hope River is a main source of water to the Mona Reservoir.

The low turbidity and total suspended solids similarly are indicative of no flood conditions occurring at the time of sampling. This watershed is known to be affected by soil erosion that leads to loss of property and disruption in communications. Considerable sums are spent doing remedial work to respond to events. Erosion is a constant threat to the functioning of the ecosystem and livelihoods (**Figure 5-11**).

Figure 5-11: Erosion near Irish Town (18.04532N -76.72725W)

Apart from the threat to property and livelihood, instances like these also contribute to sediment load in the Hope River, rendering the water unusable by the National Water Commission for public supply. This is one of the main reasons given by the NWC for disruption of public water supply/water lock offs during period of heavy rains (**Figure 5-12**).

Figure 5-12: Hope River in spate viewed from Kintyre Bridge April 20, 2022.

6 RAPID ECOLOGICAL ASSESSMENT

A Rapid Ecological Assessment (REA) guided by the RiVAMP methodology was undertaken for the sites selected in the upper, middle and lower reaches of the Hope River watershed. The REA focuses on characterising the biophysical conditions, vegetation type, biodiversity, distribution of taxa, and the general condition of the selected sites. In addition to incorporating the results of the physical assessment, the REA includes the following tasks:

6.1 Ecosystem Assessment and Habitat Mapping

Input from the literature review was used to inform the field surveys of the study area. Past resource inventories of the area, historical maps, aerial and satellite imagery, as well as most recent land cover data from the Forestry Department were reviewed and used to prioritise areas for field surveys (See section **11.3.2 Land Cover**)

6.2 Ground-truthing Surveys (Flora)

Field-based surveys (i.e., field verification) were conducted to ground-truth habitat types, and to gather more detailed data on the habitat structure, the associated flora, biodiversity, community structure, conservation value of the areas, threats, as well as non-biological data (e.g., location of infrastructure). Field data addressed gaps in baseline data identified during the desk study. All field data was georeferenced for subsequent mapping.

The Rapid Ecological Assessment (REA) covered three sites within the identified zones of upper, middle, and lower watershed areas. The Woodford area was where the sampling and data collection was focused for the upper elevation, Gordon Town and surrounding communities was the focus for the middle elevation, and the Greenwich Town area was the focus for the lower region. The species list is shown in **Appendix 3**.

Within the Woodford area, three sample sites were assessed along tributaries leading to the Hope River. Similarly, three sites were assessed along the waterway in Gordon Town area. For Greenwich Town the Fishing village was assessed, along with the broader Greenwich Town community.

Transects along the tributaries, along with observation and data collecting in the general areas, were used to determine the species diversity of the flora in the upper and middle regions. A walk-through of both the fishing village and the broader Greenwich Town community was conducted to determine the species diversity in the lower region. Photographs of the species and ecosystems were captured where possible.

From the species list collated for the three zones, their general habit, distribution, native range, IUCN status, uses and any other relevant information was tabulated and then analysed for similarities, differences trends.

From preliminary results the species composition in both the middle and upper regions have a large degree of overlap and is significantly different from that of the lower region. The anthropogenic influences in the upper and middle reaches are also similar and again different from those of the lower region. Exotic species in the middle and upper regions are having an influence on the watershed as well a farming practices and forest plantation. Exotic (or introduced) plant species are plants that are introduced by humans, intentionally or accidentally, into areas outside their natural range.

6.3 Ecosystem Assessment

6.3.1 Woodford

Woodford is a settlement in the parish of St. Andrew, located in the upper elevation zone of the Hope River WMU. The charts below represent the summary statistics of the vegetation of three sample sites from the Woodford area. The charts show the combined data however the segregated checklists of flora observed are in **Appendix 3**.

The habit class chart shows a dominance of herbs and trees within the Woodford sample areas (**Figure 6-1**). The trees were dominated by exotic species such as *Mangifera indica*, and *Brugmansia suaveolens*, while the herbs were dominated by *Sphagneticola trilobata*

(Creeping ox-eye), *Cyperus involucrata* (Umbrella sedge) and, *Cenchrus purpureus* (Elephant grass) which are also exotic species.

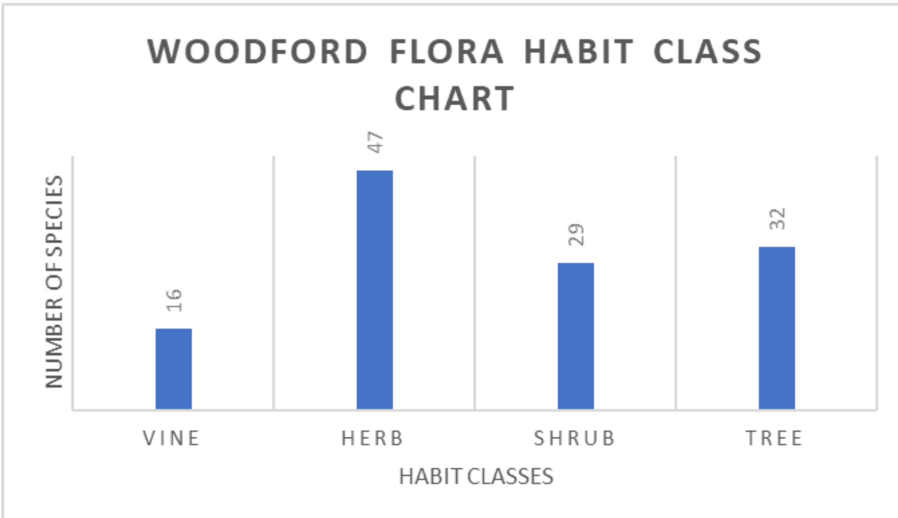


Figure 6-1: Habit class of the flora species observed in Woodford.

The distribution status chart shows a relatively even proportion of natives and exotic species (some of which were shown above to be dominant in the sample sites). The trend seen in the numbers across the three sites showed an increase in percentage of native species as the site's elevations increased (**Figure 6-2** and **Figure 6-3**).

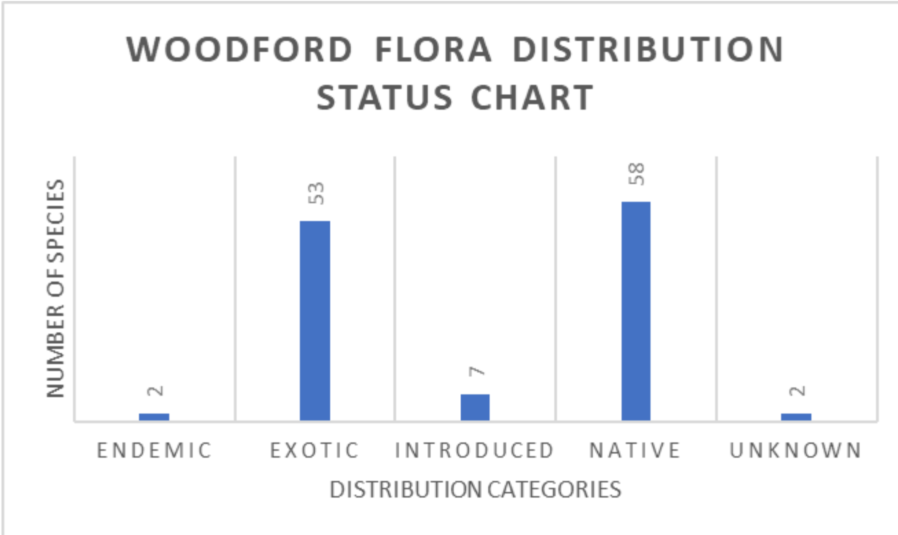


Figure 6-2: Distribution status of the species observed in Woodford.

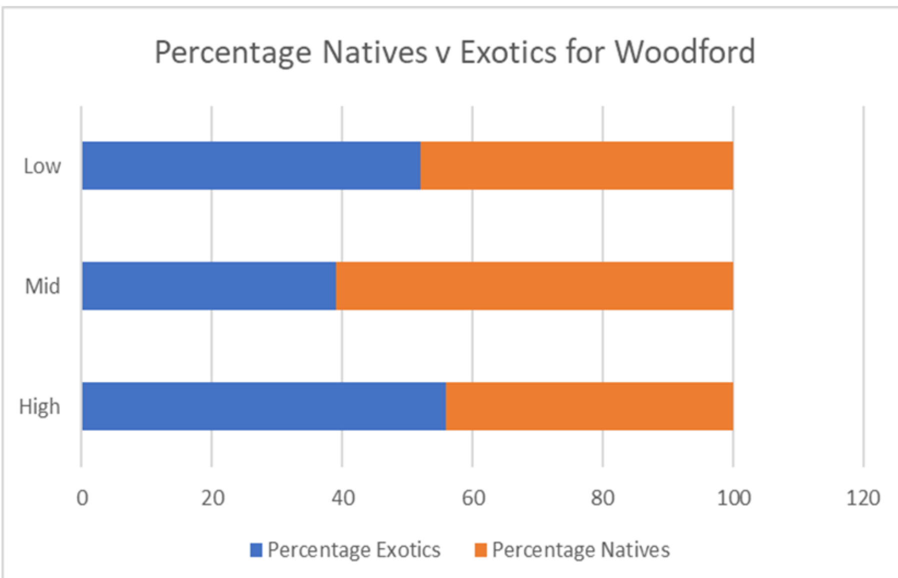


Figure 6-3: Percentage natives mapped against exotics along an elevation gradient for Woodford.

The DAFOR scale chart shows that majority of the species are occasionally found throughout the sites with less than 10 percent being abundant and dominant (**Figure 6-4**).

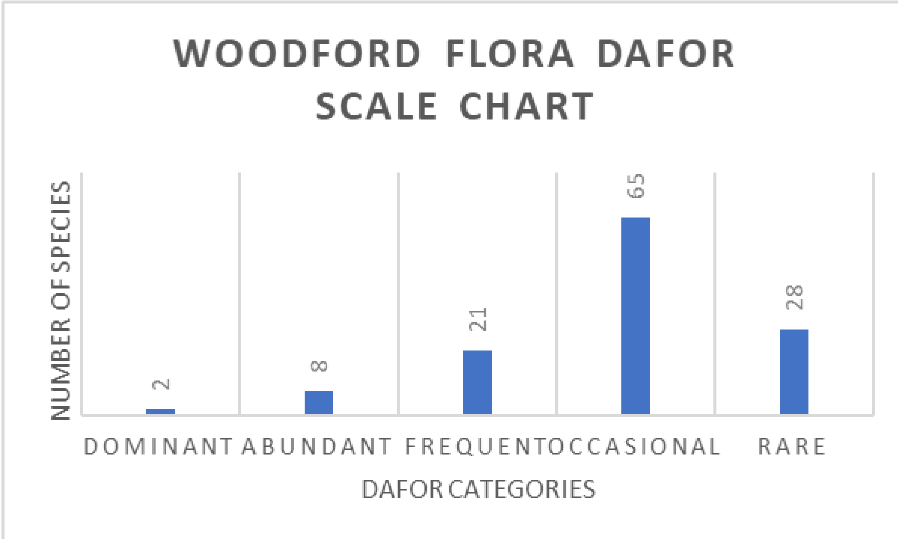


Figure 6-4: Relative abundance using the DAFOR scale for the species observed in Woodford.

The species use chart shows that most of the species observed were not utilised but rather plays some ecological function (**Figure 6-5**). A large number were also species cited in literature as ornamental and medicinal. Some of the ornamental species such as *Brillantaisia owariensis* and *Brugmansia suaveolens* (Angel's trumpet) have escaped and are abundant in the riparian zone of the Hope River and its tributaries.

Brillantaisia owariensis is outcompeting the native species and is the dominant plant species where it was observed. This indicates that it has a negative impact on the native species because is dominating the physical space within the riparian zones in which native species would have been occupying. *Brugmansia suaveolens* was generally abundant throughout the sites and would also be negatively impacting the native species. According to CABI's Compendium (2014) datasheet *B. suaveolens* is rated as having negative impacts on the general environment and human health. Further CABI indicates that *B. suaveolens* poses threats to waterways in Australia as it can form large colonies that inhibit water flow in creeks and impact riparian vegetation if left unmanaged [3].

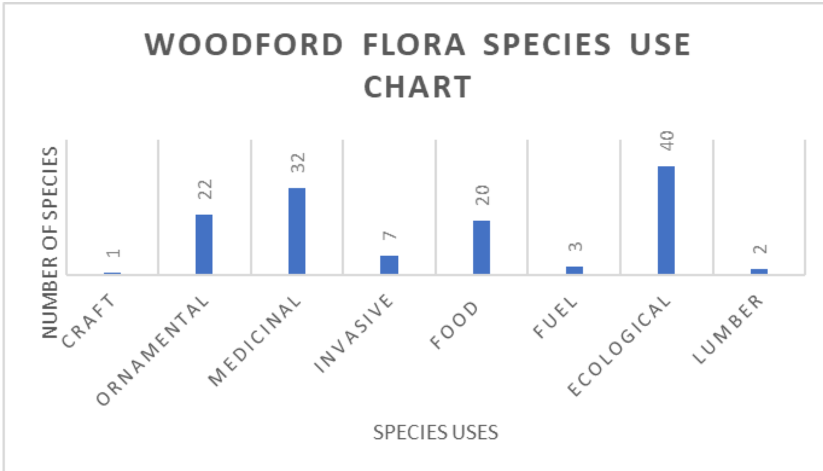


Figure 6-5: General uses of the species observed in Woodford

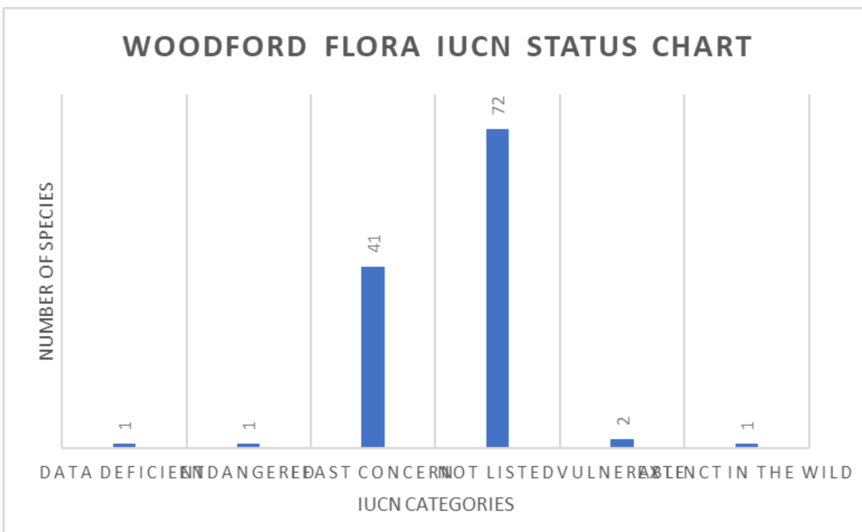


Figure 6-6: IUCN conservation status of the species observed in Woodford

---

[3] https://www.cabidigitallibrary.org/doi/10.1079/cabicompendium.107903

The IUCN chart shows that most of the species observed throughout the three sample sites in the Woodford high elevation zone are designated as not listed (assessed) or least concern on the IUCN Red list of threatened Species (**Figure 6-6**).

6.3.2 Gordon Town

Gordon Town is a settlement in the parish of St. Andrew, located in the middle elevation zone of the Hope River WMU. The charts below represent the summary statistics of the vegetation of three sample sites from Gordon Town and above. The charts show the combined data, however the segregated checklists of flora observed are in **Appendix 3.**

The Habit class chart shows a dominance of trees and shrubs within the Gordon Town sample areas (**Figure 6-7**). The trees were dominated by exotic species such as *Mangiferaindica* (Mango), *Calliandrahoustoniana* var. *calothyrsus* (Calliandra), *Artocarpusaltilis* (Breadfruit), *Brugmansiasuaveolens* (Angel's trumpet), and *Pinus* species while the shrubs were dominated by *Brillantaisiaowariensis* (Giant blue African salvia), *Ricinus communis* (Castor oil tree), *and Tithonia diversifolia* (Mexican sunflower). All of these trees and shrubs are introduced species.

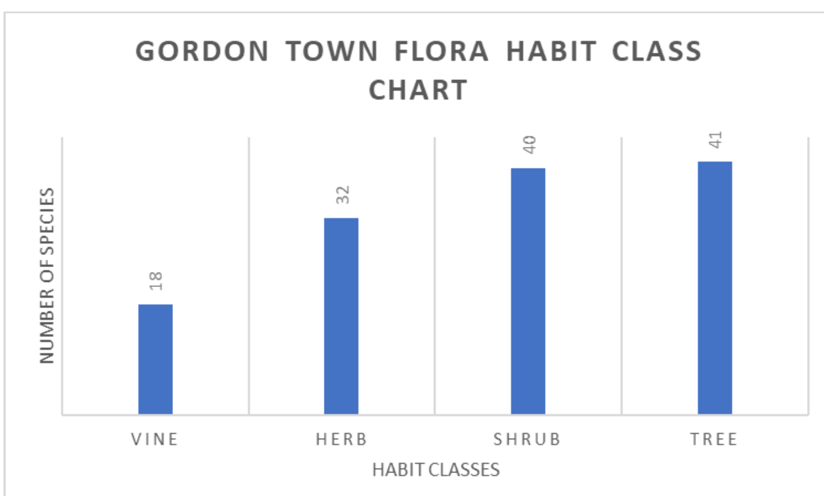


Figure 6-7: Habit class of the species observed in Gordon Town

The distribution status chart shows a relatively even proportion of natives and exotic species (some of which were shown above to be dominant in the sample sites). The trend seen in the numbers across the three sites showed an increase in percentage of native species as the site's elevations increased (**Figure 6-8** and **Figure 6-9**).

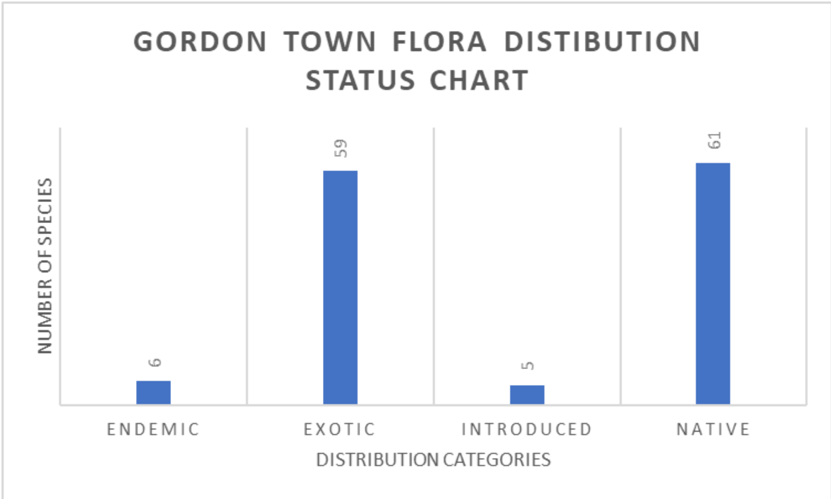


Figure 6-8: Distribution status of the species observed in Gordon Town

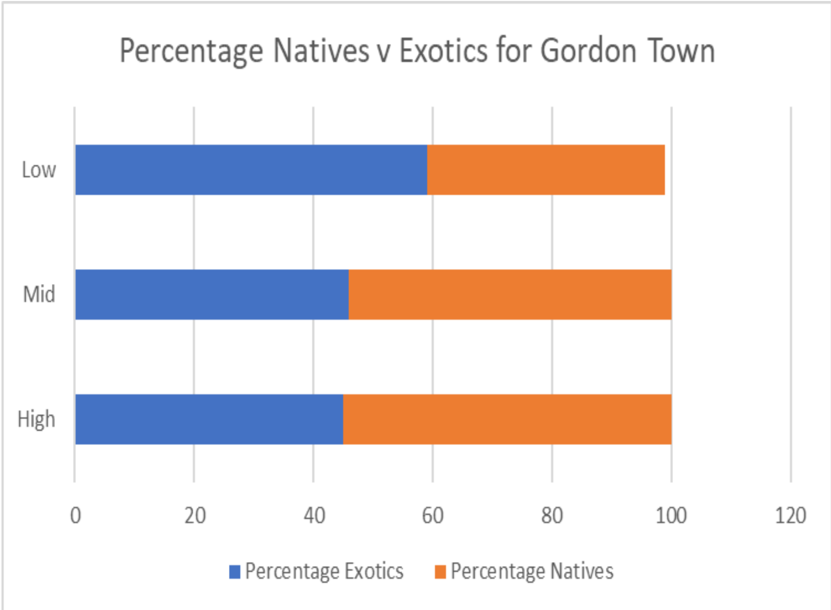


Figure 6-9: Percentage natives mapped against exotics along an elevation gradient in Gordon Town.

According to the DAFOR Scale chart, most of the species are occasionally found across the surveyed sites, with less than 10 percent classified as abundant, indicating lower levels of coverage or frequency (**Figure 6-10**).

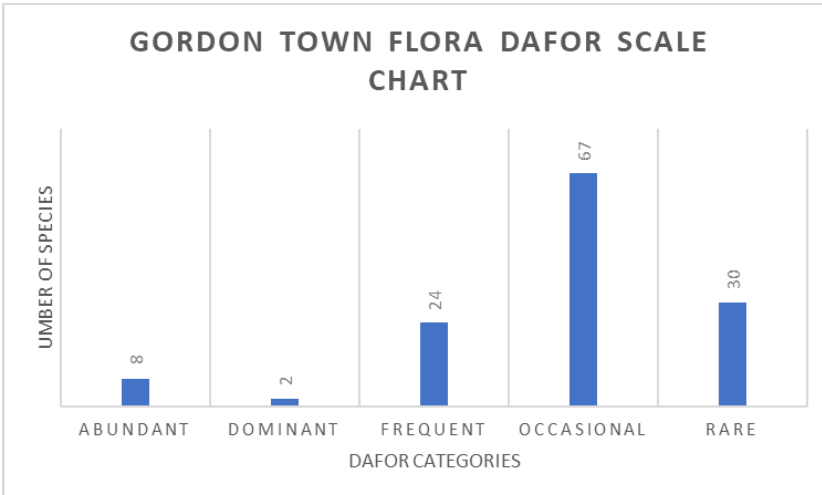


Figure 6-10. Relative abundance using the DAFOR scale for the species observed in Gordon Town.

The species use chart shows that most of the species observed were not utilised but rather plays some ecological function (**Figure 6-11**). A large number were also species cited in literature as ornamental and medicinal. Some of the ornamental species such as

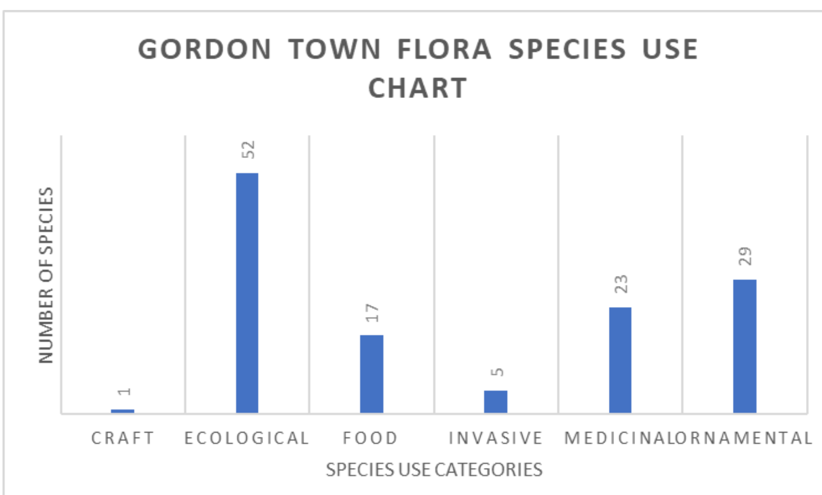


Figure 6-11: General uses of the species observed in Gordon Town

Brillantaisia owariensis have spread and are now abundant in the riparian zone of the Hope River and its tributaries.

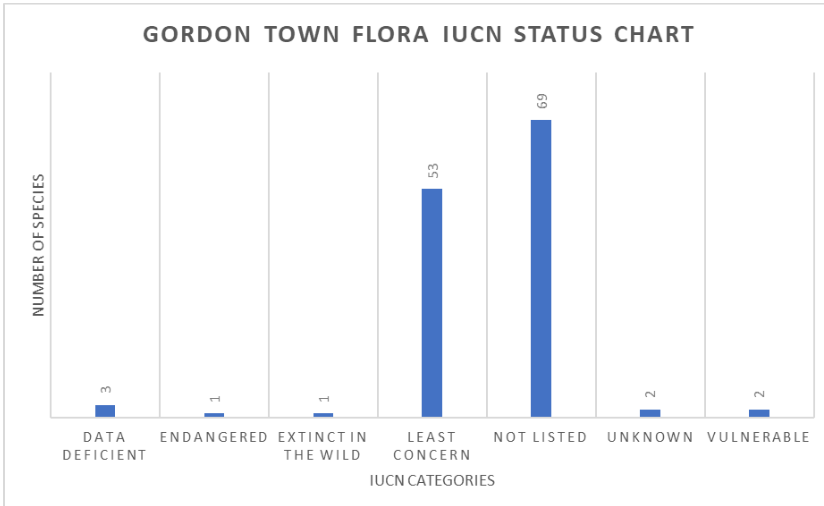


Figure 6-12: IUCN status of the species observed in Gordon Town

The IUCN chart shows that most of the species observed throughout the three sample sites in the Gordon Town mid elevation zone are designated as least concern or not listed (assessed) on the IUCN Red list of threatened Species (**Figure 6-12**).

6.3.3 Greenwich Town

Greenwich Town represents an urban space and as such the vegetation assessment was restricted to visual sampling while driving or walking through the fishing village and wider community. The charts below represent summary statistics of the vegetation of both the fishing village and wider community combined however the segregated checklists can be perused in **Appendix 3**.

The ecosystems expected to be represented in the Greenwich Town Fishing Village (GTFV) is a mangrove forest or coastal wetland. There are remnants of this observed on the side of the community however this is in the form of a very small patch of mangroves to the north-eastern of the GTFV. The vegetation in the rest of the area has been cleared and houses and shops built along the narrow stretch of land bordering the Petrojam Limited complex. Some plants have been added to the landscape for food and shade by the fisherfolk living in the village.

The ecosystems expected to be represented in the Greenwich Town Community (GTC) is an induced savanna, secondary communities or thorn scrub based on Asprey and Robbins (1953). Remnants of what seemed to have been a thorn scrub can be observed on the outskirts of the GTC but within the GTC proper there are only cultivated plants again which are added for food, shade of aesthetics by the residents. In waste places a few typical herbaceous species such as *Tridax procumbens*, *Sida acuta*, *Portulaca oleracea*, and *Kallstroemia maxima* which may have also been found in low-lying thorn scrub ecosystems are present.

Both communities have significantly impacted the ecosystem that was originally present and novel systems now exist. Though not able to function or maintain the species that would normally be found in these systems, the areas still fall within a broader ecological framework even with the significant levels of disturbance over time and which is continuing. These novel ecosystems still however play a role though diminished in the provision of services including habitat provisioning, food and genetic resources among others.

The habit chart (**Figure 6-13**) shows a dominance of trees and herbaceous species within the combined sites. The trees are predominantly fruit bearing trees such as *Mangifera indica* (mango), *Blighia sapida* (ackee), and *Artocarpus altilis* (breadfruit) in the GTC and mangroves on the fringes of the GTFV.

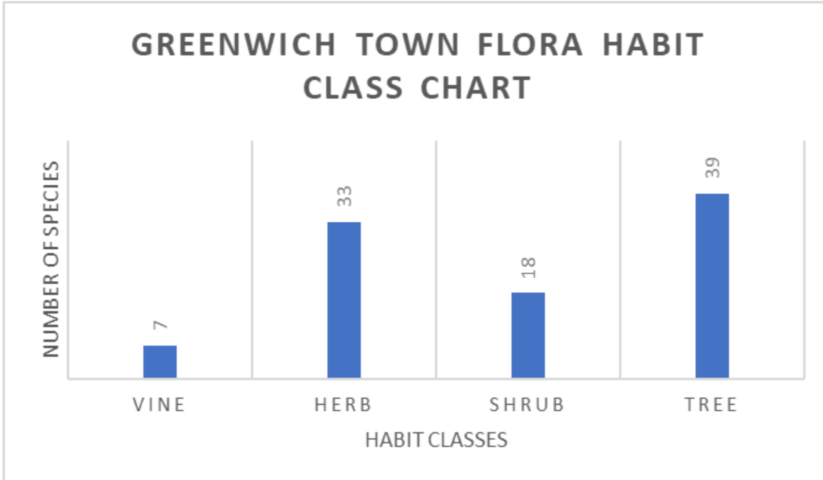


Figure 6-13: Habit class of the species observed in Greenwich Town

The distribution chart shows dominance in exotic species compared to native species and an absence of any endemic species (**Figure 6-15**).

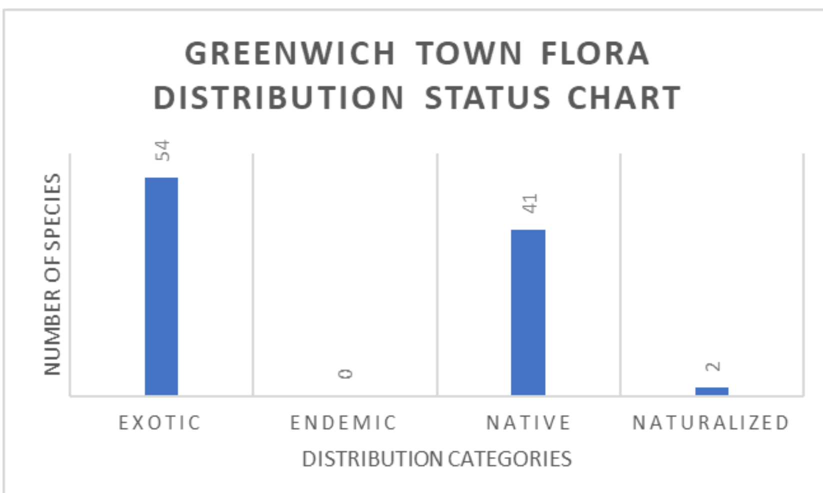


Figure 6-14: Distribution status of the species observed in Greenwich Town

The DAFOR chart (**Figure 6-15**) shows that there is no dominant species, and this is because of the impact of the modifications made to the original ecosystems.

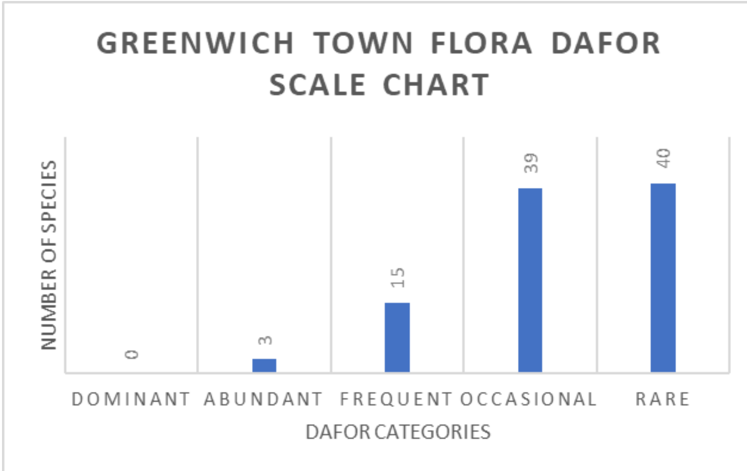


Figure 6-15: Relative abundance using the DAFOR scale for the species observed in Greenwich Town

The species use chart shows various uses of the species observed with the majority being listed as ecological however this group would be represented primarily by species that are weedy and found in marginal spaces (**Figure 6-16**).

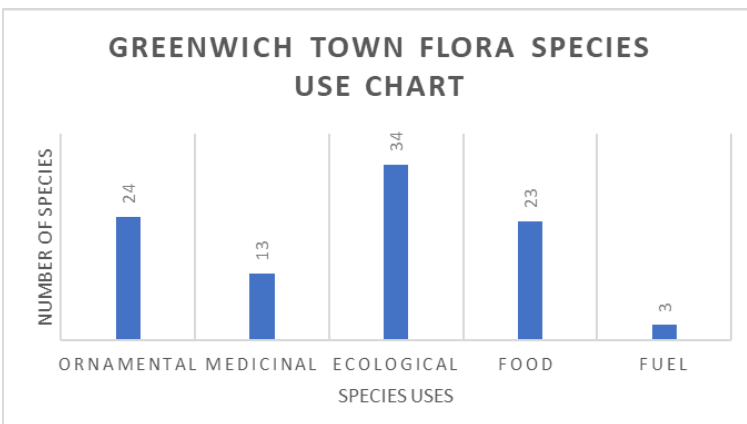


Figure 6-16. Chart showing the general uses of the species observed in Greenwich Town

The IUCN status chart shows that most of the species in these sites are either of least concern of not listed (assessed) (

Figure 6-17). This is expected because these species are mainly weedy and cultivated species.

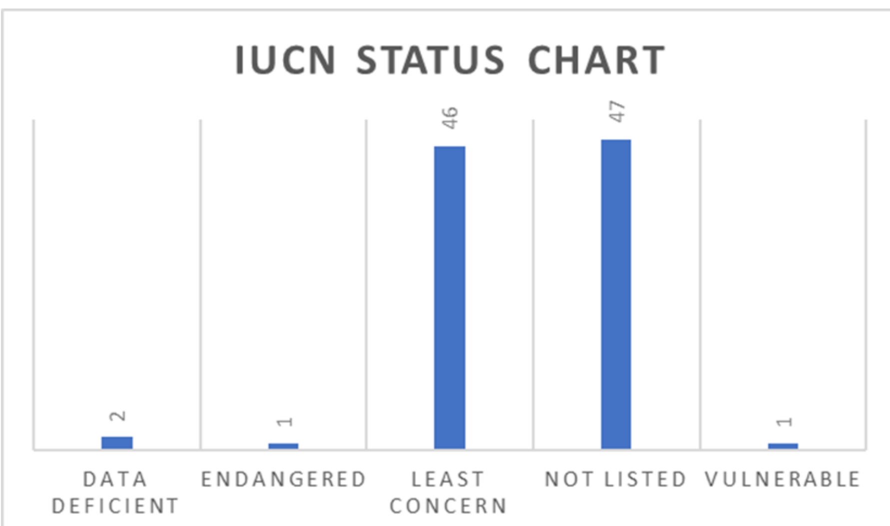


Figure 6-17: IUCN status of the species observed in Greenwich Town.

7 SOCIOECONOMIC ASSESSMENT

A socio-economic assessment (SA) was undertaken to examine the socio-economic setting and the factors that will most likely affect well-being of local communities, including livelihood characteristics, population growth, planned economic activities, disaster risk, and land-use change within the broader boundaries of the Hope River watershed management unit. The socio-economic baseline included descriptions of existing infrastructure such as wastewater, roads and transportation, electricity, water, telecommunications, and health facilities. Literature sources included Population Censuses, Socio-Economic Studies, the Survey of Living Conditions, the Economic and Social Survey of Jamaica, and Community Profiles. The assessment focused on communities from the upper, middle and lower reaches of the watershed management unit (WMU).

7.1 Community Selection

The selection of communities in the upper and middle regions was restricted to the natural boundary of the Hope River watershed. At the request of TNC/UNEP, attempts were made to locate Petersfield, located within the Content Gap area. We were also asked to extend the study boundary to the Hope watershed management unit in selecting the community from the lower region. Of the 79 communities provided, 23 are located within the natural watershed. The communities were assigned to upper, middle and lower reaches based on elevation. There are 10 communities within the upper reaches, 6 in the middle and 8 in the lower reaches. Communities were selected based on assessment of the available data for the ecological, socio-economic, and physical criteria. The selected communities capture ecological (ecosystem/habitat), population, and risk gradients from the upper to lower reached of the WMU. **Table 7-1** outlines the criteria and variables for each region/ community.

The communities selected were:

- Lower watershed region - Greenwich Town

- Middle watershed region - Gordon Town in (in addition to Content Gap and Petersfield)
- Upper watershed region – Woodford (including Redlight and New Castle, which are located within the same enumeration district and poverty map community boundaries)

Table 7-1. Site selection criteria

	Lower Hope River WMU	**Middle Hope River WMU**	**Upper Hope River WMU**
Criteria	**Greenwich Town**	**Gordon Town/ Content Gap/ Petersfield**	**Woodford (New Castle, Redlight)**
Ecosystem Health	Highly degraded urban/ low habitat diversity	Moderately degraded rural/ moderate habitat diversity	Moderately healthy rural/ high habitat diversity
Dependency of Ecosystem	Moderate	Moderate to High	High
Main Ecosystem Services	1- Provisioning	5 - Provisioning, water, erosion protection, biodiversity, and existence	5-6 - Provisioning, water, erosion protection, biodiversity, existence, recreation/tourism
Hazard History	High pollution	High landslide	High Landslide and flood
Population	Relatively high	Moderate	Moderate
Vulnerable Population (<15 and >65years)	62%	63%	60%
Sex Ratio (male to female)	0.91	1.06	0.99
Housing Vulnerability (% wood construction)	19%	20%	11%
Actively Unemployed Population	<9%	1%	3.3%

7.2 Socioeconomic Baseline

7.2.1 Demography

7.2.1.1 Parish Level

The Hope River watershed Management unit (HOPE RIVER WMU) spans the parish of Kingston and sections of the parish of St. Andrew. According to recent population figures released for Jamaica by the Statistical Institute of Jamaica (STATIN) at the end of 2019, the parishes of Kingston and St. Andrew had a combined population of 662,491 persons (**Table 7-2**), a decline of 0.02 per cent over 2018 levels. The decline is due in part to the declining population growth rate of the parish of Kingston, which recorded a 7% decline in the size of its population between the 2001 and 2011 censuses. In contrast, the population of the parish of St. Andrew increased by 3% during the same intercensal period.

Disaggregation of the latest population data by parish, showed Kingston had 90,554 persons and St. Andrew 571,940 at the end of 2019. The current population figure for Kingston is 2% higher than the 89,057 number recorded in the 2011 census, giving the parish an annual growth rate of 0.21% since the 2011 census. This rate resulted in the parish having the fourth smallest population size in Jamaica and one of the slowest growth rates in the island. The parish presently accounts for 3.3% of Jamaica's total population (STATIN, 2022). This figure has remained fairly consistent since 2001, though there has been a noted decline of 8% when compared with 2001 figures. In 2011, 3.3% of Jamaica's population resided in Kingston, compared to 3.7% in 2001.

The parish of St. Andrew has an estimated population of 571,947 persons. The figure represents an estimated 0.2% decline over 2011 census figures. According to the 2011 Census the parish of St. Andrew had 573,369 persons. The parish which accounts for 20.9% of the total population of Jamaica, is the most populous parish (**Table 7-2**).

Table 7-2: Population at National and Parish Level 2014-2019

Parish	2014	2015	2016	2017	2018	2019[P]	% of country population (2018)
Jamaica	2,715,657	2,719,471	2,721,665	2,725,883	2,730,983	2,734,093	100.0%
Kingston & St. Andrew	662,822	662,793	662,252	662,259	662,618	662,491	24.2%
Kingston	89,641	89,823	89,901	90,113	90,368	90,544	3.3%
St. Andrew	573,181	572,970	572,351	572,146	572,250	571,947	20.9%
p –preliminary							

Source: Statistical Institute of Jamaica, 2022

Kingston and St. Andrew (KSA) is the largest urban centre in Jamaica. In 2011, 93% of the population of the combined parishes resided in urban areas. The entire parish of Kingston is considered urban, while 86% of St. Andrew is deemed urban (**Table 7-3**). The parish of Kingston along with the urban sections of the parish of St. Andrew forms the Kingston Metropolitan Area (KMA), which is the largest urban centre in Jamaica.

Table 7-3: Urban Population at Parish Level 2001 and 2011

Parish	2011			2001		
	Total	% of country population	% of population in urban areas	Total	% of country population	% of population in urban areas
Kingston	89,057	3.3	100.0	96,052	3.7	100.0
St. Andrew	573,369	21.3	86	555,828	21.3	87
KMA	584,627	21.7	100%	579,137	22.2	100.0

Source: STATIN, 2013

Sex Distribution - Sex disaggregation data for Kingston shows the parish had a male to female population ratio of 101.64, i.e., for every 101.64 males there were 100 females (**Table 7-4**). According to the 2011 Census, males accounted for 50.4% of the total population of the parish, a 2.0 percentage point increase over 2001 levels, when females accounted for 51% of the total population of the parish. The sex distribution pattern in the parish of Kingston is currently not in line with national trends, where women account for the majority of the population of Jamaica. It is however consistent with sex patterns observed in nine (9) other parishes.

In the parish of St. Andrew, the proportion of females in the parish has remained consistently higher than their male counterparts over the last two intercensal periods. The parish had a sex ratio of 91.73 according to the 2011 census, i.e., for every 91.7 males there were 100 females (**Table 7-4**). The sex ratio of the parish is consistent with national patterns. The data shows that the percentage of males in the parish has grown since the last census in 2001 by 1.4%. In 2001 males accounted for 47.17% of the total population of the parish and in 2011, the figure stood at 47.84%.

Table 7-4: Sex Distribution by Parish, 2011

Parish/ Community	**Total**	**Male**	**Female**	**Sex Ratio (Males per 100 females)**
Jamaica	2,697,983	1,334,533	1,363,450	97.9
Kingston	89,057	44,891	44,166	101.64
St. Andrew	573,369	274,320	299,049	91.73

Source: STATIN, 2013

Age Distribution - The age distribution trends observed at the parish level for Kingston are similar to those observed nationally. Approximately twenty-eight percent (27.9%) of the total population of Kingston is under the age of 15, some 66.0% are between the ages of 15 and 64 and 6.1% are 65 and over. Some 56.5% of the population is 29 years or younger, 2 percentage points higher when compared to the population at the national level. The age group 30-64 constitutes the largest segment of the population and accounts for 37.4% of the total parish population (**Table 7-5**).

In the parish of St. Andrew, 22.6% of the total population is under the age of 15; 69.8% between the age of 15 and 64 and; 7.5% being 65 and over. Approximately 51.7% of the population is 29 years and younger, 2 percentage points lower when compared to the population at the national level. The age group 30-64 constitutes the largest segment of the population accounting for 40.7% of the total parish population.

Table 7-5: Age Distribution of Population at Parish Level, 2011

Parish	**Total**	**Under 15**	**15-29**	**30-64**	**65 and over**
Jamaica	2,697,985	702,836	751,493	1,025,314	218,342
Kingston	89,057	24,860	25,451	33,326	5,420
St. Andrew	573,369	129,412	167,227	233,457	43,273

Table 7-6: Age Dependency Ratio, 2011

Parish	**Total Young + Elderly (under 15 & 65 and over)**	**Total Working-age (15-64)**	**Age Dependency Ratio**
Jamaica	921,178	1,776,807	51.8
Kingston	30,280	58,777	51.5
St. Andrew	172,685	400,684	43.1

Disaggregation of the data by age and sex shows that the 30-64 age group had the largest proportion of both males and females at the national and parish levels. However, the parish of St. Andrew had 42% of the female population in the 30-64 age group, higher than the national level and the parish of Kingston, both with 38% (**Table 7-7**). In the under 15 age group, the proportion of females in St. Andrew was lower than the proportion of males as well as the proportion of females at the national level and in Kingston.

Table 7-7: Age Distribution by Sex at the Parish Level, 2011

Parish	Under 15		15-29		30-64		65 and over	
	Male	Female	Male	Female	Male	Female	Male	Female
Jamaica	357,082	345,754	374,941	376,552	501,735	523,579	100,777	117,565
Kingston	12,622	12,238	13,199	12,252	16,638	16,688	2,432	2,988
St. Andrew	65,613	63,799	81,430	85,797	108,373	125,084	18,904	24,369

Age Dependency Ratio - The age dependency ratio is a measure of the total number of dependents (persons aged under 15 years and those aged 65 years and older) relative to the working-age population (15-64 years). The ratio represents the number of economically inactive people that each economically active person is expected to support (PIOJ, 2021). It is this dependency that contributes to this segment of the population being considered vulnerable.

Jamaica's age dependency ratio was 51.8 according to 2011 census data (Statin, 2013) (Table 7-6). The PIOJ estimated that there were 44.1 dependents per 100 persons of working age in 2020 (PIOJ, 2021). This represents a 15% decline from the 51.8 dependents for every 100 working persons recorded in the last 2011 census. The parish of Kingston had an overall dependency ratio of 51.5 in 2011, in line with the national dependency ratio of 51.8 (STATIN, 2013). The parish of St. Andrew had an age dependency ratio of 43.1, lower than the national ratio.

Community Level - A total of seven communities (as delineated by the Poverty Map, 2012) communities located in the lower, middle, and upper regions of the Hope River WMU were included in the socioeconomic study components. The communities included in the study had a combined total population of 14,984 according to the 2011 census, of which 51.9% is considered urban (**Table 7-8**, **Figure 7-1**).

Table 7-8: Population at Community level, 2011

Watershed Region	Communities	ED	Total Population	% of population in urban areas
Lower	Greenwich Town/ Newport West	Special Area	7,783	100.0
Middle	Gordon Town	Special Area	3,268	0
	Petersfield	ER10	716	0
	Content Gap	ER8; ER19	1,533	0
Upper	Woodford (including Newcastle and Redlight)	ER1; ER4	1,684	0
	Total		14,984	51.9

Source: STATIN, 2013

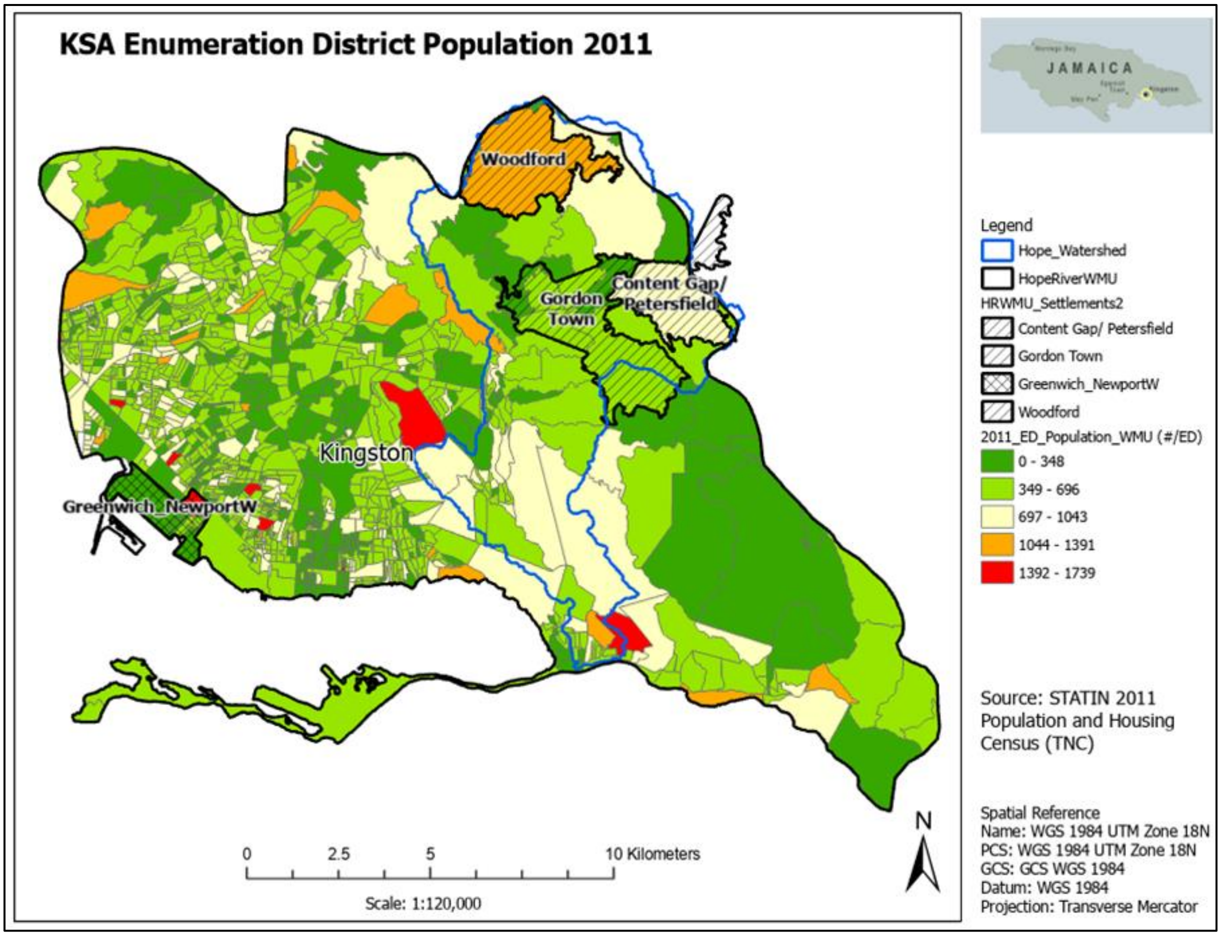


Figure 7-1: Study Communities and KSA Population Enumeration District

7.2.1.2 Community Level

7.2.1.2.1 Lower Watershed Population

Population - The Greenwich Town community falls within the Greenwich Town/Newport West Special Area of the parish of St. Andrew for the 2011 census. The community is situated in the lower watershed area of Hope River WMU. The community had a population of 7,783 persons in 2011, a growth of 3% compared to the 2001 census (**Table 7-8**). At an estimated 3.13 square kilometres land area, the population density of Greenwich Town is 2,487 per square kilometre.

Sex Distribution - Greenwich Town has larger population of female with 51.3% of the population being females while 48.7% are males. The community has a sex ratio of 94.9, i.e., for every 94.9 males there were 100 females. This is 3.2 points higher than the sex ratio for the parish of St. Andrew (**Table 7-9**).

Table 7-9: Greenwich Town Community Sex Distribution, 2011

Watershed Region	Communities	Male	Female	Sex Ratio	Total Population
Lower	Greenwich Town/ Newport West	3,790	3,993	94.9	7,783

Age Distribution and Age Dependency Ratio - Disaggregation of population by age shows that the largest proportion of the population belongs to the economically productive age group (15-64 years) (**Table 7-10 (a)**). Some 69% of the population aged 15-64 compared with 26% under 15 years and 6% in the 65 and over age group. The age dependency ratio is 45.3 dependents for every 100 persons of working age in the community (**Table 7-10 (b)**). This is higher than the ratio for the parish of St. Andrew of 43.1), but lower than the national ratio of 51.8. There is a slightly larger number of females in the economically active age group compared to the number of males. Females represent 50.9% of that group, while males represent 49.1% (**Table 7-10 (a)**). Similarly, the younger population has a slightly larger female representation.

Table 7-10: (a) Age Distribution of Greenwich Town, 2011; (b) Age Dependency Ratio, 2011

(a)	Under 15		15-29		30-64		65 & over	
	Male	Female	Male	Female	Male	Female	Male	Female
Greenwich/ Newport West	962	1,062	1,179	1,293	1,450	1,434	199	204
% Total Population	12.4	13.6	15.1	16.6	18.6	18.4	2.6	2.6
% Population by Age Group	26		32		37		6	

(b)	Age Dependency Ratio, 2011		
Community	Total Young + Elderly	Total Working-age	Age Dependency Ratio
Greenwich	2,427	5,356	45.3

Source: STATIN, 2013

7.2.1.2.2 Middle Watershed Population

Population - The middle watershed area is represented by three communities, namely, Gordon Town, Petersfield and Content Gap, with Gordon Town located along the banks of the Hope River. The communities had a combined population of 5,517 according to the 2011 census, with Gordon Town being the most populous with almost 60% of the total population (**Table 7-11**). Content Gap is the second most populous accounting for 27.8% of the total population while Petersfield has 13% of the population.

Gordon Town was estimated to cover an area that is 4.49 square kilometres, making the population density 728 persons per km2 (Statin, 2012). The population density of Petersfield was estimated at 103 persons per sq. km (Statin, 2012); while Content Gap had a density of 263 persons per km2.

Sex Distribution - The sex distribution of the population varies by community with Gordon Town having a sex ration of 99, i.e., 99 males per 100 females (49.7% males) (**Table 7-11**). Petersfield has 109 males per 100 females (52.1% males), while Content Gap has 91.1 males per 100 females (52.3% males).

Table 7-11: Sex Distribution by Community, Middle Watershed, 2011

Watershed Region	Communities	ED	Male	Female	Sex Ratio	Total Population
Middle	Gordon Town	Special Area	1,625	1,642	99.0	3,268
	Petersfield	ER10	373	343	108.7	716
	Content Gap	ER8; ER19	731	802	91.1	1,533
	Total		2,729	2,787	97.9	5,517
	Sex Percent Total		49.5%	50.5%		100%

Age and Age Dependency Ratio - Disaggregation of population by age shows that almost 70% of the population of the middle watershed communities belong to the economically productive age group (15-64 years) (**Table 7-12 (a)**). Approximately 23.4% are aged 15-64 while 6.7% are in the 65 and over age group. The age dependency ratio for the combined communities with 43.1 dependents per 100 persons of working age (**Table 7-12 (b)**). This is consistent with the age dependency ratio for the parish of St. Andrew (43.1), but notably lower than the national ratio of 51.8. There is a slight difference between representation of sexes in the economically active age group with males accounting for 50.6%, and females account for 49.4%, a difference of 1.2 percentage points (**Table 7-12 (a)**). Both the younger and elderly population groups have higher number of males than females for the middle watershed communities.

Table 7-12: (a) Age Distribution of Middle Watershed Communities, 2011; (b) Age Dependency Ratio, 2011

(a)	Under 15		15-29		30-64		65 & over	
	Male	Female	Male	Female	Male	Female	Male	Female
Gordon Town	389	366	508	534	614	626	115	116
Petersfield	93	83	123	117	144	123	13	20
Content Gap	182	179	247	204	314	301	59	47
Total	664	628	878	855	1,072	1,050	187	183
% Total Population	12.0%	11.4%	15.9%	15.5%	19.4%	19.0%	3.4%	3.3%
% Population by Age Group	23.4%		31.4%		38.5%		6.7%	

(b)	Age Dependency Ratio, Middle Watershed Communities		
Community	**Total Young + Elderly**	**Total Working-age**	**Age Dependency Ratio**
Gordon Town	986	2,282	43.2
Petersfield	209	507	41.2
Content Gap	467	1,066	43.8
Total	1,662	3,855	43.1

Source: STATIN, 2013

7.2.1.2.3 Upper Watershed Population

Population - The community of Woodford was selected as the representative community for the upper watershed region by aapplying a list of criteria and specific request from TNC/UNEP (see description in methodology at beginning of socioeconomic section). The community of Woodford had a population of 1,684 in 2011 (**Table 7-13**). At an estimated area of 5.84 square kilometres, Woodford had a population density of 78 persons per km2.

Sex Distribution - The population is relatively evenly distributed by sex with 49.5% being males and 50.5% females, in 2011 (a sex ratio or 99.0)

Table 7-13: Population of Upper Watershed Communities by Sex, 2011

Watershed Region	Communities	ED	Male	Female	Sex Ratio	Total Population
Upper	Woodford/ Newcastle/ Redlight	ER1; ER4	834	850	99.0	1,684
	Sex Percent Total		49.5%	50.5%		100%

Source: STATIN, 2013

Age and Age Dependency Ratio - Disaggregation of population by age shows that 70% of the population of the upper watershed community of Woodford belong to the economically productive age group (15-64 years) (**Table 7-14 (a)**). Twenty four percent (24.0%) are aged 15-64 while 6.0% are in the 65 and over age group. The age dependency ratio was 43.0 dependents per 100 persons of working age (**Table 7-14 (b)**), consistent with the communities in the middle watershed, the parish of St. Andrew (43.1). There is a relatively even representation of sexes in the economically active age group with males accounting for 50.3%, whiles females account for 49.7% (**Table 7-14 (a)**). There is a higher number of females than males in both the younger and elderly population groups for the Woodford community.

Table 7-14: (a) Age Distribution of Upper Watershed Communities, 2011; (b) Age Dependency Ratio, 2011

(a)	Under 15		15-29		30-64		65 & over	
	Male	Female	Male	Female	Male	Female	Male	Female
Woodford	196	209	228	262	364	324	46	55
% Total Population	11.6%	12.4%	13.5%	15.6%	21.6%	19.2%	2.7%	3.3%
% Population by Age Group	24.0		29.1		40.9		6.0	

(b)	Age Dependency Ratio, Upper Watershed Communities		
Community	**Total Young + Elderly**	**Total Working-age**	**Age Dependency Ratio**
Woodford	506	1,178	43.0

Source: STATIN, 2013

7.2.2 Housing

7.2.2.1 Parish Level Housing

According to the 2011 Population Census the parish of Kingston had 14,785 housing units while St. Andrew had 124.775 units. The combined Kingston and St. Andrew (KSA) accounted for 20% of the housing units of the country. The data shows that both parishes have a larger number of dwelling units with Kingston having an estimated 28,835 dwelling units while St. Andrew had approximately 184,831 units (**Table 7-15**). The combined KSA accounted for 25% of all dwelling units in Jamaica in 2011. Nationally, the number dwelling units increased by 18% over 2001 baseline figures. Similarly, there were also notable increases in the number of households at the parish and national levels in 2011 compare with 2001. Nationally there has been a seventeen percent (18%) increase in the number of households over 2001 figures (**Table 7-15**). The number of households in Kingston increased by 5%, while there was a 17% increase in the number of households in St. Andrew. The number of persons per household declined at both the national and parish levels.

Table 7-15: National/ Parish Housing Parish Data 2001 and 2011

	Number of Dwelling Units		**Number of Households**		**Household Size**	
	2011	**2001**	**2011**	**2001**	**2011**	**2001**
Jamaica	853,668	723,041	881,089	748,326	3.1	3.5
Kingston	28,834	27,204	29,518	28,199	3.0	3.4
St. Andrew	184,831	156,137	192,112	164,513	3.0	3.4

Source: STATIN, 2013

Type Housing Units and Material of Outer Walls - Ninety percent (90%) of the housing units nationally were separate detached units with another 8% being detached units, according the 2011 census (**Table 7-16**). Other types of housing units reported were part of commercial (1%) and improvised unit (1%). Concrete and blocks were the most popular type of building material for the outer walls of housing units, accounting for 70% if total units. Wood (18%) and wood and concrete (8%) were also common materials of outer wall.

For the parish of Kingston, 71% of housing units were separate detached units, 25% were attached units (Table 7-16). Part of commercial building accounted for 2% and improvised units, 1%. While concrete and block were the most common material of outer walls in Kingston, the proportion (63%) was 7% lower than at the national level. Units with outer walls constructed of wood; and wood concrete, accounted for 14% each, while stone and brick; and nog each accounted for 2%, and wood and brick 3%. The household size within the impact zone ranges between 2.9 and 3.7 persons per household (**Table 7-17**).

Table 7-16: National/ Parish Type of Housing Units

	Separate Detached	Attached Unit	Part of Commercial Building	Improvised Unit	Other Type	Not Reported	Total Housing Units
Jamaica	642,650	53,753	4,518	4,595	851	4,964	711,331
Kingston	10,433	3,637	308	142	10	255	14,785
St. Andrew	105,654	16,117	746	507	446	1,305	124,775

Source: STATIN, 2013

Table 7-17: National/ Parish Materials of Outer Walls[4]

	Concrete and Blocks	Stone and Brick	Nog[5]	Wood	Wood and Concrete	Wood and Brick	Other/ Not Reported	Total Housing Units
Jamaica	499,659	3,605	7,381	128,711	59,595	2,839	9,541	711,331
Kingston	9,242	354	243	2,076	2,038	495	337	14,785
St. Andrew	98,007	794	695	13,878	8,948	676	1,777	124,775

[4] Categories are as presented by the Statistical Institute of Jamaica in the published census.

[5] A popular construction technique of former times in which mortar is used to fill the vacancies in a wooden frame.

Housing Tenure - As it relates to tenure of dwellings, 61% of Jamaican households owned their dwellings, while 20% rented and 16% live rent-free (**Table 7-18**). Almost 2% of dwellings were leased and 1% squatted.

The data shows that in Kingston, there was more even split in the most common tenure types across owned (30%), rented (30%) and rent-free (31%) dwellings. Some 3% of dwellings were squatted.

For the parish of St. Andrew, 49% of dwellings were owned, while 30% rented, 15.2% rent-free and 3% leased.

Table 7-18: National/ Parish Housing Tenure

	Own	Leased	Rented	Rent Free	Squatted	Other*	Not Reported	Total Dwellings
Jamaica	534,353	15,069	176,871	136,835	8,823	1,149	7,989	881,089
Kingston	8,931	375	9,409	9,095	954	65	684	29,513
St. Andrew	93,761	4,934	58,225	29,265	2,911	315	2,701	192,112

Source: STATIN, 2013

7.2.2.2 Community Level Housing

7.2.2.2.1 Greenwich Town Housing

The Greenwich Town community had a total of 1,537 housing units in 2011 (**Table 7-19**).

Table 7-19: Greenwich Town Type of Housing Unit

	Separate Detached	Attached Unit	Part of Commercial Building	Improvised Unit	Other Type	Not Reported	Total Housing Units
Greenwich Town	1,379	68	30	38	0	22	1,537

Ninety percent (90%) of housing units were separate detached, 4% attached units, while 2% were part of commercial building and 2% improvised units. The most common material of outer wall was concrete and blocks, accounting of 80% of units (**Table 7-20**). Wood (11%) was the second most common material of outer wall, followed by wood and concrete (7%). Over 36% of Greenwich Town households owned their dwelling, 33% leased and 25% lived rent-free.

Table 7-20: Greenwich Town Material of Outer Walls

	Concrete and Blocks	Stone and Brick	Nog	Wood	Wood and Concrete	Wood and Brick	Other/ Not Reported	Total Housing Units
Greenwich Town	911	88	22	289	143	31	53	1,537

Table 7-21: Greenwich Town Housing Tenure

	Own	Leased	Rented	Rent Free	Squatted	Other*	Not Reported	Total Dwellings
Jamaica	957	46	839	655	97	0	48	2,642

7.2.2.2.2 Gordon Town/ Content Gap/ Petersfield Housing

Gordon Town, the most populous community in the middle watershed study area, had 1,165 housing units and 1,360 dwelling units. Ninety seven percent of housing units are separate detached, 1.0% attached, and 1.0% improvised (**Table 7-22**). Most of the housing units had outer walls of concrete and blocks (76%), wood (12.9%) and a 6% made of a combination of wood and concrete (**Table 7-23**). Some 67%of households own their dwellings, while 17% live rent-free and 12% rented (**Table 7-24**).

Table 7-22: Middle HRWS Type of Housing Units

	Separate Detached	Attached Unit	Part of Commercial Building	Improvised Unit	Other Type	Not Reported	Total Housing Units
Petersfield	161	0	0	0	0	5	166
Content Gap	382	4	1	1	0	1	389
Gordon Town	1,125	15	4	11	0	10	1,165

Table 7-23: Middle HRWS Material of Outer Walls

	Concrete and Blocks	Stone and Brick	Nog	Wood	Wood and Concrete	Wood and Brick	Other/ Not Reported	Total Housing Units
Petersfield	98	0	7	52	3	0	6	166
Content Gap	311	0	8	28	35	1	6	389
Gordon Town	882	7	25	150	71	5	25	1,165

Table 7-24: Middle HRWS Housing Tenure

	Own	Leased	Rented	Rent Free	Squatted	Other*	Not Reported	Total Dwellings
Gordon Town	67.1	2.9	12.4	16.5	0.2	0.1	0.8	100
Rest of St. Andrew	69.1	2.0	10.8	16.2	0.6	0.0	1.2	100

Content Gap had 389 housing units, of which 98% are separate detached and 1% detached. Most of the housing units had outer walls of concrete and block (80%), while 13% were made of wood and 6% of wood and concrete.

Petersfield had 166 housing units, 97% separate detached and 1% attached. Consistent with all other areas, concrete and blocks were the most common material of outer walls, accounting for 59% of total number of units. This community had the highest percentage of housing with wood as material of outer walls with 31% of units constructed of wood (**Table 7-23**).

There was no available housing tenure data for the Petersfield and Content Gap communities, however the 2011 census reported housing tenure for areas of the Parish of St. Andrew as 69% owned, 15% rent-free, 11% rented and 2% leased **Table 7-24**.

7.2.2.2.3 Woodford/ Redlight/ Newcastle Housing

The communities of Woodford, Redlight and New Castle are located with the same enumeration district in the 2011 census and hence referred to a Woodford. Woodford had 444 housing units in 2011, of which 83% were separate detached and 13% attached units (**Table 7-25**). Some 71% of units had outer walls of concrete and blocks, 15% were made of wood and concrete and 10% of wood (**Table 7-26**).

Table 7-25: Upper HRWS Type of Housing Unit

	Separate Detached	Attached Unit	Part of Commercial Building	Improvised Unit	Other Type	Not Reported	Total Housing Units
Woodford	369	57	1	1	0	16	444

Source: STATIN, 2013

Table 7-26: Upper HRWS Material of Outer Walls

	Concrete and Blocks	Stone and Brick	Nog	Wood	Wood and Concrete	Wood and Brick	Other/ Not Reported	Total Housing Units
Woodford	315	0	1	44	65	1	19	444

Source: STATIN, 2013

7.2.2.3 Utilities

Water - NWC supplies water to the Kingston Metropolitan Area (KMA), maintained by flows for the Hope, Yallahs/Negro, Moresham, Boar, and Wag Water Rivers (NWC, 2016). Water sources in the KSA are inadequate to meet demands, especially during extended periods of drought conditions. In response the NWC implement rationing through lock-offs. There are four main treatment facilities which supply water to the KSA, these are Constant Spring Treatment Plant (CSTP), Mona Treatment Plant (MTP) Hope Filter Plant) and Seaview Treatment Plant. These are supplied by several other water supply distribution systems (tanks) in the KSA. Under the Jamaica Water Supply Improvement Project (JWSIP), the NWC has undertaken the improvement and upgrading of existing water supply systems (pipelines, treatments plants, water infrastructure fixtures etc.) across the Kingston Metropolitan Area, which includes the parishes of Kingston and St. Andrew.

According to the 2011 census, 71% of households in the parish of St. Andrew had public source piped into dwelling as their main source of water for domestic use, while 18% had public source piped into yard (**Table 7-27**). This is notably higher than water source at the National level and in the neighbouring parish of Kingston.

At the community level, Greenwich Town in the lower WMU, had 51% of households with public water piped into dwelling and 43% piped into the yard. The only other reported source was standpipe, utilised by 3% of households.

For selected communities in the middle WMU, the main sources of water for domestic use were more varied across multiple sources by community. In Gordon Town, the most populous of the communities, public source piped into dwelling (67%), yard (13%) and public source piped into dwelling (7%) were the most common sources. Three percent (3%) of households in Gordon Town had spring or river as their main source of water.

In Content Gap, 49% of households had public water piped into dwellings, and 11% piped into yard. Some 18% relied on public sources piped into dwelling while 7% relied on spring or river as their main source. Another 7% had catchment as their main source. The Petersfield community had the highest level of dependence on ecosystem services with 23% households having spring or river as their main source of water for domestic use. Some 31% of households had standpipe as their main source while 12% had public source piped into dwelling and another 12% piped into yard.

In Woodford, located in the upper WMU, 59% of households had public water piped into dwelling as their main of water for domestic use. Some 12% of households had public source piped into yard, 12% had private source piped into dwelling, 7% spring of river and 5% on catchment, as their main source.

Of note is the fact that between 3% to 23% of households in middle and upper watershed communities identified spring or river as their main source of water for domestic purposes, demonstrating direct dependence on the ecosystem services of the HRWS.

Table 7-27: Main Source of Water for Domestic Use, 2011

	Public Source				**Private Source**					
	Piped into Dwelling	**Piped into Yard**	**Standpipe**	**Catchment**	**Piped into Dwelling**	**Catchment**	**Spring or River**	**Trucked Water/ Water Truck**	**Other**	**Not Reported**
Jamaica	50	16	7	2	6	10	3	2	2	1
Kingston	51	40	2	1	2	0	0	0	1	2
St. Andrew	71	18	2	1	3	1	1	0	1	1
Greenwich Town	51	43	3	0	0	0	0	0	0	2
Petersfield	12	12	31	0	17	1	23	1	0	4
Content Gap	49	11	2	0	18	7	7	2	1	2
Gordon Town	67	13	2	0	7	1	3	0	4	2
Woodford	59	12	2	0	12	5	7	0	0	4

Source: Statin, 2013

Electricity - According to the 2011 Census an estimated 96% of households in St. Andrew had access to electricity; 4% below the national level. At the community level four of the five communities included in the study had between 91.5% and 93.7% access to electricity (**Table 7-28**). For Woodford, 43.8%; however, 42% of households did not report their source of lighting.

Table 7-28: Percent of Households by Source of Lighting

	Source of Lighting				
	Electricity	**Kerosene**	**Other**	**Not Reported**	**Total Households**
Jamaica	91.9	5.5	0.8	1.8	100
Kingston	95.9	0.9	0.5	2.7	100
St. Andrew	96.3	1.1	0.3	2.2	100
Greenwich Town	92.5	2.5	2.3	2.7	100
Woodford	43.8	1.1	12.9	42.2	100
Petersfield	88.8	6.2	0.6	4.5	100
Content Gap	93.7	4.5	0.9	0.9	100
Gordon Town	91.5	3.2	0.8	4.4	100

Sewage - The NWC is the primary provider of wastewater/ sewage services in Jamaica. The NWC currently operates fourteen (14) sewage treatment facilities in the parishes of Kingston and St. Andrew., including a 5mgd capacity primary treatment plant located in Greenwich Town. The communities in the middle and upper WMU are not connected to any of the existing treatment plants. Septic tanks and absorption pits are used as the main systems for the collection, treatment, and disposal of sewage from dwellings in these communities.

Solid Waste - MPM Waste Management Ltd. (MPM) is responsible for the collection and disposal of solid waste in the communities in the Hope River WMU. The MPM serves the parishes of Kingston and St. Andrew, St. Catherine, Clarendon and St. Thomas and is responsible for the management of the Riverton (Kingston) and Church Corner (St. Thomas) disposal sites.

According to 2011 census data, over 60% of households in the Content Gap (60%), Petersfield (65%) and Woodford (67%) communities dispose of their garbage by burning. In Gordon Town 45% burn their garbage while 19% dispose of garbage at a municipal site. Some 26% of households in Petersfield and 9% of those in Content Gap also reported disposing of garbage in sea/river/pond/gully.

8 Socioeconomic Survey

8.1 Survey Design

The socio-economic survey collected primary data on the communities' conditions and factors most likely to affect well-being, livelihoods, the natural environment, and ecosystem services. Information collected included household activities and practices that affect the ecosystem, non-household development and practices that affect the ecosystem, perceived value/importance of the ecosystem, vulnerability to climate-related risk, coping mechanisms, climate adaptation needs and governance of the ecosystem (existing/perceived system). Information was collected by means of a well-designed questionnaire (incorporating gender issues) which was administered in face-to-face interviews with heads of households or a household member 18 years and older who was able to represent the household head (see **Appendix 8**). Target participants were identified from various stakeholders' groups including community residents and business operators. A sample size was determined based on a combination of population data using a plus or minus 5-7 margin of error and a confidence level of 95%. Random convenience sampling was used to select participants. While personal interviews are noted to be associated with high costs and tend to be time intensive, they have the advantage of a high response rate and tend to be more favorable for open-ended questions. The interviews also facilitated building awareness of key concepts watershed and ecosystem concepts amongst participants who indicated lack of knowledge. The instrument used to collect the information is included in the Appendix.

A total of 183 interviews (99 in the lower watershed; 31 in the middle watershed; and 54 in the upper watershed) were conducted across all regions in October 2022. Data gathered was processed and analysed using statistical software (SPSS, Excel) and other software for spatial analysis (ArcGIS Pro). Findings are presented in the following sections.

8.2 Survey Results

8.2.1 Lower Watershed Management Unit

8.2.1.1 Respondent Profile

Greenwich Town

Age and Sex - A total of 99 interviews were conducted in the Greenwich Town community (42 within the community and at the 57 at the fishing beach). Surveys targeted the head of households, with 6.4% of households represented. Males accounted for 74% of respondents while females accounted for 26%. The average age of respondents was 52 years ranging from 23 years to 80 years old.

The 30-64 age group was the most represented age group among male respondents, accounting for 81% of respondents (**Table 8-1**). Seventeen percent of male respondents were 65 years and over, while 3% were aged 23-29 years. Among females, 81% were in the 30-64 years age group, similar to male participants. Fifteen percent (15%) were 65 years and over. While 4% were in the 23-29 age group.

Table 8-1: Age and sex distribution of Greenwich Town participants

		23-29	30-64	65 and over	Total
Number of Respondents	Male	2	58	12	72
	Female	1	21	4	26
Percent of Respondents	Male	3	81	17	100
	Female	4	81	15	100

Educational Profile - Approximately 15% of respondents obtained up to primary level education, while 74% attended up to secondary and 2% tertiary level. Some 4% attended junior high/secondary or vocational level education. The highest level of school attended was secondary for 75% of male respondents and 84% of female respondents. Approximately 8% of females attended up to tertiary level school.

Household Profile - Approximately 69% of respondents had households comprising 1-3 persons, while 26% had 4-6 persons, and 4% had 7-9 persons. The average household size was 2.7 persons. Al least 22% of households had one or more children living in them. Forty percent (40%) of household heads were in common law unions while 33% were single. Eight percent were married.

8.2.1.2 Economic Activity

Employment and Income - All but four of the persons interviewed in the Greenwich Town community lived in households with one or more persons employed. An estimated 54% of households had one person employed, 36% had two people in their household employed, while 7% had 3 people employed. Among those employed, 59% has full-time employment, 6% worked part-time, and 26% were self-employed (**Table 8-2**). The average weekly income of household head reported for all households was $30,363 JMD, while the average weekly income of the head of household partners was $23,383 JMD. Skilled agricultural & fishery worker was the most common occupation type, accounting for 48% of respondents, as expected for a community with an active fishing beach (**Table 8-4**). Service worker/ shop/ market and sales worker was the second most popular occupation (17%).

An estimated 60% male household heads being employed full time, 5% part time and 26% self-employed (**Table 8-2**). One percent of male household heads were however seasonally employed and 3% unemployed at the time of interview. In male headed households, average weekly income of the household head was $33,960, while their partners' income was $24,000. Incomes ranged from a minimum of $1,900 to a maximum of $100,000 weekly for male household heads, while partners' income ranged from $3,500 to $60,000. Skilled agricultural & fishery worker was the most common occupation type among male household heads (**Table 8-5**).

For female headed households, 58% of household heads were employed full time, 8% part time, 29% self-employed, while 4% were retired (**Table 8-3**). Average weekly income in female headed households were remarkably lower than their male counterparts. For the female household head, average weekly income among respondents was $20,196, and $21,357 for their partners. While minimum weekly income was higher ($5,000) for household heads, the maximum income was lower at $60,000, compared to the male household heads $100,000 maximum weekly income. The most popular occupation among female household heads was service worker/ shop/ market/ sales workers (**Table 8-5**).

Table 8-2: Employment status of household head (Greenwich)

Employment status of household head				
	Frequency	**Percent**	**Valid Percent**	**Cumulative Percent**
Full time	58	58.6	59.8	59.8
Part time	6	6.1	6.2	66.0
Self-employed	26	26.3	26.8	92.8
Seasonal	1	1.0	1.0	93.8
Unemployed	2	2.0	2.1	95.9
Retired	4	4.0	4.1	100.0
Total Responses	97	98.0	100.0	
Non-Response	2	2		
Total	99	100.0		

Table 8-3: Household head employment status by sex

Employment status of household head * Sex of head of household Cross tabulation				
Count				
		Sex of head of household		Total
		male	female	
employment status of household head	full Time	44	14	58
	part Time	4	2	6
	self-employed	19	7	26
	seasonal	1	0	1
	unemployed	2	0	2
	retired	3	1	4
Total		73	24	97

Table 8-4: Occupation of household head

Occupation of household head				
	Frequency	Percent	Valid Percent	Cumulative Percent
Professionals, Senior Officials and Technicians	3	3.0	3.3	3.3
Clerk	1	1.0	1.1	4.4
Service Workers, Shop, Market and Sales Workers	16	16.2	17.6	22.0
Skilled Agricultural & Fishery Worker	44	44.4	48.4	70.3
Crafts and Related Trade Workers	9	9.1	9.9	80.2
Plant & Machine Operators and Assemblers	4	4.0	4.4	84.6
Elementary Occupations	11	11.1	12.1	96.7
Occupation Not Stated	3	3.0	3.3	100.0
Total	91	91.9	100.0	
Non-Response	8	8.1		
Total	99	100.0		

Table 8-5: Occupation of household head by sex

Occupation of household head * Sex of head of household Cross tabulation				
Count				
		Sex of head of household		Total
		male	female	
Occupation of household head	Professionals, Senior Officials and Technicians	1	2	3
	Clerk	0	1	1
	Service Workers, Shop, Market and Sales Workers	5	11	16
	Skilled Agricultural & Fishery Worker	42	2	44
	Crafts and Related Trade Workers	9	0	9
	Plant & Machine Operators and Assemblers	4	0	4
	Elementary Occupations	5	6	11
	Occupation Not Stated	2	1	3
Total		68	23	91

Some 38% of participants reported owning their own business, 63% of which were male and 37% female. The types of businesses were mostly fishing, including catching fish, and vending (58% of total), retail/wholesale (21%), beauty services (1%) and restaurant/cook shop/bar (23%). Fishing was male dominated while retail/ wholesale had more females.

8.2.1.3 Housing and Land Tenure

Within the Greenwich Town Community

Approximately 42% of interviews were conducted in the Greenwich Town community. Among participants interviewed within the community, 50% have resided in the community for 30-49 years, while 17% have resided there for 50 or more years. An estimated 72% of residents reportedly owned (45%) or inherited (26%) the plot of land on which their dwelling sits, while 76% reportedly owned (55%) of inherited (21%) the dwelling. Another 14% lease or rent the plot of land and the dwelling. Lease and rent agreements range from one to five years with average monthly payments of $15,250.

Most dwellings were constructed with outer walls of concrete block and steel (69%). An estimated 21% were constructed of timber/board, while 10% were constructed of brick or a mix of materials. The condition of dwellings ranked by interviewers' observations based on the criteria listed below, were very good (10%), good (34%), fair (42%) and poor (15%).

- Very good: Sound physical structure, freshly painted. Doors and Windows are intact and looks good.
- Good: Structure good, may not be freshly painted, but in good physical condition.
- Fair: May or may not need painting, may have need for minor repairs.
- Poor: Structural damage, cracks, missing windowpanes or blades and doors.
- Very Poor: Not fit for human habitation.

Greenwich Town Fishing Beach

Among the 58% of participants interviewed at the fishing beach, 27% have been living/operating there for 40-49 years, while a combined 18% have been there for 20-39 years. An estimated 48% reportedly owned (34%) or inherited (14%) the structure at the beach that they occupy. Twenty percent (20%) occupy the structure rent-free with owner's permission, 11% occupy without the owner's permission. Others paid dues to occupy GOJ fishing quarters built for fishers. Only one respondent reported monthly payments on the beach of $10,000.

Structures were constructed with outer walls of concrete block and steel (54%); timber/board (30%), or other materials such zinc or a mix of materials (16%). Based on interviewers' observations, 67% of the structures were in fair to good condition, while 33% were in poor condition.

8.2.1.4 Utilities and Municipal Services

Water

Within the Greenwich Town Community

The main source of water among households within the Greenwich Town community was water piped into dwelling (67%) or piped into yard (23%). Approximately 10% of respondents reported using a community standpipe. Alternate sources of water, for example during service disruptions was storage in private drums or tanks (64%), trucked water (13%), purchased water (3%) and water from the Petrojam Refinery (15%) and other factories in the area (5%).

Greenwich Town Fishing Beach

The main source of water at the fishing beach was standpipe (46%), and water piped into yard (34%). An estimated 18% also reported having water piped into their structure/ houses, while 2% used trucked water stored in private tank or drums. Like those within the Greenwich Town community, those at the fishing beach used private drums, tanks, bottles, buckets, etc., as alternate source during service disruptions. A combined 44% obtained water from Petrojam (22%) or water truck (22%), while 5% purchase water. Some 4% of respondents reported having no alternate source of water.

Sewage/ Wastewater

Within the Greenwich Town Community

Approximately 69% of dwellings within the community had access to indoor flush toilet facilities (67% not shared and 2% shared). Another 21% had access to outdoor flush toilet, while 5% used pit latrines. Despite the location of a sewage treatment plant in the community, connection to the central sewer plant appeared low based on responses. An estimated 79% of respondent reported septic tank with soak away (14%) or absorption pit (68%) as the sewer type used at their dwellings, while only 12% reported being connected to the central sewer system.

Greenwich Town Fishing Beach

Absorption pit, septic tank with soak away were identified as the type of sewage disposal used at the beach, accounting for 37% and 9% of respondents, respectively. Some 39% reported connection to the central sewer, 9% reported none, and 2% other (cesspool truck and waste thrown into the ocean).

Solid Waste

Within the Greenwich Town Community

The main method of garbage disposal was collection by garbage truck, utilised by 86% of households. Burning (7%) and Burying (2%) were other reported methods.

Greenwich Town Fishing Beach

Garbage truck collects the solid waste of over 67% of respondents at the beach, while 18% burn their waste. Another 2% dumping in the gully.

8.2.1.5 Community Organisation and Social Linkages

An estimated 25% of respondents indicated that there are active community groups in the Greenwich Town community. Some were considered active (22%), very active (3%), or inactive (16%). Fourteen percent (14%) of respondents also believed that these community groups are effective while 8% thought they were ineffective. When asked about membership to community organisations, 30% of participants reported belonging to a community group. The groups identified were:

- Citizens Association/Community Action Group (1%)
- Fisherman Group/Cooperative (14%)
- Benevolent Society/CBO (6%)
- Church (1%)
- Community Centre/Training Institute (1%)

8.2.1.6 Ecological Assessment

Understanding of watershed and Ecosystems - Over half (55%) of Greenwich Town participants had no understanding on the concept of a watershed. However, after an explanation, 66% stated that they understood its importance. In terms of the HRWS, 62% thought that the watershed was not being effectively managed. Ways they thought the management of the HRWS could be improved included:

- Improve monitoring and enforcement to include use of rangers/wardens (1%)
- River training (1%)
- Utilise retaining walls/gabion baskets (4%)
- Improve sanitation practices to include the provision of skips (2%)
- Dam cleaning and maintenance (1%)
- Planting/replanting trees (2%)
- Debushing activities (2%)
- Not sure/don't know how management of watershed can be improved (1%)
- Take better care of the environment (1%)
- Drain cleaning (4%)
- Improve drainage (1%)
- Build/improve storage of water for community community/increase the number of dams (1%)

Almost half of participants stated that they did not understand the concept of ecosystems. This would have prompted the interviewer to provide an explanation of the concept before moving on. After the explanation, 85% noted that they depend on the ecosystem for goods and services. This is expected given the importance of fishing to the community.

8.2.1.6.1 Dependence on Ecosystem Services

Dependence on the ecosystem correlated to two main ecosystem services, regulating and provisioning. Approximately 62% of total participants noted services/resources they get from the ecosystem, with many identifying multiple services. An estimated 98% of respondents identified provisioning services, such as water, fisheries, livelihoods, food (crops, farming, chickens, fish), raw material (wood for charcoal) from the ecosystem. Additionally, 9% noted clean air and clean water (regulating function of the ecosystem).

The list of ecosystem services and an explanation of each was provided to participants. They were then asked to rank the importance of these services to their community. As shown in Error! Reference source not found., (**Table 8-6**) the highest proportion of respondents thought the ecosystem services were very important. Consistent with the ecosystem services that respondents identified as those on which they were most dependent, receiving, provisioning, and regulating services ranked the highest importance.

Table 8-6: Importance of ecosystem services ranked.

	Not Important	**Somewhat Important**	**Important**	**Very Important**	**I don't Know/ No Response**	**Total**
Regulating	5.1	6.1	35.4	49.5	4	100
Supporting	4	5.1	32.3	53.5	5	100
Cultural	2	11.1	38.4	42.4	6	100
Provisioning	3	6.1	28.3	58.6	4	100
Average	3.5	7.1	33.6	51.0	4.8	100

When asked what activities they observe in the community and the broader HRWS that are detrimental to the ecosystem, 51% identified improper disposal of solid waste (**Table 8-7**), while 14% identified, pollution from sewage and effluent from large companies.

Table 8-7: Activities observed in the community /broader Hope River watershed that are detrimental to the ecosystem.

Activities observed in the community/ broader Hope River watershed that are detrimental to the ecosystem (e.g., land clearing for farming, diversion of water, invasive species)		
	Frequency	**Percent**
Improper disposal of solid waste	50	51
Land clearing for farming	5	5
Pollution from sewage and effluent from large companies	14	14
Pollution from farming related activities	5	5
Increase in construction /squatting	3	3
Burning of garbage	1	1
Pollution from fishing related activities	1	1
None observed	15	15
Infrequent garbage collection	2	2
Deforestation	3	3
Total	99	100

Observed land use change and ecosystems - Participants were also asked how land use changes have affected the ecosystem services in the past 5-10 years. Increase in the number of houses/ranches/shacks and squatting was identified by 14% of respondents. Eleven percent (11%) cited pollution, and 7% cited reduced fish populations. The full list of responses is provided in **Table 8-8**.

Table 8-8: Ways land change use has affected ecosystem services in past 5-10 years.

Activities in the community /broader Hope River watershed that are detrimental to the ecosystem		
	Frequency	**Percent**
No change observed	7	7
Increase landslides	1	1
More pollution	11	11
Deforestation	3	3
Increase in the number of houses/ranches/shacks /squatting	14	14
More infrastructure	5	5
Displacement or migration of fish	1	1
Increased flooding	4	4
Destruction of mangroves	2	2
Reduced fish populations	7	7
Increase in fish kill	1	1
Reduced rainfall and inflows in river	2	2
Increase in temperature	6	6
Erosion	2	2
Loss of Flora and fauna	2	2
Don't Know or not sure	31	31
Total	99	100

8.2.1.6.2 Perception of climate-related risks and hazards

Sixty-seven percent (67%) of Greenwich Town respondents have experienced climate-related, natural/ environmental hazard impacts in the community. When asked about specific hazards, flooding and tropical storms/ hurricanes were the most common hazards experienced (**Table 8-9**). At the time of the survey, 13% of respondents indicated that they had experienced their most recent hazards less than a month ago, 26% 1-6 months before and 16% over one year but less than 2 years ago. Flooding, tropical storm, turbid waters, rough seas, fish kill, and heat were identified as most recent hazard impacting the community.

Table 8-9: Climate-related hazards experienced in community.

Hazard	% Respondents
Flooding	47
Landslide	1
Earthquake	1
Tropical Storms/ Hurricanes	24
Bush Fire	1
Excess Dust	7
Water Contamination	10
Other: High tide; storms; rough seas	9
Other: Decrease fishing population	1
Other: Deforestation	0
Other: Heat	1

The climate specialist identified potential hazards of climate change projected to impact Jamaica. Participants were asked to state if their household had been impacted by these hazards in the past 5-10 years. The top three impacts experienced by respondents were higher temperatures (68% of respondents), more frequent flooding (34%), changes in the 1-day maximum intensity of rainfall (10%) and Increase in the maximum sustained wind speeds and rainfall associated with hurricanes (10%) (**Table 8-10**).

Table 8-10: Climate-related hazards experienced in the last 5-10 years

Climate-related hazards	% Respondents
More Frequent Flooding	34
Changes in 1-day maximum intensity of rainfall	10
More Severe and longer lasting droughts	8
Increase in the maximum sustained wind speeds and rainfall associated with hurricanes	10
Drying of the watershed	2
Higher temperatures	68
Other: Lower temperatures	0
Other: more landslides, changing course of river	0

Most frequent natural/environmental-related hazards - Participants also ranked the hazards they perceived to affect the community most frequently. Flooding and higher temperatures were the hazards that most frequently impacted the Greenwich Town community (**Table 8-11).**

Table 8-11: What climate-related or natural/ environmental hazards do you think affect the community most? Please rank by frequency with 1 being most frequent: NUMBER 4

Rank	Hazard Type and % respondents ranking	
1 – most frequent hazard	Flooding (28%)	Higher Temperatures (22%)
2 – 2nd most frequent hazard	Increase storms/ hurricanes (12%)	Flooding (9%)
3 – 3rd most frequent hazard	Increase storm/ hurricanes (3%)	Higher temperature (2%)
4 – 4th most frequent hazard	Flooding (5%)	Excess dust (1%)

Contributors to climate-related hazards - Ways residents contribute to the climate-related, natural/ environmental hazards experienced in the Greenwich Town community, included:

- Deforestation (3%)
- Construction (13%)
- Dumping of garbage (37%)
- Sewage (11%)
- Use of chemicals (pesticides and fertilisers (2%)
- Blocked drains with construction materials (2%)
- Gas from factory (1%)

The perceived reasons given for deforestation were housing (identified by 17% of respondents), charcoal (7%), and furniture (1%).

An estimated 56% of respondents also believed that residents contribute to climate-related, natural/environmental hazards in the community. Over 61% of respondents thought that residents' actions that contribute to climate-related, natural/ environmental hazards were due to ignorance (22%), lack of care (19%) and lack of alternative (20%). Others attributed it to cultural practices.

Some steps that respondents thought could be effective in changing behaviours are provided in:

- Educational workshops (42%)
- Increase alternatives (34%)
- Financial support (28%)
- Denouncement of action (30%)
- Regulations and enforcement (24%)
- Nothing (2%)
- Other: community environmental club, employment, more cleaning of the sea, education (6%)

8.2.1.6.3 Ecosystem Protection

Protective services of the ecosystem - Forty percent (40%) of respondents believed that the ecosystem protected the community from hazards/ disasters experienced. **Table 8-12** lists some ways the ecosystem has provided protection to the community.

Table 8-12: Ways the ecosystem has protected the community from any of the disasters/hazards experienced.

Ecosystem protection	Frequency	Percent
Trees protect from breeze/wind	2	2.0
Trees cool temperature	1	1.0
Reefs protect shoreline	6	6.1
Ecosystem Provides Food, Water, Clothing and Shelter	3	3.0
Mangroves Protect Shoreline and helps prevent Flooding	13	13.1
Ecosystem protects fish	1	1.0
Ecosystem provides fresh air	2	2.0
Ecosystem protects from flooding/landslide	3	3.0
Provides buffer against storm surge, winds	3	3.0
Wind from the ocean keeps the beach cool	1	1.0
No flooding in beach area	1	1.0
No response	63	63.6
Total	99	100.0

Some 51% of respondents believed that their households continued to be vulnerable to climate-related, natural/ environmental hazards (**Table 8-13**). The level of vulnerability varied across respondents. An estimated 27% believed their households were vulnerable, 13% moderately vulnerable, and 11% very vulnerable to climate-related hazards.

Table 8-13: Perceived vulnerability to climate-related hazards

	Frequency	Percent
Very vulnerable	11	11
Vulnerable	27	27
Moderately vulnerable	13	13
Low vulnerable	11	11
Not vulnerable	24	24
No response	13	13
	99	100

However, they are aware of some measures that have been taken by the community or other representatives to protect and preserve the ecosystem:

- Proper Garbage Disposal (2%)
- Beach Clean-up Activities (6%)
- Build Garbage Disposal Skips (3%)
- Cleaning of Drains (1%)
- Planting of Trees (1%)
- Planting of Crops and Flowers (1%)
- Dump up Yard with Dirt/Marl (5%)
- Maintaining Mangroves (1%)
- Use of Sandbags (2%)
- Climate Change Adaptation Project (1%)
- Build Small Drains in Yard (1%)

An estimated 34% of respondents were also aware of how many of the protection measures were financed. Financing mechanisms included:

- Households/ Individuals (9%)

- Political Representatives (1%)
- Government Agencies (RADA, JSIF, Forestry Dept., JAS) (15%)
- Environmental Foundation of Jamaica (EFJ) (1%)
- Petrojam (4%)
- Collaboration between Community Members (2%)
- Church assistance (1%)
- School assistance (1%)

An estimated 80% of participants believed that the protection of the ecosystem should be the responsibility of both residents and the government. Some 11% believed that ecosystem protection should be the responsibility of the government, while 3% believed that it should be the responsibility of residents. Respondents also suggested actions to protect the ecosystem (**Table 8-14**).

Table 8-14: Recommended ecosystem protection measure

Recommended ecosystem protection measures	# of Responses	% of Participants *
Improve garbage disposal/ waste management (encourage recycling; increase the number of garbage receptacles/skips across the community; and increase collection frequency)	23	23.2
Education/ Training/ Community outreach and sensitisation	15	15.2
Improve drainage system; more frequent cleaning of drains and gullies	14	14.1
Monitoring and enforcement ("consider establishing environmental wardens in communities"; "stronger penalties against companies")	13	13.1
Community cleanup	5	5.1
Engineering solutions - retaining walls; coastline protection	4	4.0
Prevent dumping in rivers and gullies and the ocean	4	4.0
Increase efforts at ecosystem protection	3	3.0
Prevent sewage flow into the Harbour	3	3.0
Prevent/Reduce burning	3	3.0

Recommended ecosystem protection measures	# of Responses	% of Participants *
Reforestation (including planting more fruit trees)	3	3.0
Stricter regulations: increase penalties against dumping of Petrojam chemicals; Increase penalties for illegal dumping; discharging raw sewage into the Harbour	3	3.0
Build capacity in the community for sound environmental practice and management	3	3.0
Community action and partnership among users to protect the ecosystem. Regular meetings involving multiple communities across the watershed	2	2.0
Community/Government/Business partnership	2	2.0
Foster community pride in the environment (encourage the youth to protect the ecosystem; start in schools)	2	2.0
Alternative employment	1	1.0
Cleanup fishing village	1	1.0
Conservation (prevent overfishing by finding alternate means of employment)	1	1.0
Improve practices at factories	1	1.0
Improve water catchment management	1	1.0
Incentivise conservation in communities; penalise those who cause harm to the environment	1	1.0
Reduce pollution	1	1.0
Implement marine garbage collection using "garbage boat"	1	1.0
Funding for beach cleanup activities	1	1.0
Improve infrastructure	1	1.0

**Note - Total percent sums to more the 100% due to multiple responses*

8.2.1.7 Middle Watershed Management Unit

Gordon Town/Content Gap/Petersfield

8.2.1.7.1 Respondent Profile

Age and Sex - A total of 31 interviews were conducted in three communities in the middle Hope River WMU (17 in Gordon Town, 11 in Content Gap and 3 in Petersfield). Surveys targeted the head of households, representing 1.8% of households. Males accounted for 65% of respondents while females accounted for 36%. The average age of respondents was 51 years ranging from 20 years to 93 years old.

The 30-64 age group was the most represented age group among male respondents, accounting for 65% of respondents (**Table 8-15**). An estimated 25% of male respondents were 65 years and over, while 10% were aged 20-29 years. Among females, 82% were in the 30-64 years age group, while the remaining 18% were 65 years and over.

Table 8-15: Age and sex by percent Middle Watershed household heads

		23-29	30-64	65 and over	Total
Number of Respondents	Male	2	13	5	20
	Female	0	9	2	11
Percent of Respondents	Male	10	65	25	100
	Female	0	82	18	100

Educational Profile - Approximately 42% of respondents obtained up to secondary level education, while 32% attended up to tertiary level. The remaining 25% responded other or did not report. The highest level of school attended was secondary for 50% of male and female household heads. Approximately 36% of males and 40% of females attended up to tertiary level school.

Household Profile - Approximately 77% of respondents had households comprising 1-3 persons, while 13% had 4 persons, 7% had 5 persons, and 3% had 8 persons. The average household size was 2.6 persons. At least 28% of households had one child or more living in them. Forty-seven percent (47%) of household heads were single, while 25% were married. Eight percent were married.

8.2.1.7.2 Economic Activity

Employment and Income - All but four of the people interviewed in the middle watershed communities lived in households with one or more persons employed. Fifty percent (50%) of households had one person employed, 28% had two people in their household employed, while 3% had 3 people employed, and 3% had 7 persons in the same household employed. Among those employed, 46% had full-time employment, 7% worked part-time, and 26% were self-employed (**Table 8-16**).

The average weekly income of household head reported for all households was $45,060 JMD, while the average weekly income of the head of household partners was $47,500 JMD. Professionals, Senior Officials and Technicians were the most common occupation type, accounting for 25% of respondents (**Table 8-17**). Service worker/shop/market and sales worker was the second most popular occupation (19%).

An estimated 45% of male household heads were employed full time, 5% part time and 25% self-employed. Five percent of male household heads were unemployed, and 20% retired at the time of interview. In male headed households, average weekly income of the household head was $48,161, while their partners' income was $39,375. Incomes ranged from a minimum of $15,000 to a maximum of $130,000 weekly for male household heads, while partners' income ranged from $10,000 to $90,000. Professionals, Senior, Officials and Technicians was the most common occupation type among male household heads (**Table 8-19**).

For female headed households, 45% of household heads were employed full time, 9% part time, 27% were self-employed, 9% was unemployed and 9% retired (**Table 8-19**). Average weekly income in female headed households were remarkably lower than their male counterparts. For the female household head, average weekly income among respondents was $38,854, and $80,000 for their partners. While minimum weekly income for female household heads was lower at $8,000, the maximum was $150,000 was higher than the income of male household heads. The most popular occupations among female household heads were service worker/ shop/ market/ sales workers and Professionals, Senior Officials and Technicians **(Table 8-19**).

Table 8-16: Employment status of household head (Middle Watershed)

Employment status of household head					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid		Frequency	Percent	Valid Percent	Cumulative Percent
	full Time	14	45.2	45.2	45.2
	part Time	2	6.5	6.5	51.6
	self-employed	8	25.8	25.8	77.4
	unemployed	2	6.5	6.5	83.9
	retired	5	16.1	16.1	100
	Total	31	100	100	

Table 8-17: Household head employment status by sex

Employment status of household head * Sex of head of household Cross tabulation				
Count				
		Sex of head of household		Total
		male	female	
employment status of household head	full Time	9	5	14
	part Time	1	1	2
	self-employed	5	3	8
	unemployed	1	1	2
	retired	4	1	5
	Total	20	11	31

Table 8-18: Occupation of household head

occupation of household head					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Professionals, Senior Officials and Technicians	8	25.8	33.3	33.3
	Service Workers, Shop, Market and Sales Workers	5	16.1	20.8	54.2
	Skilled Agricultural & Fishery Worker	2	6.5	8.3	62.5
	Crafts and Related Trade Workers	3	9.7	12.5	75
	Plant & Machine Operators and Assemblers	3	9.7	12.5	87.5
	Elementary Occupations	2	6.5	8.3	95.8
	Occupation Not Stated	1	3.2	4.2	100
	Total	24	77.4	100	
	No Response	7	22.6		
		31	100		

Table 8-19: Occupation of household head by sex

occupation of household head * Sex of head of household Cross tabulation Count				
		Sex of head of household		Total
		male	female	
occupation of household head	Professionals, Senior Officials and Technicians	5	3	8
	Service Workers, Shop, Market and Sales Workers	1	4	5
	Skilled Agricultural & Fishery Worker	2	0	2
	Crafts and Related Trade Workers	3	0	3
	Plant & Machine Operators and Assemblers	3	0	3
	Elementary Occupations	0	2	2
	Occupation Not Stated	1	0	1
Total		15	9	24

Some 19% of participants reported owning their own business, 50% of which were male and 50% female. The types of businesses included a backyard garden and rental of property, bar/game shop, barber shop, grocery shop/meat mart, sell retail items (bleach and fabric softener), shopkeeper.

8.2.1.7.3 Housing and Land Tenure

Survey participants in the middle watershed communities have resided in their communities for between one and 63 years. A combined 43% have resided in the community for 30-49 years, while 17% have resided there for 50 or more years. An estimated 80% of residents reportedly owned (74%) or inherited (16%) the plot of land on which their dwelling sits. For the dwelling, 74% reportedly owned and (10%) inherited the dwelling in which they reside. Another 3% rent the plot of land, while 7% rented their dwellings. Rent agreements range from one to two years with average monthly payments of $50,500.

Most dwellings were constructed with outer walls of concrete block and steel (97%), while the others were constructed of mix of concrete/ block and steel and timber/board. The condition of dwellings ranked by interviewers' observations based on the criteria listed below, were very good (29%), good (48%), and fair (19%).

> Very good: Sound physical structure, freshly painted. Doors and Windows are intact and looks good.
>
> Good: Structure good, may not be freshly painted, but in good physical condition.
>
> Fair: May or may not need painting, may have need for minor repairs.
>
> Poor: Structural damage, cracks, missing windowpanes or blades and doors.
>
> Very Poor: Not fit for human habitation.

Utilities and Municipal Services

Water - The main source of water among households in the middle HRWS communities was water piped into dwelling (97%), and private tank/drum (rainwater catchment) (3.2%). Alternate sources of water, for example during service disruptions were private catchment (tanks, bottle, buckets, drums, etc.) utilised by 45% of respondents. An estimated 16% identified natural spring/ stream as their alternate source while 10% reported not having any water problems.

Sewage/ Wastewater - Approximately 93% of dwellings within the communities had access to indoor flush toilet facilities (90% not shared and 3% shared). Outdoor flush toilet shared and not shared were the only other toilet facility reported. An estimated 58% of respondent reported absorption pit as the type of sewage system used by their household. Another 29% identified septic tank with soak away, while 10% identified central sewer and 3% other.

Solid Waste - The main method of garbage disposal was collection by garbage truck, utilised by 45% of households. Burning (42%), dump in river (3%) and other 7%) were other methods of garbage disposal used by households.

Community Organisation and Social Linkages

Participants indicated that each of the communities of the middle HRWS have active community organisations. As shown in **Table 8-20**, 71% of respondents indicated that Gordon Town has active or very active community groups. The Gordon groups were ranked as effective to very effective (**Table 8-21**). In Content Gap, 33% of respondents indicate active and very active community groups. However, no opinion was given on their effectiveness. In Petersfield, 33% of respondents indicated that there were active groups in the community, however the group was deemed ineffective. When asked about membership to community organisations, respondents in all three communities had membership in community groups. The groups identified were:

- Gordon Town: Gordon Town Association / Gordon Town Citizen Association
- Content Gap: JAS and SDC
- Petersfield: Farmers Field School; RADA, JAS

Table 8-20: Community Organisation activity ranking

Would you describe these groups that you have identified as (select 1 from each category) - Status * Community Cross tabulation					
Count					
		Community			Total
		Gordon Town	Content Gap	Petersfield	
Would you describe these groups that you have identified as (select 1 from each category) - Status	Active	8	1	1	10
	Very Active	4	1	0	5
	Inactive	1	0	0	1
	No Response	4	4	2	10
Total		17	6	3	26

Table 8-21: Community Organisations effectiveness ranking

Would you describe these groups that you have identified as (select 1 from each category) - Effectiveness * Community Cross tabulation					
Count					
		Community			Total
		Gordon Town	Content Gap	Petersfield/ Petersfield	
Would you describe these groups that you have identified as (select 1 from each category) - Effectiveness	Effective	6	0	0	6
	Very Effective	2	0	0	2
	Not Effective	0	0	1	1
	No Response	7	6	2	15
Total		15	6	3	24

8.2.1.7.4 Ecological Assessment

Understanding of watershed and Ecosystems - Understanding of the concepts of watershed and its importance was high among participants in the middle watershed communities.

Approximately 75% of respondents indicated that they understood the concept of a watershed. After an explanation, 91% stated that they understood the importance of watersheds. As it relates to the HRWS, 47% thought that the watershed was being effectively managed, while 47% believed that it was not. Ways they thought the management of the HRWS could be improved included:

- Improve monitoring and enforcement to include use of rangers/wardens (25%)
- River training (925%)
- Utilise retaining walls/gabion baskets (6%)
- Improve sanitation practices to include the provision of skips (9%)
- Dam cleaning and maintenance (3%)
- Planting/replanting trees (6%)
- Not sure/don't know how management of watershed can be improved (9%)
- Reduce the number of houses in watershed (3%)
- Education & Training (13%)

Understanding of the concept of ecosystem was also high among respondents with 75% indicating an understanding. After the explanation of the concept to the 31% of respondents who did not understand the concept, 63% noted that they depend on the ecosystem for goods and services.

8.2.1.7.4.1 Dependence on Ecosystem Services

Dependence on the ecosystem correlated to two main ecosystem services, regulating and provisioning. Approximately 44% of total participants noted services/resources they get from the ecosystem, with many identifying multiple services. The ecosystem services that respondents identified included provisioning services, such as water, farming / livelihoods, food. Additionally, the regulating services of clean air and clean water the protection of nature.

The list of ecosystem services and an explanation of each was provided to participants. They were then asked to rank the importance of these services to their community. As shown in **Table 8-22**, the highest proportion of respondents thought the ecosystem services were very important. The ecosystem services ranked highest among respondents were supporting and provisioning.

Table 8-22: Importance of ecosystem services ranked.

	Not Important	Somewhat Important	Important	Very Important	I don't Know/ No Response	Total
Regulating	15.6	9.4	12.5	59.4	3.1	100
Supporting	3.1	9.4	9.4	71.9	6.3	100
Cultural	6.3	25.0	6.3	56.3	6.3	100
Provisioning	31.3			62.5	6.3	100
Average						100

When asked what activities they observe in the community and the broader HRWS that are detrimental to the ecosystem, 44% identified improper disposal of solid waste (**Table 8-23**), while 22% identified, land clearing for farming.

Table 8-23: Activities observed the community /in broader Hope River watershed that are detrimental to the ecosystem

What are some activities you observe in your community /in broader Hope River watershed that are detrimental to the ecosystem (e.g., land clearing for farming, diversion of water, invasive species)		
	Frequency	Percent
Improper disposal of solid waste	14	43.8
land clearing for farming	7	21.9
Pollution from farming related activities	3	9.4
Increase in construction /squatting	1	3.1

What are some activities you observe in your community /in broader Hope River watershed that are detrimental to the ecosystem (e.g., land clearing for farming, diversion of water, invasive species)		
	Frequency	Percent
Pollution from fishing related activities	2	6.3
None observed	1	3.1
deforestation	2	6.3
sand mining	1	3.1
Total	31	96.9

8.2.1.7.4.2 Observed land use change and ecosystems

Participants were also asked how land use changes have affected the ecosystem services in the past 5-10 years. Increase in the number of houses/ranches/shacks and squatting was identified by 14% of respondents. Eleven percent (11%) cited pollution, and 7% cited reduced fish populations. The full list of responses is provided in **Table 8-24**

Table 8-24: Ways land change use has affected ecosystem services in past 5-10 years.

Activities in the community /in broader Hope River watershed that are detrimental to the ecosystem		
	Frequency	Percent
No change observed	7	21.9
Increase landslides	2	6.3
More pollution	1	3.1
Increase in the number of houses/ranches/shacks /squatting	6	18.8
Increase rainfall	2	6.3
Reduced rainfall and inflows in river	7	21.9
Increase in temperature	1	3.1
Loss of Flora and fauna	2	6.3
Don’t know or not sure	3	12.5

Activities in the community /in broader Hope River watershed that are detrimental to the ecosystem		
	Frequency	Percent
Total	31	100

8.2.1.7.4.3 Perception of climate-related risks and hazards

Eighty-one percent (81%) of respondents have experienced climate-related, natural/ environmental hazard impacts in the community. When asked about specific hazards, land slippage/ landslides and fires were the most common hazards experienced (**Table 8-25**). At the time of the survey, 38% of respondents indicated that they had experienced their most recent hazards less than a month ago, 44% experienced a hazard 1-6 months before. 6% experienced it 7-12 months prior, and 9% over year but less than 2 years ago. Landslides, road breakaway and tropical storms, were identified as the most recent hazard impacting the community.

Table 8-25: Climate-related hazards experienced in community

Hazard	% Respondents
land slippage/landslides	8
Flooding	2
Restrictions due to hazard	2
Fires	5
Displacement	1
Total	18

The climate specialist identified potential hazards of climate change projected to impact Jamaica. Participants were asked to state if their household had been impacted by these hazards in the past 5-10 years. The top three impacts experienced by respondents were higher temperatures (68% of respondents), more frequent flooding (34%), changes in the 1-day maximum intensity of rainfall (10%) and Increase in the maximum sustained wind speeds and rainfall associated with hurricanes (10%) (**Table 8-26**).

Table 8-26: Climate-related hazards experienced in the last 5-10 years

Climate-related hazards	% Respondents
More Frequent Flooding	15.6
Changes in the 1-day maximum intensity of rainfall	25.0
More Severe and longer lasting droughts	15.6
Increase in the maximum sustained wind speeds and rainfall associated with hurricanes	-
Drying of the watershed	50.0
Higher temperatures	18.8
Other: more landslides, trying to change the course of the river, closing the catchment piped that blocks to build riverbed	3.1

Most frequent climate -related hazards - Participants also ranked the hazards they perceived to affect the community most frequently. Landslides and drying of the watershed/less water in the river, were the hazards that most frequently impacted the communities (**Table 8-27**).

Table 8-27: What climate-related or natural/ environmental hazards do you think affect the community most? Please rank by frequency with 1 being most frequent

Rank			
1 – most frequent hazard	**2 – 2nd most frequent hazard**	**3 – 3rd most frequent hazard**	**4 – 4th most frequent hazard**
Landslides (62.5%)		Drought (3.1%)	Flooding (3.1%)
Increase/ intense rainfall (9.4%)	Landslides (18.8%)	Bushfires (3.1%)	Increasing winds (3.1%)
Flooding (6.3%)	Drying of the watershed/Less water in river (12.5%)	Higher temperatures (6.2%)	
Drying of the watershed/ less water in river (6.3%)	Flooding (9.4%)	Fire 3.1%)	

Rank			
1 – most frequent hazard	**2 – 2nd most frequent hazard**	**3 – 3rd most frequent hazard**	**4 – 4th most frequent hazard**
	Fire (9.4%)	Environmental pollution (Oil and Chemical, solid) (3.1%)	
Increase storms/ hurricanes (3.1%)	Environmental pollution (Oil and Chemical, solid) (6.3%)	Increase / intense rainfall (3.1%)	
	Increase / intense rainfall (6.3%)	Increase Storms/hurricanes (3.1%)	
	Drought (3.1%)	Deforestation (6.3%)	
	Bushfires (3.1%)		
	Higher temperatures (3.1 %)		

Contributors to climate-related hazards - Ways residents contribute to the climate-related, natural/ environmental hazards experienced in the Greenwich Town community, included:

- Diverting waterway (6.3%)
- Deforestation (50%)
- Construction (3.2%)
- Dumping of garbage (15%)
- Use of chemicals (pesticides and fertilisers) (6.3%)
- Improper undercutting of slope (3%)

The perceived reasons given for deforestation were housing (identified by 53% of respondents), farming (22%), and fence posts (6.3%).

An estimated 75% of respondents also believed that residents contribute to climate-related, nature/environmental hazards in the community. Respondents thought that residents' actions that contribute to climate-related, natural/ environmental hazards were due to ignorance (31%), lack of care (31%), lack of alternative (13%) and lack of regulation, lack of reasoning/critical thinking (3%)

Some steps that respondents thought could be effective in changing behaviours are:

- Educational workshops (47%)
- Increase alternatives (38%)
- Financial support (3%)
- Community denouncement of action (6%)
- Regulations and enforcement (50%)
- Nothing (44%)

8.2.1.7.4.4 Ecosystem Protection

Protective services of the ecosystem - Seventy- two percent (72%) of respondents believed that the ecosystem protected the community from hazards/disasters experienced. **Table 8-12 Table 8-28** lists some ways the ecosystem has provided protection to the community.

Table 8-28: Ways the ecosystem has protected the community from any of the disasters/hazards experienced

Ecosystem protection	**Frequency**	**Percent**
Trees holds soil and help prevent landslides	11	34.4
Trees protect from breeze/wind	1	3.1
Trees Cool Temperature	2	6.3
Ecosystem Provides Food, Water, Clothing and Shelter	1	3.1
Trees Helps Prevent Flooding	1	3.1
Ecosystem protects from flooding/landslide	2	6.3
Less Drought	1	3.1
Trees Planted	1	3.1
Ecosystem Provides Fresh Air	1	3.1

Some 44% of respondents believed that their households continued to be vulnerable to climate-related, natural/ environmental hazards (**Table 8-29** and **Table 8-27**). Twenty-five percent (25%) thought they were moderately vulnerable, and 19% believed they were vulnerable.

Table 8-29: Perceived vulnerability to climate-related hazards

	Frequency	Percent
vulnerable	6	18.8
moderately vulnerable	8	25.0
low vulnerable	5	15.6
not vulnerable	13	40.6
Total	32	100.0

Some measures that have been taken by the community or other representatives to protect and preserve the ecosystem.

- Build Retaining Walls (3%)
- Proper Garbage Disposal (6%)
- Build Garbage Disposal Skips (6%)
- Planting of Trees (28%)
- River Training (3%)

An estimated 28% of respondents were also aware of how many of the protection measures were financed. Financing mechanisms included:

- By households
- Forestry Department
- Government people come and enforce rules like no bathing in the river etc.

- Government through Forestry Department
- Government/funding agency
- MP (Member of Parliament)
- RADA, JAS, Forestry
- Residents fund most of the projects
- Seems to be political or NGO

An estimated 88% of participants believed that the protection of the ecosystem should be the responsibility of both residents and the government. Some 6% believed that ecosystem protection should be the responsibility of the government, while 3% believed that it should be the responsibility of residents. Respondents also suggested a number of actions to protect the ecosystem (**Table 8-30**).

Table 8-30: Recommended ways to protect the ecosystem

Recommended ecosystem protection measures	**# of Responses**	**% of Participants ***
Better land use practices (zoning for specific use, conservation)	3	9.7
Create and enforce riparian buffer around riverbanks to prohibit construction of houses along riverbanks	2	6.5
Education/ community outreach and sensitisation	6	19.4
Improve garbage disposal/ waste management	3	9.7
Legislation	1	3.2
Monitoring and enforcement	7	22.6
Not sure/No Response	2	6.5
Reforestation	7	22.6
Regulate activities in rivers/streams ("limit swimming, fishing,	1	3.2

Recommended ecosystem protection measures	# of Responses	% of Participants *
and sand mining to certain days of the week")		
Community improvement (solar energy, road improvement, carpooling, water management, increase farming)	1	3.2
Increase number of rangers monitoring and enforcing	1	3.2
Manage existing trees	1	3.2

**Note - Total percent sums to more the 100% due to multiple responses*

8.2.1.8 Upper Watershed Management Unit

Woodford/ Redlight/ New Castle

8.2.1.8.1 Respondent Profile

Age and Sex - A total of 54 interviews were conducted in three communities in the upper Hope River WMU (28 in Woodford, 3 in New Castle and 23 in Redlight). Surveys targeted the head of households, representing 12.2% of households. Males accounted for 67% of respondents while females accounted for 33%. The average age of respondents was 54 years ranging from 26 years to 92 years old.

The 30-64 age group was most represented age group among male respondents, accounting for 75% of respondents (**Table 8-31).** An estimated 22% of male respondents were 65 years and over, while 3% were aged 26-29 years. Among females, 78% were in the 30-64 years age group, while the remaining 22% were 65 years and over.

Table 8-31: Age and sex by percent Middle Watershed household heads

		26-29	30-64	65 and over	Total
Number of Respondents	Male	1	27	8	36
	Female	0	14	4	18
Percent of Respondents	Male	3	75	22	100
	Female	0	78	22	100

Educational Profile - Approximately 44% of respondents obtained up to secondary level education, while 24% obtained up to primary level, and 17% up to tertiary level. The remaining 17% responded other or did not report. An estimated 56% of male household heads attended up to secondary level education, compared to 31% of female household heads. Approximately 18% of males and 19% of females attended up to tertiary level school, while 18% of males and 38% of females attended up to primary level.

Household Profile - Approximately 69% of respondents had households comprising 1-3 persons, 28% had 4-6 persons, and 2% had 7-9 persons. The average household size was 2.9 persons. At least 10% of households had one or more children living in them. Twenty-eight percent (28%) of household heads were in single, 26% were married, and 26% in common law relationships.

8.2.1.8.2 Economic Activity

Employment and Income - All but five of the persons interviewed in the upper watershed communities lived in households with one or more persons employed. Forty-one percent (41%) of households had one person employed, 41% had two persons employed, while 15% had 3 persons, 4% had 4 persons and 2% had 6 persons in the same household employed. Among those employed, 41% has full-time employment, 7% worked part-time, and 35% were self-employed (**Table 8-32**).

Table 8-32: Employment status of household head (upper watershed)

Employment status of household head					
Valid		Frequency	Percent	Valid Percent	Cumulative Percent
	full Time	22	40.7	40.7	40.7
	part Time	4	7.4	7.4	48.1
	self-employed	19	35.2	35.2	83.3
	seasonal	2	3.7	3.7	87

Employment status of household head					
	unemployed	2	3.7	3.7	90.7
	retired	5	9.3	9.3	100
	Total	54	100	100	

The average weekly income of household head reported for all household heads in the upper watershed communities was $30,546 JMD, ranging from $2,000 to $110,000. Average weekly income of the head of household head's partner was $20,357 JMD, ranging from $5,000 to $60,000. Skilled Agricultural & Fishery Worker accounted for 22% of household heads' occupation, while 20% were employed in the Professionals, Senior Officials and Technicians occupation group. Service worker/shop/market and sales worker occupation and Plant & machine operators and assemblers' groups each accounted for 9% of household heads (**Table 8-34**).

An estimated 42% of male household heads were employed full time, 6% part time and 42% self-employed. Three percent (3%) of male household heads were unemployed, 3% employed seasonally, and 6% retired at the time of interview. In male headed households, average weekly income of the household head was $36,484 while their partners' income was $23,750. Incomes ranged from a minimum of $2,000 to a maximum of $110,000 weekly for male household heads, while partners' income ranged from $5,000 to $60,000. Skilled Agricultural & Fishery Worker was the most common occupation type among male household heads (22%) followed by Professionals, Senior Officials and Technicians (17%) (**Table 8-35**).

For female headed households, 39% of household heads were employed full time, 11% part time, 22% were self-employed, 6% was unemployed, 6% seasonally employed and 17% retired (**Table 8-33**). Average weekly income in female headed households were remarkably lower than their male counterparts. For the female household head, average weekly income among respondents was $15,208, and $11,875 for their partners. Weekly income for female household heads ranged from $3,000 to $50,000. The most popular occupations among female household heads were Skilled Agricultural & Fishery Worker (17%) and Craft and Retail Trade Workers (11%) (**Table 8-35**).

Table 8-33: Household head employment status by sex

employment status of household head * Sex of head of household Cross tabulation				
Count				
		Sex of head of household		Total
		male	female	
employment status of household head	full Time	15	7	22
	part Time	2	2	4
	self-employed	15	4	19
	seasonal	1	1	2
	unemployed	1	1	2
	retired	2	3	5
	Total	36	18	54

Table 8-34: Occupation of household head

occupation of household head					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Professionals, Senior Officials and Technicians	11	20.4	23.4	23.4
	Service Workers, Shop, Market and Sales Workers	1	1.9	2.1	25.5
	Skilled Agricultural & Fishery Worker	5	9.3	10.6	36.2
	Crafts and Related Trade Workers	12	22.2	25.5	61.7
	Plant & Machine Operators and Assemblers	5	9.3	10.6	72.3
	Elementary Occupations	5	9.3	10.6	83
	Occupation Not Stated	8	14.8	17	100

occupation of household head					
		Frequency	Percent	Valid Percent	Cumulative Percent
	Total	47	87	100	
	No Response	7	13		
		54	100		

Table 8-35: Occupation of household head by sex

occupation of household head * Sex of head of household Cross tabulation				
Count				
		Sex of head of household		Total
		male	female	
occupation of household head	Professionals, Senior Officials and Technicians	6	5	11
	Service Workers, Shop, Market and Sales Workers	0	1	1
	Skilled Agricultural & Fishery Worker	5	0	5
	Crafts and Related Trade Workers	8	4	12
	Plant & Machine Operators and Assemblers	4	1	5
	Elementary Occupations	5	0	5
	Occupation Not Stated	5	3	8
Total		33	14	47

Some 32% of participants reported owning their own business, 65% of which were male and 35% female. The types of businesses included coffee farming, grocery/shop, restaurant and entertainment, information technology, craft, mason.

8.2.1.8.3 Housing and Land Tenure

Survey participants in the upper watershed communities have resided in their communities for between less than one and 84 years. A combined 52% of respondents have resided in the community for 20-49 years, while 30% have resided there for 50 or more years. An estimated 74% of residents reportedly owned (46%) or inherited (28%) the plot of land on which their dwelling sits. For the dwelling, 56% reportedly owned and 19% inherited the dwelling in which they reside. Another 7% rent, 7% lease, while 9% live with owner's permission rent-free the plot of land. An estimated 11% live with owner's permission rent free in the dwelling in which they reside, 7% rented, and 2% leased. Rent agreements range from one to two years with average monthly payments of $12,900.

Most dwellings were constructed with outer walls of concrete block and steel (82%), 17% were constructed of timber/ board, while the other 2% were constructed of mix of concrete and board. The condition of dwellings ranked by interviewers' observations based on the criteria listed below, were very good (20%), good (33%), fair (43%), and poor (2%).

> Very good: Sound physical structure, freshly painted. Doors and Windows intact and looks good.
>
> Good: Structure good, may not be freshly painted, but in good physical condition.
>
> Fair: May or may not need painting, may have need for minor repairs.
>
> Poor: Structural damage, cracks, missing windowpanes or blades and doors.
>
> Very Poor: Not fit for human habitation.

8.2.1.8.4 Utilities and Municipal Services

Water - The main sources of water among households in the upper HRWS communities were water piped into dwelling (89%), piped into yard (6%) and standpipe (2%) public tank (2%) and other – spring (2%). Alternate sources of water, for example during service disruptions were private catchment (tanks, bottle, buckets, drums, etc.) utilised by 74% of respondents. An estimated 11% identified natural spring/ stream as their alternate source while 4% reported having no alternative or no water problems.

Sewage/ Wastewater - Approximately 91% of dwellings within the communities had access to indoor flush toilet facilities (85% not shared and 6% shared). Pit latrine - shared and not shared, were the only other toilet facility reported. An estimated 78% of respondents reported absorption pit as the type of sewage system used by their household. Another 17% identified septic tank with soak away, while 4% identified reported "none".

Solid Waste - The main method of garbage disposal was collection by garbage truck, utilised by 65% of households. Burning (6%), dump in gullies/ hillsides (4%) and other (26%) were other methods of garbage disposal used by households. Other methods included bringing it to a skip (community or central), or location in Gordon Town and Kingston which garbage trucks service.

8.2.1.8.5 Community Organisation and Social Linkages

Participants indicated that each of the communities of the upper HRWS have active community organisations. As shown in **Table 8-36**, 83% of respondents indicated that Woodford has active or very active community groups (**Table 8-36**). The Woodford groups were ranked as effective to very effective (

Table 8-37). In New Castle 67% of respondents indicate active community groups and one respondent believed the groups to be effective. In Redlight, 23% of respondents indicated that there were active groups in the community. These groups were deemed effective by some and ineffective by others. When asked about membership to community organisations, respondents in all three communities had membership in community groups. The groups identified were:

- Action Group
- Building Community Together Non-Profit
- CDC Woodford Action Group
- Citizen Association
- Cottage Farmers Group
- Cottage Farmers Group

- Farmers Group
- Fisherman Association
- Middleton Farmers Group
- Police Youth Club
- Senior Citizen Group

Table 8-36: Community Organisation activity ranking

Would you describe these groups that you have identified as (select 1 from each category) - Status * Community Cross tabulation					
Count					
		Community			Total
		Woodford	New Castle	Redlight	
Would you describe these groups that you have identified as (select 1 from each category) - Status	Active	19	2	5	26
	Very Active	1	0	0	1
	Inactive	3	1	9	13
	No Response	1	0	8	9
Total		24	3	22	49

Table 8-37: Community Organisations effectiveness ranking

Would you describe these groups that you have identified as (select 1 from each category) - Effectiveness * Community Cross tabulation					
Count					
		Community			Total
		Woodford	New Castle	Redlight	
Would you describe these groups that you have identified as (select 1 from each category) - Effectiveness	Effective	7	1	2	10
	Very Effective	3	0	1	4
	Not Effective	2	0	0	2
	No Response	7	0	13	

Would you describe these groups that you have identified as (select 1 from each category) - Effectiveness * Community Cross tabulation				
Count				
	Community			Total
	Woodford	New Castle	Redlight	
Total	19	1	16	36

8.2.1.8.6 Watershed Management Awareness

Understanding of watershed and Ecosystems - Understanding of the concepts of watershed and its importance was high among participants in the upper watershed communities. Approximately 69% of respondents indicated that they understood the concept of a watershed. After an explanation of the concept, 82% stated that they understood the importance of watersheds. As it relates to the HRWS, 67% thought that the watershed was not being effectively managed, while 15% though it was being managed effectively. Ways they thought the management of the HRWS could be improved are shown in **Table 8-38**.

Table 8-38: Ways to manage the HRWS

Management Method/ Tool	Percent
Improve monitoring and enforcement to include use of rangers/wardens	1.9
River training	3.7
Utilise retaining walls/gabion baskets	3.7
Improve sanitation practices to include the provision of skips	1.9
Dam cleaning and maintenance	5.6
Reduce the number of houses in watershed	1.9
Education & training	1.9
Reduce deforestation	1.9
Build/improve storage of water for community community/increase the number of dams	1.9
Prevent farming near the river	1.9

Management Method/ Tool	Percent
Terracing	1.9
Plant/ replant trees	1.9

There was some level of understanding of the concept of ecosystem among respondents with 50% indicating an understanding. After the explanation of the concept, 85% of respondents determined that they depend on the ecosystem for goods and services.

8.2.1.8.6.1 Dependence on Ecosystem Services

Dependence on the ecosystem correlated to two main ecosystem services, regulating and provisioning. Approximately 83% of total participants noted services/resources they get from the ecosystem, with many identifying multiple services. The ecosystem services that respondents identified included provisioning services, such as water, farming/livelihoods, food. Additionally, respondents identified the regulating services of clean air and clean water.

The list of ecosystem services and an explanation of each was provided to participants. They were then asked to rank the importance of these services to their community. As shown in **Table 8-39**, the highest proportion of respondents thought the ecosystem services were very important. The ecosystem services ranked highest among respondents were supporting and provisioning.

Table 8-39: Importance of ecosystem services ranked

	Not Important	Somewhat Important	Important	Very Important	I don't Know/ No Response	Total
Regulating	11.1	7.4	9.3	72.2	-	100.0
Supporting	-	14.8	18.5	66.7	-	100.0
Cultural	1.9	5.6	9.3	83.3	-	100.1
Provisioning	14.8	3.7	1.9	79.6	-	100.0

Average	9.3	7.9	9.8	75.5		100.0

When asked what activities they observe in the community and the broader HRWS that are detrimental to the ecosystem, 28% identified improper disposal of solid waste (**Table 8-40),** while 20% identified land clearing for farming, and 13% pollution from farming activities.

Table 8-40: Activities observed the community /in broader Hope River watershed that are detrimental to the ecosystem

What are some activities you observe in your community /in broader Hope River watershed that are detrimental to the ecosystem (e.g., land clearing for farming, diversion of water, invasive species)		
	Frequency	Percent
Improper disposal of solid waste	15	27.8
Land clearing for farming	11	20.4
Pollution from farming related activities	7	13
Pollution from fishing related activities	2	3.7
Diversion of water	2	3.7
Invasive species	1	1.9
None observed	10	18.5
Deforestation	2	3.7
Sand mining	1	1.9
Building in the river	1	1.9
Washing of clothes in the river	1	1.9
No response	1	1.9
Total	54	100.0

8.2.1.8.6.2 Observed land use change and ecosystems

Participants were also asked how land use changes have affected the ecosystem services in the past 5-10 years. The increase in the number of houses/ranches/shacks and squatting was identified by 16% of respondents. Thirteen percent (13%) cited deforestation, and 13% cited increase landslides. The full list of responses is provided in **Table 8-41**.

Table 8-41: Ways land change use has affected ecosystem services in past 5-10 years

Activities in the community /in broader Hope River watershed that are detrimental to the ecosystem		
	Frequency	Percent
No change observed	13.0	24.1
Increase landslides	7.0	13.0
More pollution	4.0	7.4
Deforestation	7.0	13.0
Increase in the number of houses/ranches/shacks /squatting	9.0	16.7
River can no longer be used for recreation/domestic purposes	1.0	1.9
Affect water flow	1.0	1.9
Reduced fish	1.0	1.9
More people protect the environment	1.0	1.9
Increase in temperature	1.0	1.9
Erosion	1.0	1.9
Loss of Flora and fauna	1.0	1.9
Missing	5.0	9.3
Don't Know or not sure	2.0	3.7
Total	54.0	100.5

8.2.1.8.6.3 Perception of climate-related risks and hazards

Ninety-one percent (91%) of respondents have experienced climate-related, natural/ environmental hazard impacts in the community. When asked about specific hazards, land slippage/ landslides and fires were the most common hazards experienced (**Table 8-42**). At the time of the survey, 32% of respondents indicated that they had experienced their most recent hazards less than a month before being interviewed. Approximately 41% experienced a hazard 1-6 months before, 2% experienced it 7-12 months prior, and 15% over year but less than 2 years ago. Landslides and tropical storms were identified as the most recent hazard impacting the community.

Table 8-42: Climate-related hazards experienced in community

Hazard	% Respondents
Not affected	3
land slippage/landslides	19
Flooding	1
Restrictions due to hazard	9
Storms/hurricanes	4
Damage to property	3
Total	39

The climate specialist identified potential hazards of climate change projected to impact Jamaica. Participants were asked to state if their household had been impacted by these hazards in the past 5-10 years. The top three impacts experienced by respondents were changes in the 1-day maximum intensity of rainfall (54%), higher temperatures (39% of respondents), drying of the watershed (28%) and more severe and longer lasting droughts (15%) (**Table 8-43**).

Table 8-43: Climate-related hazards experienced in the last 5-10 years

Climate-related hazards	**% Respondents**
More Frequent Flooding	5.6
Changes in the 1-day maximum intensity of rainfall	53.7
More Severe and longer lasting droughts	14.8
Increase in the maximum sustained wind speeds and rainfall associated with hurricanes	11.1
Drying of the watershed	27.8
Higher temperatures	38.9
Other	3.7

Most frequent climate-related hazards - Participants also ranked the hazards they perceived to affect the community most frequently. Landslides and drying of the watershed/less water in the river, were the hazards that most frequently impacted the communities (**Table 8-44**).

Table 8-44: What climate-related or natural/ environmental hazards do you think affect the community most? Please rank by frequency between 1 and 4, with 1 being the most frequent.

Rank			
1 – most frequent hazard	**2 – 2nd most frequent hazard**	**3 – 3rd most frequent hazard**	**4 – 4th most frequent hazard**
Landslides (63%)	Landslides (14.8%)	Drought (7.4%)	Drought (2%)
Increase/ intense rainfall (18.9%)	Higher temperatures (9.3%)	Increase storms/ hurricanes (3.7%)	Bush fires 92%)

Contributors to climate-related hazards - Ways residents contribute to the climate-related, natural/ environmental hazards experienced in the Greenwich Town community, included:

- Deforestation (4%)
- Construction (28%)
- Dumping of garbage (15%)
- Use of chemicals (pesticides and fertilisers) (7%)
- Improper undercutting of slope (2%)
- Sewage (2%)

The perceived reasons given for deforestation were housing (identified by 33% of respondents), farming (28%), use of fire to clear land (slash and burn) (6%), and fence posts (6%).

An estimated 54% of respondents also believed that residents contribute to climate-related, nature/environmental hazards in the community. Respondents thought that residents' actions that contribute to climate-related, natural/ environmental hazards were due to ignorance (43%), lack of care (7%), lack of alternative (7%), and survival (farming) (2%).

Some steps that respondents thought could be effective in changing behaviours were:

- Educational workshops (72%)
- Increase alternatives (41%)
- Financial support (22%)
- Community denouncement of action (6%)
- Regulations and enforcement (19%)
- Nothing (4%)
- Provide facility to dispose of garbage (2%)

Protective services of the ecosystem - Seventy- two percent (70%) of respondents believed that the ecosystem protected the community from hazards/ disasters experienced. **Table 8-45** lists some ways the ecosystem has provided protection to the community.

Table 8-45: Ways the ecosystem has protected the community from any of the disasters/hazards experienced

Ecosystem protection	**Frequency**	**Percent**
Trees holds soil and help prevent landslides	18	33.3
Trees protect from breeze/wind	6	11.1
Trees Cool Temperature	1	1.9
Hilly Terrain Protects Against Strong Wind	1	1.9
Ecosystem Provide protection and keep land slippage from happening	1	1.9
Ecosystem Provides Fresh Air	1	1.9
No Flooding due to hilly terrain	1	1.9
Ecosystem protects from flooding/landslide	2	3.7
Trees Planted	1	1.9

Some 46% of respondents believed that their households continued to be vulnerable to climate-related, natural/ environmental hazards. As seen in **Table 8-46** , 32% believed they were moderately vulnerable, 9% believed they were vulnerable and 6% believed their households were very vulnerable.

Table 8-46: Perceived vulnerability to climate-related hazards

	Frequency	Percent
Very vulnerable	3	5.6
Vulnerable	5	9.3
Moderately vulnerable	17	31.5
Low vulnerable	10	18.5
Not vulnerable	14	25.9
No response	5	9.3
Total	54	100

8.2.1.8.6.4 Ecosystem protection

Respondents were aware of measures that have been taken by the community or other representatives to protect and preserve the ecosystem.

- Build Retaining Walls (11.1%)
- Proper Garbage Disposal (3.7%)
- Cleaning of Drains (3.7%)
- Planting of Trees (9.3%)
- Planting of Crops and Flowers (1.9%)
- Build Catchment (1.9%)
- Share Information to Educate Residents/Farmers/Fisher Folks (5.6%)
- Enforce No Tree Cutting by Rangers (3.7%)
- Retain Environmental Police (1.9%)

An estimated 28% of respondents were also aware of how many of the protection measures were financed. Financing mechanisms included:

- Households/Individuals
- Political Representatives
- Government Agencies (RADA, JSIF, Forestry Dept., JAS)
- NGO
- Holywell Reps
- Collaboration Between Community Members

An estimated 56% of participants believed that the protection of the ecosystem should be the responsibility of both residents and the government. Some 20% believed that ecosystem protection should be the responsibility of the government, while 13% believed that it should be the responsibility of residents. Respondents also suggested the following actions to protect the ecosystem shown in **Table 8-47** below.

Table 8-47: Upper watershed communities recommended ecosystem protection measures

Recommended ecosystem protection measures	**# of Responses**	**% of Participants**
Improve garbage disposal/ waste management (including recycling)	12	22.2
Monitoring and enforcement	6	11.1
Reforestation (including establishing fruit orchards)	6	11.1
Education/ community outreach and sensitisation	5	9.3
Increase efforts at ecosystem protection and conservation (incentivise conservation in communities)	5	9.3
Improve farming practices (including less land clearing for farming; reducing use of chemicals, fertilisers that is releases into rivers)	4	7.4
Engineering solutions - retaining walls, slope monitoring to identify weaknesses along faults	3	5.6
Better land use practices (such as identifying lands for farming)	2	3.7
Create and enforce riparian buffer around riverbanks to prohibit construction of houses along riverbanks	1	1.9
Forest conservation	1	1.9
Foster community pride in the environment	1	1.9
Community action	1	1.9

8.3 Socioeconomic Key Findings

The key findings of the socioeconomic assessment were identified for integration into the vulnerability assessment model along with other study components for identification of potential impacts and EbA strategies. The socioeconomic variables were examined to determine exposure, vulnerability, sensitivity and the adaptative capacity of the communities to climate-related events.

8.3.1 Exposure

Exposure is defined as 'The presence of people, livelihoods, species or ecosystems, environmental functions, services, and resources, infrastructure, or economic, social, or cultural assets in places and settings that could be adversely affected.' (IPCC 2014a, p. 39). Socioeconomic variables that determine the exposure of communities in the Hope River WMU to climate-related hazards were population and housing characteristics.

Population – data shows that an estimated 14,984 persons reside in the study communities, with the population size highest in the lower watershed region and decreasing in the middle watershed and lowest in the upper watershed (**Table 8-48**). The total population represents 2.3% of the population of the Kingston and St. Andrew, and the Hope River watershed Management Unit. Disaggregation of the population by sex shows that the female population is slightly higher in all communities. The economically active/ working age group (15-64 years) is the most represented in all study communities. For both the lower and middle watershed 69% of the population belong to this working age group while 31% consists of the young and elderly (**Table 8-49**). For the upper watershed community, 70% of the population belongs to the working age group. Available data at the parish level indicates a growing population in the KSA which increases exposure to climate-related hazards and potential impact.

Table 8-48: Population Characteristics

Watershed Region	Communities	Male	Female	Sex Ratio	Total Population
	Jamaica	1,334,533	1,363,450	97.9	2,697,983
KSA	Kingston	44,891	44,166	101.64	89,057
	St. Andrew	274,320	299,049	91.73	573,369
Lower	Greenwich Town/ Newport West	3,790	3,993	94.9	7,783
Middle	Gordon Town/ Content Gap/ Petersfield	2,729	2,787	99.6	5,517
Upper	Woodford/ Newcastle/ Redlight	834	850	99.0	1,684

Table 8-49: Population distribution by age group

		% Population by Age Group			
Watershed Region		**Under 15**	**15-29**	**30-64**	**65 & over**
Lower	Greenwich Town	26.0	32.0	37.0	6.0
Middle	Gordon Town/ Content Gap/ Petersfield	23.4	31.4	38.5	6.7
Upper	Woodford	24.0	29.1	40.9	6.0

Housing units – There are an estimated 5,105 housing units and households in the study communities (

Table 8-50). In the middle and upper watershed regions, over 67% of households owned their homes. Home ownership was lower in the lower watershed region at 36.2%, where rented and rent-free homes were more popular. As population increases, it is expected that the number of housing units will also increase to accommodate the population.

Table 8-50: Housing units and household size

Watershed Region		Total # Housing Units/ Households	Household Size
	Jamaica	881,089	3.1
KSA	Kingston	29,513	3.0
	St. Andrew	192,112	3.0
Lower	Greenwich Town	2,642	2.9
Middle	Gordon Town/ Content Gap/ Petersfield	1,985	3.1
Upper	Woodford	478	3.4

Population Density – In addition to number of people and housing units. The population density of a community is an indicator of exposure to climate-related hazards. The higher the density of an area the more concentrated the population is, increasing the vulnerability over a small geographic range. The study shows that population density in the Hope River WMU, runs on a gradient from very dense in the lower watershed region to moderately dense in middle and low population density in the upper watershed regions as documented in **Table 8-51**.

Table 8-51: Population density by watershed region

	Lower Watershed Greenwich Town	**Middle Watershed Gordon Town/ Petersfield / Content Gap**	**Upper Watershed Woodford**
Population Density (inhabitants per km^2)	2487	495.2	78

8.3.2 Socioeconomic Vulnerability

Vulnerability is 'The propensity or predisposition to be adversely affected. Vulnerability encompasses a variety of concepts and elements including sensitivity or susceptibility to harm and lack of capacity to cope and adapt.' (IPCC 2014a, p. 39).

The socioeconomic variables that determined vulnerability for this study include:

- Dependency on ecosystems services
- Material of outer walls for housing
- Perception of vulnerability

Dependence on ecosystem services – While initial understanding of the concept ecosystems and their services were relatively low across the regions, interviewers were able to provide a guided overview of the key concepts to each participant. This helped to determine that dependence on ecosystems services is very high in the study communities. In the upper and lower watershed regions, 85% of respondents indicated that they are dependent on the ecosystem for goods and services. In the middle watershed region, a smaller proportion of participants (63%) indicated that they are dependent on the ecosystem for goods and services. The high dependence on ecosystems goods and services is evident in the percentage of households that identified spring or river as the main or alternate source of water.

Source of water – According to the most recent census data, communities in the middle and upper watershed regions were dependent on spring or river as the main source of water for domestic use. Some 11.0% and 6.9% of households in the middle and upper watershed region, respectively, have spring or river as the main source of water for domestic use (**Table 8-52**). Similarly, some 11% of participants in the middle watershed region and 7.0% of upper watershed participants indicated dependence on natural spring or stream as their households' alternate source water for domestic use (**Table 8-53**). Alternately, and as expected given its urban, coastal setting, the lower watershed community has no dependence on natural water sources for either main or alternate source of water. While the use of natural springs and streams is considered an indicator of dependence and vulnerability, it should be noted that the Hope River is a major source of potable water for the entire Hope River WMU.

Occupation – Another indicator of dependence on ecosystem services is the percentage of households where primarily farming/fishing income is the occupation of the head of household. This is more representative across all regions. Some 44% of respondents in the lower watershed community are fishers, operating from the Greenwich Fishing Beach (**Table 8-53**). In the middle and upper watershed regions, farming was the ecosystem-dependent occupation, with 14% of respondents in the middle and 22% in the upper watershed communities engaged in farming as their primary occupation.

Table 8-52: Socioeconomic vulnerability variables

	% Housing with Wood as Material of Outer Walls	**Spring of River as Main Source of Water for Domestic Use**
Jamaica	18.1	3.0
Kingston	14.0	0.0
St. Andrew	11.1	1.2
Greenwich Town	11.3	0.0
Gordon Town/ Petersfield / Content Gap	17.1	11.0
Woodford	9.9	6.9

Housing quality – Another indicator of vulnerability to climate-related hazards is the quality of the housing stock. This is measured using the Housing Quality Index (HQI) which aggregates six benchmark indicators. The benchmark indicator used to determine vulnerability in this study is the material of outer walls. According to the PIOJ (2021), walls of concrete block and steel are an indicator of durability for withstanding the elements of weather and for providing occupants with a greater level of security. It is therefore assumed that housing with wood as the material of outer walls would be less durable and more vulnerable to climate-related hazards. An average of 12.8% of households have vulnerable housing. Among study communities, housing vulnerability is highest for middle watershed communities at 17.1% followed by 11.3% in the lower watershed and 9.9% in the upper watershed regions (**Table 8-52**).

Perceived vulnerability to climate-related hazards – Participants experience and perception of their communities and households' vulnerability to climate-related hazards was also assessed. More than half (52.0%) of respondents in the lower watershed community believed that their household's vulnerability to CC was moderate to very high. The perceived vulnerability was 5.0% percent lower among upper watershed communities with 47.0% of respondents indicating that their household is moderate to very vulnerable. Perceived vulnerability was lowest among middle watershed communities at 39.7%.

Table 8-53: Perception of vulnerability to climate-related hazards

Perception Survey Variables	Greenwich Town	Gordon Town/ Petersfield / Content Gap	Woodford
% Households primarily farming/ fishing income (survey: head of household occupation)	44.0	14.0	22.0
% Households using natural spring/ stream as alternate source of water	0.0	11.0	7.0
% Households perceive moderate to very high vulnerability to climate-related hazards	52.0	39.7	47.0
Experienced Flooding (%)	47.5	42.7	43.0
More Frequent Flooding (%)	34.0	1.7	3.0
Experienced Landslide (%)	1.0	100.0	88.9
Experienced Tropical Storms/ Hurricanes (%)	24.2	32.0	40.7

Perceptions are likely influenced by participants past experiences with natural hazards. Participants were asked what climate-related hazard they have experienced in their communities. Flooding, landslides, and tropical storms were the most common. Respondents in all regions reported experiencing flooding in their community. Experience with flooding was more prevalent in the lower watershed community as indicated by 47.5% of respondents. Responses were similar for the middle and upper watershed communities with an estimated 43.0% of respondents having experienced flooding. It is interesting to note that while experience with flooding is relatively similar across all regions, only 34.0% of respondents reported experiencing more frequent flooding, one effect of climate change. As shown in **Table 8-53**, participants in the middle and upper watershed have not experienced more frequent flooding.

Experience with landslides is prevalent in the middle and upper watershed with 100.0% of respondents in the middle watershed and 88.9% in the upper watershed having experienced landslide hazards. An average of 32.2% of survey participants have experienced tropical storms and/or hurricane in their community. Some 40.7% of participants in the upper watershed, 32% in the middle watershed and 24.2% in the lower watershed have experienced tropical storms and/or hurricanes.

8.3.3 Socioeconomic Sensitivity

Sensitivity describes factors that affect the magnitude of consequences of a hazard, and may include social attributes such as age structure, and income structure. The following sensitivities were identified for the Hope River WMU study communities.

- Age dependency ratio
- Incidence of poverty
- Employment status

As noted in the demography section above, the age dependency ratio is a measure of the total number of dependents (persons aged under 15 years and those aged 65 years and older) relative to the working-age population (15-64 years). The ratio represents the number of economically inactive people that each economically active person is expected to support (PIOJ, 2021). It is this dependency that contributes to this segment of the population being considered vulnerable. The age dependency ratio for the study communities ranges from 42.7% to 45.3% (**Table 8-54**). This indicates that over 42% of respondents are dependent on the working age population in the community. This portion of the population would likely be more sensitive to climate-related hazards without the means to engage in their own preparedness and recovery efforts if impacted.

Table 8-54: Age dependency by watershed region

Watershed Region	Community	Total Young + Elderly	Total Working-age	Age Dependency Ratio by Community
Lower	Greenwich Town	2,427	5,356	45.3
Middle	Gordon Town/ Content Gap/ Petersfield	1,662	3,855	42.7
Upper	Woodford	506	1,178	43.0

Similarly, the segment of the population without employment and those living in poverty would be unable to prepare and recover/adapt to climate-related events. The rate of unemployment for the study communities ranged from 2% to 6.5% (**Table 8-55**). The rate was lowest in the lower watershed region (2.0%) and highest in the middle region at 6.5%. Unemployment was lowest in the upper watershed communities. The rate of unemployment among survey participants was lower than the nation rate of 7.1% in October 2021 (PIOJ, 2022). Unemployment was higher among females at (9.0% compare with 7.1% among males) at the national level. Though at much lower levels at the community level, rates differed for only the lower watershed region, where males had a higher level of unemployment. This may be due to the larger numbers of male participants.

The incidence of poverty is highest in the lower watershed region at 35.9%, indicating high sensitivity to climate-related hazards. Though markedly lower, 7.9% or middle watershed and 8.2% of upper watershed population are sensitive due to their poverty status (**Table 8-55**).

Table 8-55: Socioeconomic sensitivity – poverty and unemployment

Watershed Region		**Incidence of Poverty (2012)**	**% Population unemployed (Survey Participants)**
	Jamaica	19.8	-
	Kingston	28.6	-
	St. Andrew	17.7	-
Lower	Greenwich Town	35.9	2.0
Middle	Gordon Town/ Petersfield / Content Gap	7.9	6.5
Upper	Woodford	8.2	3.7

In conclusion, the findings show that a large proportion of the population of communities within the Hope River WMU are exposed to and very vulnerable to climate-related hazards. The high levels of dependence on the ecosystems and the regulating, supporting, cultural and provisioning services they provide is an indicator that nature-based solutions (NbS) and ecosystems-based solutions (EbA) for building climate resilience of these communities is appropriate. Actions to protect the ecosystem recommended by survey participants included:

- Monitoring, enforcement, regulations that protect ecosystems, penalties for polluters (22.4%)
- Sanitation and waste management (20.8%)

- Education/Training/Community outreach and sensitisation to build capacity in the communities for sound environmental practice and management (15.8%)
- Improve drainage system; more frequent cleaning of drains and gullies (7.7%)
- Community action and partnerships (2.7%)
- Conservation/reforestation/Plant more trees/Create and enforce riparian buffer around riverbanks to prohibit construction of houses along riverbanks (11.5%)
- Better land use and farming practices (zoning for specific use, conservation) (4.9%)

8.4 Stakeholder Consultation

Stakeholder consultation was ongoing throughout the duration of the REA and socio-economic assessment. In addition to collaborations during the planning and data collection phases of the study, a draft report presenting the findings and recommendations of the various components of the study was prepared and presented to the TNC/UNEP in February 2023. A presentation was also delivered in an Expert Group Consultation Virtual Session held Friday 3rd March 2023. Comments received were incorporated into the final report.

9 Climate Analysis

The impact of climate change can be examined by looking at key variables- rainfall, temperature, tropical cyclone activity and rainfall. The key reports used to compose this summary of impacts include a review of the Near-Term Climate Scenarios for Jamaica (CSGM 2014), the 2015 State of the Jamaican Climate Report (CSGM 2017), the State of the Caribbean Climate (CSGM 2020), the State of the Jamaican Climate Volume III (CSGM 2022), the Working Group I contribution to the Intergovernmental Panel on Climate Change (IPCC) Sixth Assessment Report (IPCC 2021) and the IPCC's Special Report on Global Warming of 1.5°C (Hoegh-Guldberg et al. 2018). These reports revealed the following trends in climate variability for overall Caribbean with special focus on Jamaica.

10 Historical Trends

Analysis of historical trends spanning 1981 through to 2021 utilised accessible station data from Jamaica's Meteorological Service as well as the Climate Hazards Group InfraRed Precipitation with Station data (CHIRPS). This dataset is a gridded 35+ year (1981 to near-present) quasi-global rainfall data set that spans 50°S-50°N (and all longitudes) by incorporating 0.05° resolution satellite imagery, and in-situ station data. Additional analysis of temperature variables was done using the Climatic Research Unit (CRU TS 3.24) gridded data set which covers the period 1901-2015 and all land areas globally, excluding Antarctica, at 0.5° resolution. This is complemented by reviews of the current state of knowledge for observed climatic variability and trends in Jamaica (with a focus on the Hope River watershed WMU and the urban communities located within) from authoritative literature. Both the climatology and historical trends in mean and extreme indices are evaluated for temperature and rainfall, based on existing literature or as was derived from accessible historical data.

10.1 Future Near to Long-Term Climate Projections

In order to generate climate change information at scales close to the size of the Hope River watershed management unit, dynamical downscaling using the International Centre for Theoretical Physics (ICTP) Regional Climate Model (RegCM) version 4.3.5 was employed. The RegCM4.3.5 model, which is situatable over any part of the globe and with adequate computing resources can produce climate change information at 1Km, was driven by representative concentration pathways (RCP - RCPs are explained below) data from Global Climate Model (GCMs) available at 150Km to produce climate projections for the Hope River WMU at a resolution of approximately 20km. The driving GCMs were used to produce historical climate data spanning 1971 through to 2005 and future projections from 2021 through to 2100. Using these future trends in climate, trends over three time slices were calculated: 2030s (2030-2039) – near term, 2050s (2050-2059) – medium term, and end of the century (2080 - 2097) for 3 RCPs (RCP2.6, RCP4.5, and RCP8.5) relative to a 1980-2003 baseline. The variables investigated were rainfall, temperature and relative humidity for annual and seasonal changes. Additionally, rainfall extremes namely Consecutive Dry Day (CDD), Maximum 1-Day Precipitation (Rx1) as well as the annual count of days where daily precipitation in more than 10 mm per day (R10) are also investigated. Seasons examined are December – March (DJFM), April-June (AMJ), July (J) and August-November (ASON). Projections in relation to sea level rise and tropical cyclones are obtained from literature and from online resources.

Representative Concentration Pathways are a set of four pathways on which long-term and near-term modelling experiments are based. They make predictions of how concentrations of greenhouse gases in the atmosphere will change in the future as a result of human activities. The four RCPs range from very high (RCP8.5) through to very low (RCP2.6) future concentrations. The numerical values of the RCPs (2.6, 4.5, 6.0 and 8.5) refer to the concentrations in 2100. Climate research utilizes the socio-economic and emission scenario to provide credible future climate projections with respect to a number of variables – e.g. technological change, socio-economic change, emissions of greenhouse gases and air pollutants and energy and land use. Each RCP represents a radiative forcing value which includes the net effect of all variables. (D. P. van Vuuren, et al. 2011 and www.coastadapt.com.au)

On a large scale, future rainfall and temperature estimates are generated from the Coupled Model Intercomparison Project 5 (CMIP5) ensemble of general circulation models (GCMs) run under three Representative Concentration Pathways (RCPs). Information about the

CMIP5 project and its associated data can be gleaned from https://esgf-node.llnl.gov/projects/cmip5/. The use of the CMIP5 ensemble members is augmented by outputs from a high-resolution regional climate model from which output for the 3 RCPs is also gleaned. Where possible, projections of future rainfall extremes are derived using statistical downscaling techniques. Statistical downscaling is especially useful for generating projections at a location, once sufficient historical data are available, thus offering an improvement (engendering community scale projected changes) to the national or parish scope available from GCMs and Regional Climate Models (RCMs), respectively.

10.2 Rainfall

Climate change has a profound impact on rainfall variability. It may impact both the frequency and intensity of the rainfall events. The Caribbean can largely be divided into various regions with similar climate and rainfall patterns referred to as rainfall zones (CSGM, 2020; McLean et al., 2015). Jamaica is in rainfall zone 3 (**Figure 10-1**) according to CSGM (2020). This zone is characterised by a clear bi-modal rainfall pattern. The early rainfall season peaks in May followed by a slight drop-in precipitation in May-June which is referred to as the mid-summer drought. The rainfall then increases following the mid-summer drought to its annual maximum level during September-November. Based on long term historical rainfall data Jamaica's rainfall can be classified into four distinct geographical areas determined by similarities in rainfall amounts and patterns. These four rainfall zones are shown in **Figure 10-1**.

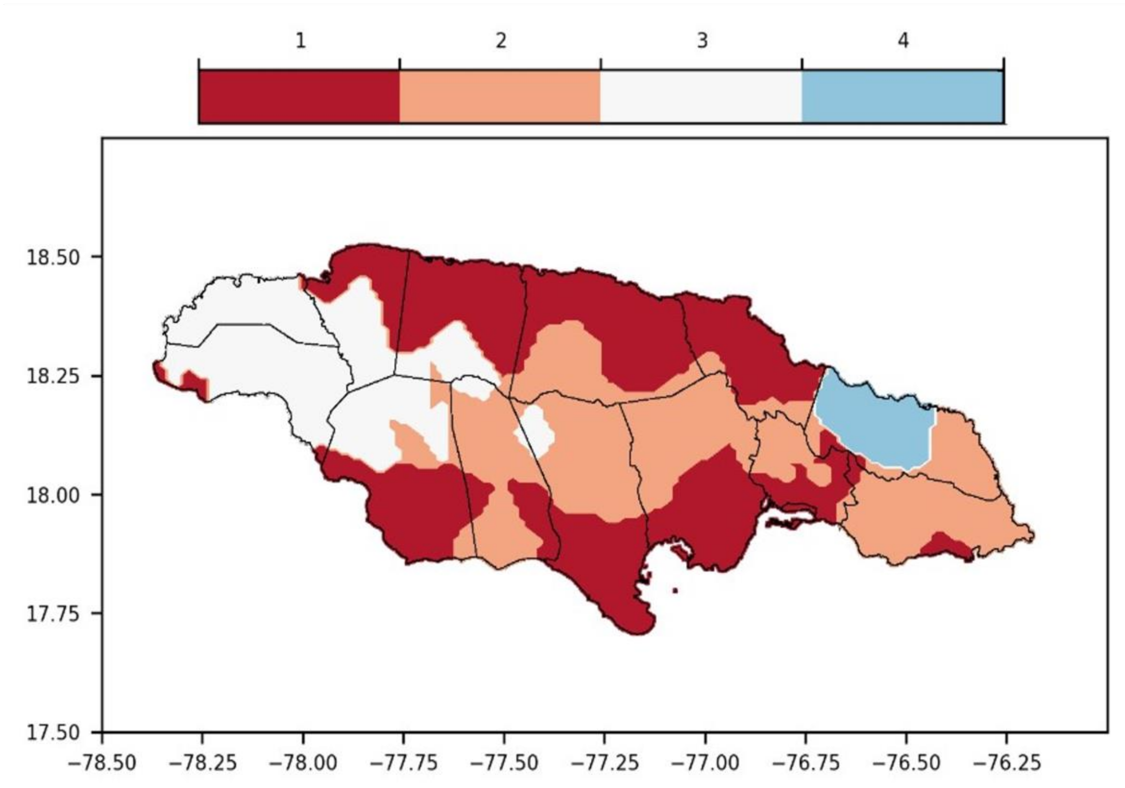


Figure 10-1: Map illustrating Jamaica's 4 rainfall zones. Source SOJC (2021)

Average annual rainfall anomalies over Jamaica for 1881-2019 do not show a statistically significant trend. Rainfall is dominated by year-to-year fluctuations, which generally means trends are near zero and not statistically significant. Seasonal anomalies over the same period are also not statistically significant. The intensity and occurrence of extreme rainfall events have been increasing over 1940-2010. Positive trends are observed for annual total rainfall on the wettest days on record (R95p and R99p), monthly maximum one and five-day precipitation (RX1 and RX5), and the proportion of rainfall intensity to rainfall occurrence (SDII). The average indices also indicate a decrease in consecutive dry days.

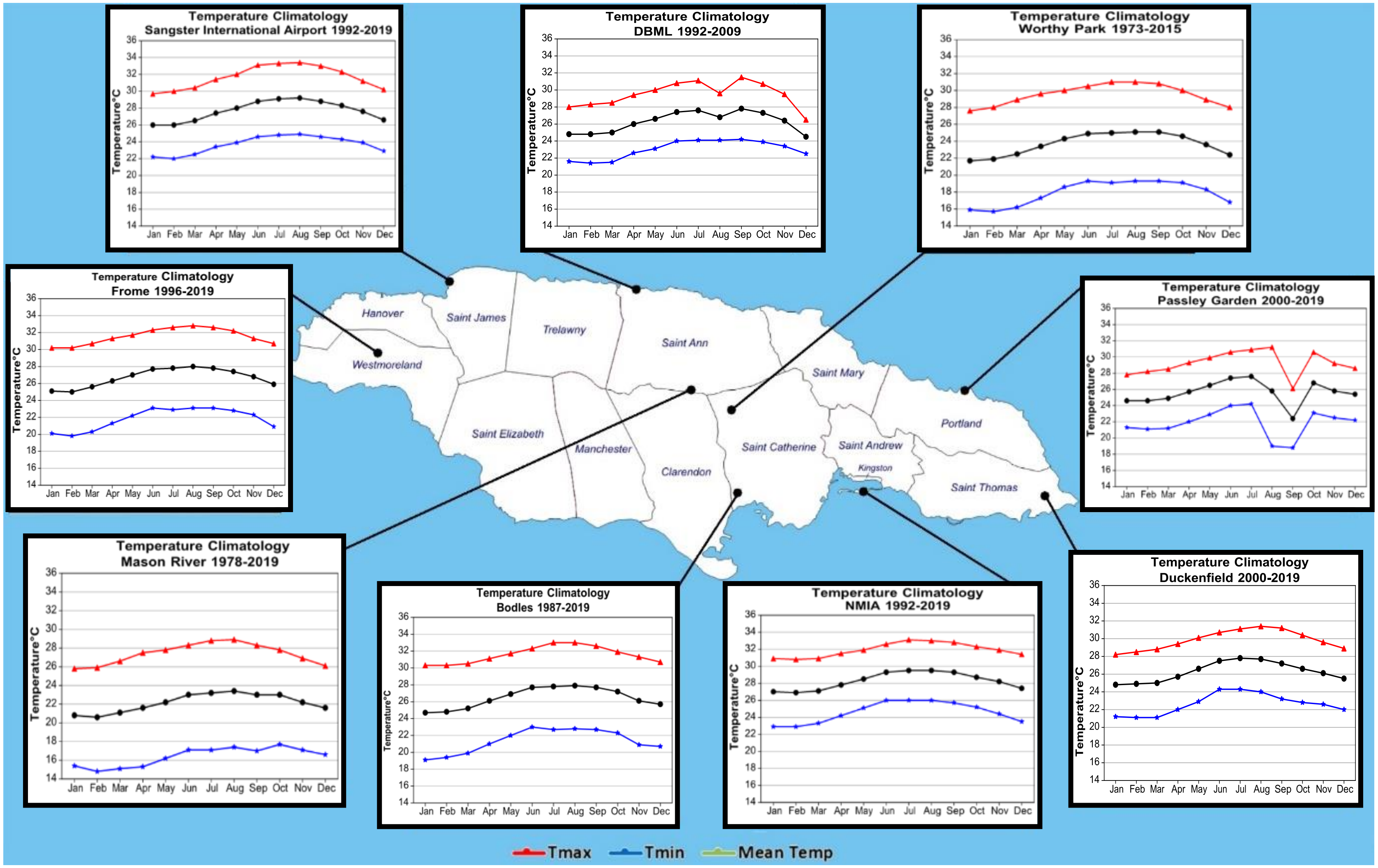


Figure 10-2: Temperature climatology of nine meteorological sites across Jamaica. Maximum temperatures are shown in red, mean temperatures in black and minimum temperatures in blue. Data are averaged over varying periods between 1978 and 2019 for each station.

10.3 Temperature

Globally, near surface air temperature and sea surface temperature (SST) have seen significant changes in the recent past as a result of global warming and anthropogenic climate change. There has been an increase in global mean temperatures of both air and SST. Global surface temperature was 1.09°C higher in 2011-2020 than 1850-1900, with larger increases over land (1.59°C) than over the ocean (0.88°C) (IPCC 2021). This increase is reflected in the Caribbean region where there is a linear increasing trend for both the near surface air temperature and SST which impacts the temperature variability region (CSGM, 2020). In Jamaica the temperatures peak during the summer period between June and August. Jamaica has seen a warming of 0.20 – 0.31 °C per decade according to station records at airports (**Figure 10-2**). The Climatic Research Unit (CRU TS 3.24) gridded data over Jamaica shows that for the 1900-2019, the rate of increase of minimum temperature (~0.27°C/decade) was higher than the rate of increase of maximum temperature (~0.06°C/decade). Mean temperatures are increasing at an approximate rate of 0.16°C/decade (CSGM 2022). This increase in warming has resulted in increases in warm-days and warm-nights alongside a reduction in cold days and nights (CSGM, 2014). Increases in SST may also be conducive to the formation and rapid growth of tropical cyclones.

10.4 Hurricanes

Tropical cyclone/Hurricane activity in the Caribbean is well documented in the Caribbean region. Hurricanes are one of the most destructive natural phenomena that impact the Caribbean, through strong winds and storm surge. The rainfall zone in which Jamaica is located has seen the passage of 25 hurricanes within 200km of it between 1980 and 2016 (CSGM, 2020). Category 4 storms which are classified as strong storms, and are the second highest intensity level for storms was found to be the most frequent to travel within the range of this rainfall zone. The southern coat of Jamaica is more exposed to tropical cyclone activity as it faces the Caribbean Basin which is the path many storms travel on their way to the south coast of the United States. The Hope River empties into the Caribbean Sea on the south coast therefore hurricanes may impact the Hope River WMU. In recent year there has been an increase in the intensity of storms. This may have impacted the recent sea level extremes.

10.5 Sea levels

The Caribbean region is highly vulnerable to sea level rise because of the low elevation and high concentration of the population as well as economic and infrastructural resources in the coastal areas of the many Caribbean islands. Globally the mean seas level has risen by 0.20m between 1901 and 2018. This equates to roughly 1.7 mm/year average sea level rise over this period according to IPCC estimate. The late 20th century into the 21st century has seen acceleration in the rate of sea level rise. Mean sea level increased by 0.20 m between 1901 and 2018. The average rate of increase was 1.3 mm/year between 1901 and 1971, increasing to 1.9 mm/year between 1971 and 2006, and further increasing to 3.7 mm/year between 2006 and 2018 (IPCC 2021). Caribbean Sea levels have increased at a rate which is almost equal to the global mean sea levels. The average sea level in the region rose at a rate of 1.8 ± 0.1 mm/year between 1950 and 2009. The global higher average rates of increase have been observed in more recent periods (for example 2.5 mm/year between 1993 and 2010) (CSGM 2022). Increased intensity of storms will drive greater levels of wind driven storm waves (storm surge) which will cause higher extreme seas levels.

10.6 Climatologies and Means

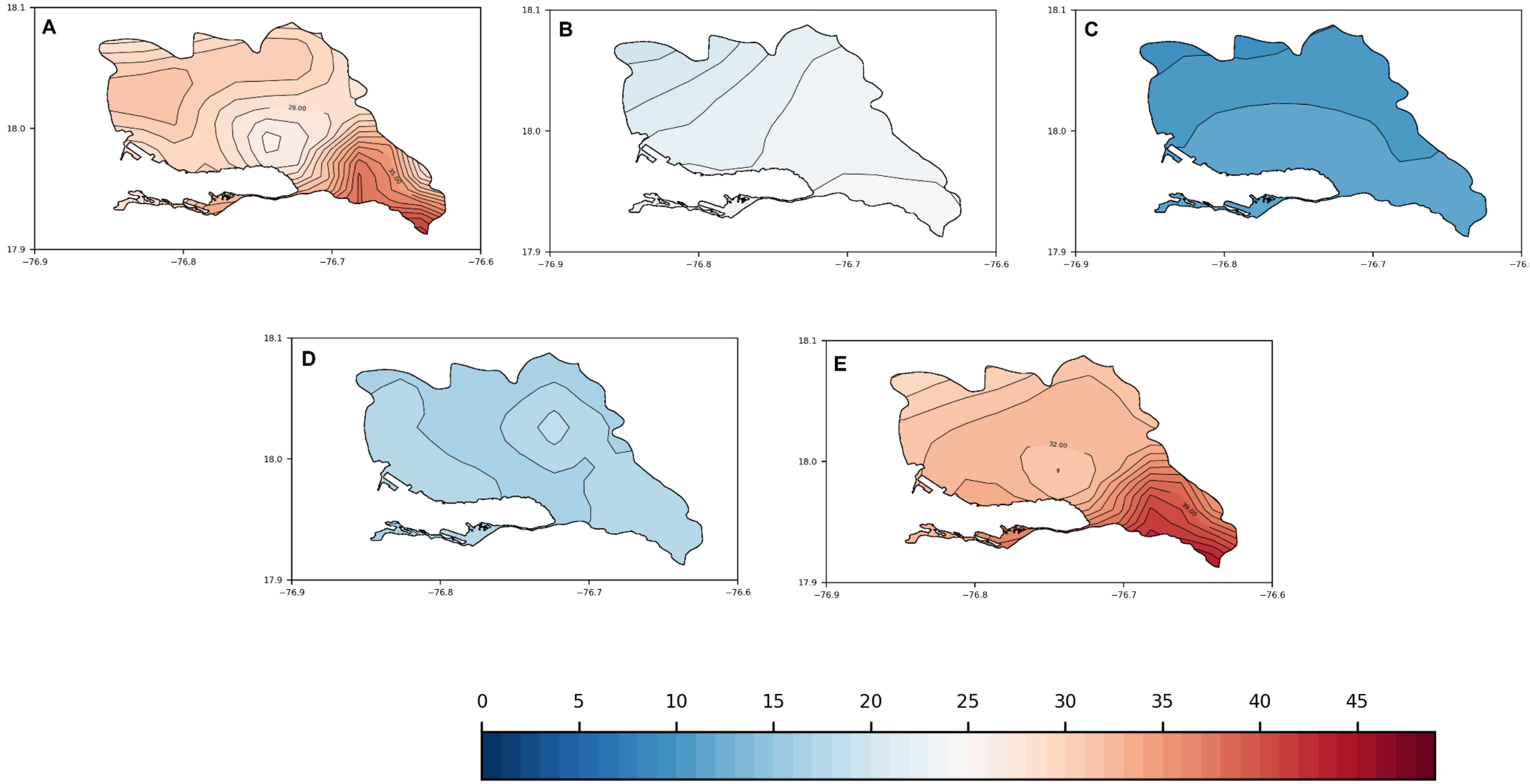


Figure 10-3: Average seasonal and annual maximum consecutive dry days for (a) December – March; (b) April – June; (c) July; (d) August – November and (e) Annual for 1981-2021.

The overall trend in the extremes exhibits an increase in rainfall extremes such as consecutive dry days. The trends in CDD for the Hope River WMU show an annual increase in CDD to a maximum of 28 days on average for the entire WMU (**Figure 10-3**). The increases in CDDs are especially pronounced in the December-March portion of the year which shows up to 29 CDDs (**Figure 10-3**). This coincides with the winter season, suggesting longer dry periods during this time of year. The centre of the WMU along the coast within Kingston Harbour shows marginally less increases in CDD than the rest of the WMU. The minimum increases in CDDs occurs in the August - November period of the year. The maximum daily rainfall for each year was highest in the southeastern region of the Hope River WMU, reaching up to 90mm, and lowest in the western region, reaching only 40mm. The higher observations of maximum daily rainfall were experienced in the August- November period while the lower end coincided with the December-March season (**Figure 10-4**). This was also seen for the number of days where rainfall exceeded 10mm. The south-eastern section of the Hope River WMU experienced up to 35 days while areas in the western section experienced only 20 such days **(Figure 10-5).**

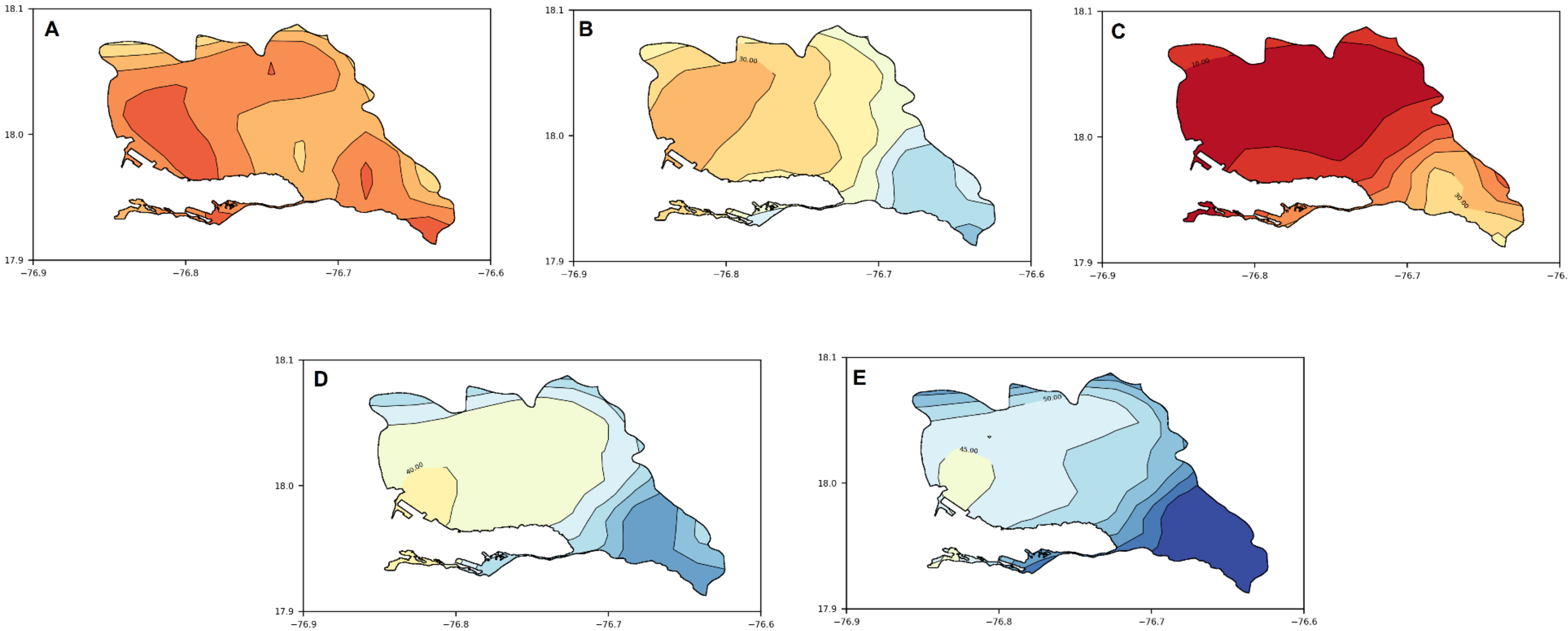


Figure 10-4: Annual seasonal and annual maximum daily rainfall (in mm) for (a) December – March; (b) April – June; (c) July; (d) August – November and (e) Annual for 1981-2021.

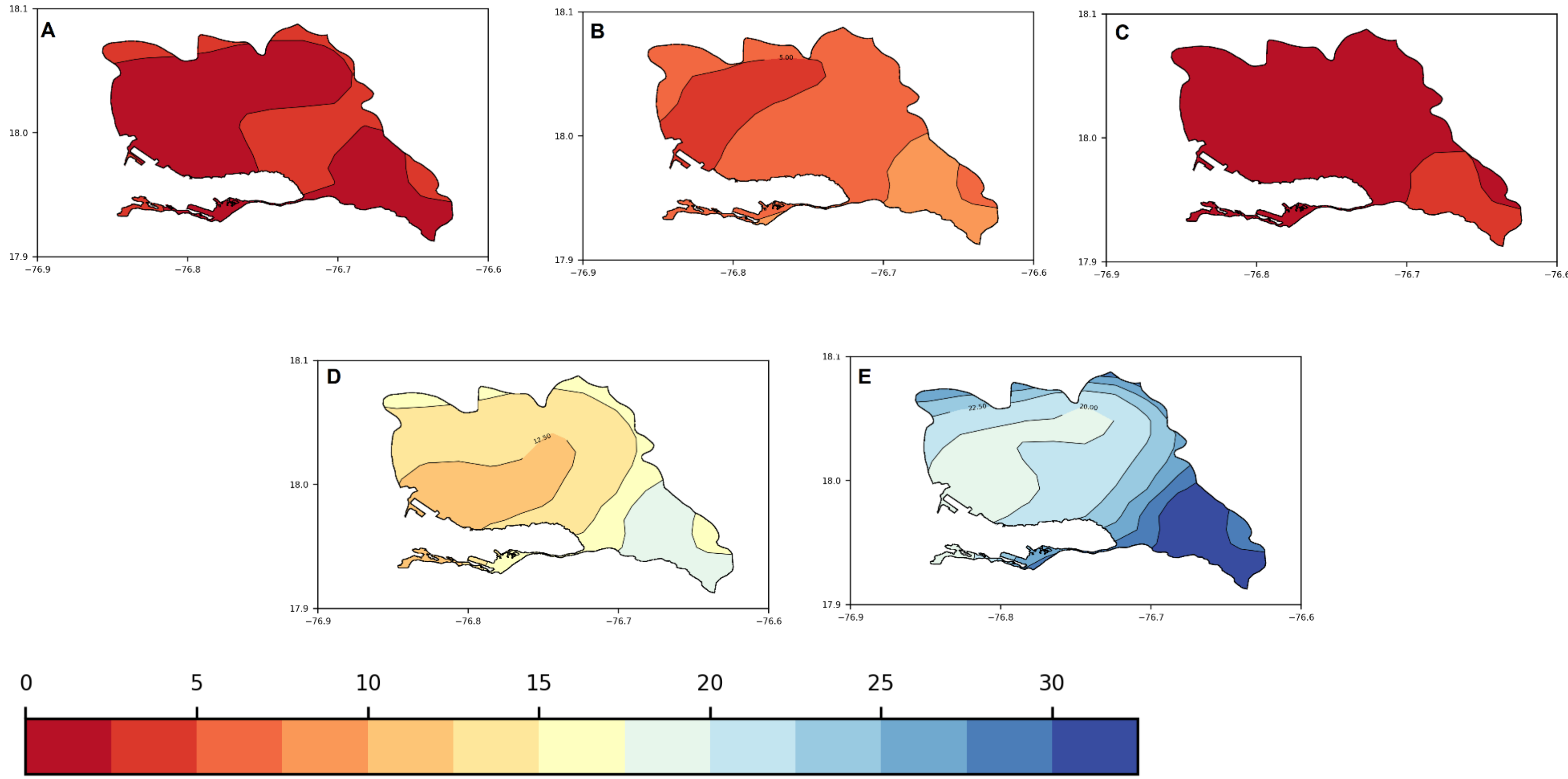


Figure 10-5: Average seasonal and annual days rainfall is greater than or equal to 10 mm (in days) for (a) December – March; (b) April – June; (c) July; (d) August – November and (e) Annual for 1981-2021.

10.7 Storms and Hurricanes

Figure 10-6 and **Figure 10-7** show the number of named storms and hurricanes respectively per 100 years. June and July are omitted because there are no values around Jamaica. For August, October and November (east of the island), 10-29 storms may be observed per 100 years. The maximum is recorded in September where 30-49 named storms may be experienced per 100 years. For hurricanes, 5-19 events may be evident per 100 years for each month (August – October). In September the band of 20-34 hurricanes per 100 years is just north of the island.

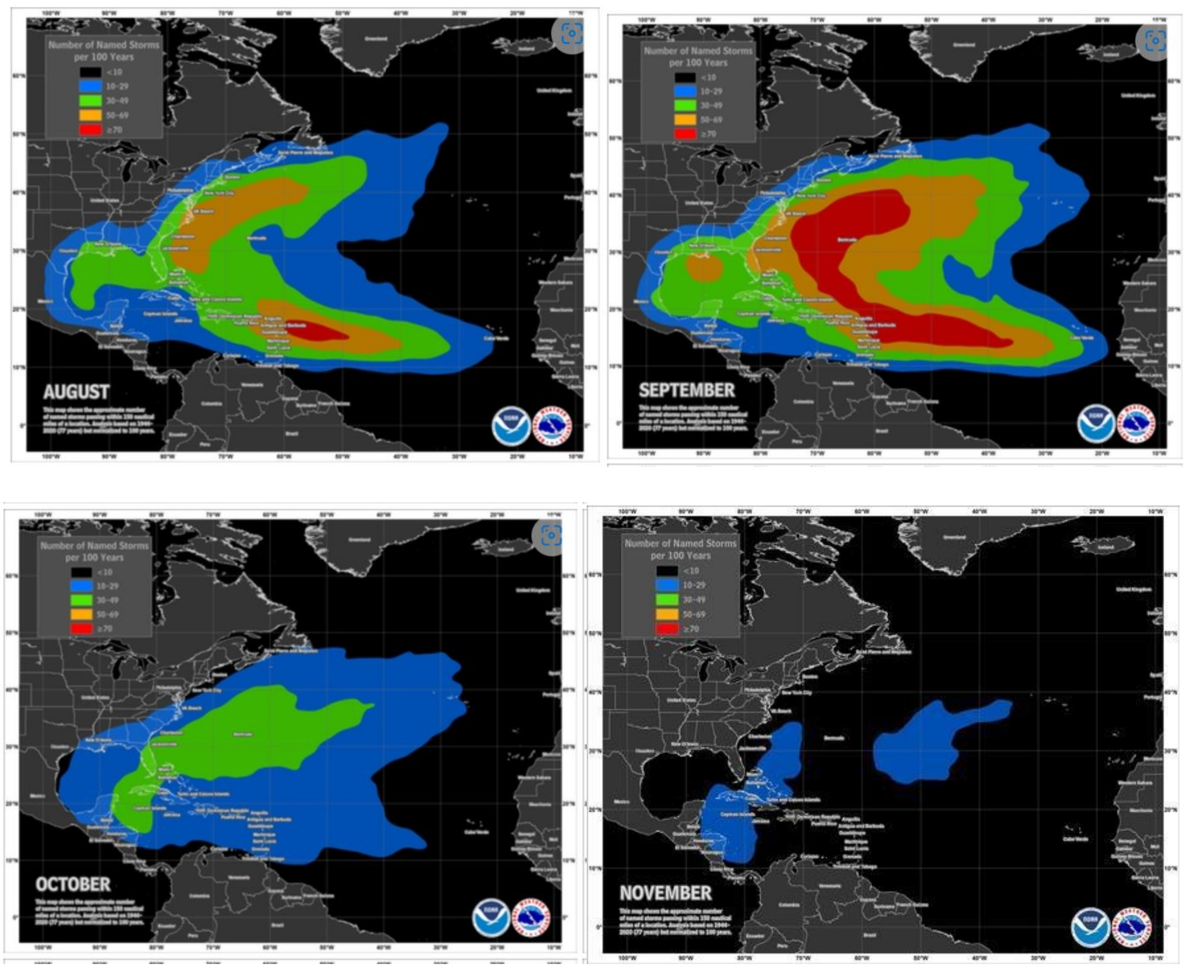


Figure 10-6: Number of named storms per 100 years for August to November. <10 (Black). 10-29 (blue). 30-49 (green).50-69 (orange). ≥70 (red).

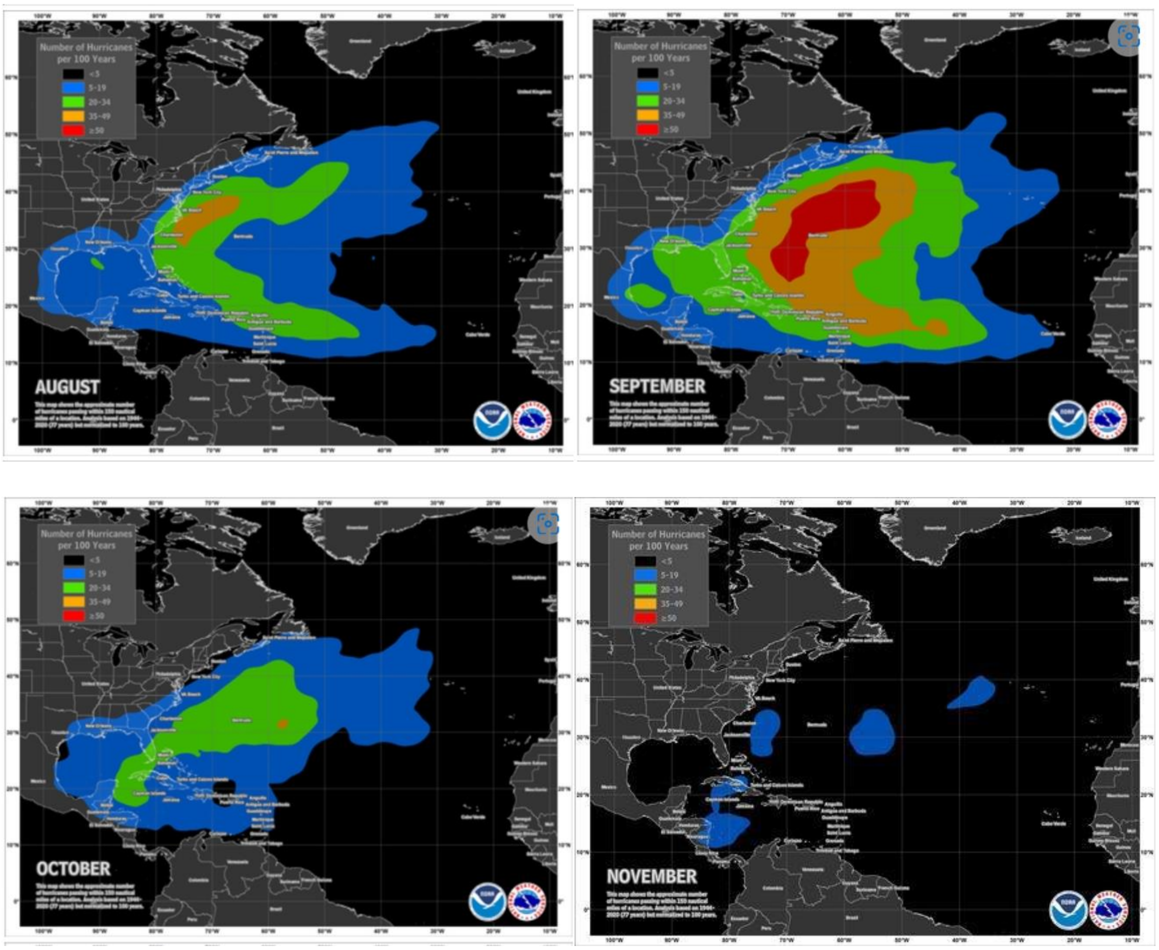


Figure 10-7: Number of hurricanes per 100 years for August to November. <5 (Black). 5-19 (blue). 20-34 (green).35-49 (orange). ≥50 (red).

10.8 Projections - Future Near to Long-Term Climate Projections

10.8.1 Annual Changes

Projected changes in annual rainfall, minimum temperature, maximum temperature and wind from RegCM4.3.5 for Hope River WMU are shown in **Figure 10-8** to **Figure 10-10**. RCP4.5. Projection of annual rainfall for the Hope River WMU in the near-term (2030-39) shows variability within the region. The southeastern portion of the WMU is projected to receive up to 10% more rainfall during this period, while the northern section is expected to receive largely the same amounts as the baseline period. In the medium term (2050-59) these wetter conditions in the southeast are projected to be reduced to less than 5% more rainfall than present while the northern section will experience drier conditions than present with -5% less rainfall. The projections show a shift to drier conditions for the entire WMU by the end of century (2080-97). The projections for maximum annual surface wind speed show slight strengthening of 0.05m/s (near-term), 0.1m/s (medium-term) and .2m/s (end of century) above the baseline period. Model projections for temperature change indicate increases in the maximum and minimum temperature in the coming decades (**Figure 10-10**). There is a relatively uniform increase in maximum temperatures of 1.15^{o}C in the near–term, throughout the Hope River WMU. In this same period the northern region of the WMU shows increase in minimum temperature by 1.2^{o}C while the coastal region shoes increase up to 1.1^{o}C. The projections for the medium-term show increases in minimum temperature of up to 1.5^{o}C and maximum temperature up to 1.6^{o}C which by the end of century reach above 1.9^{o}C for both the minimum temperatures and maximum temperatures (**Figure 10-10**).

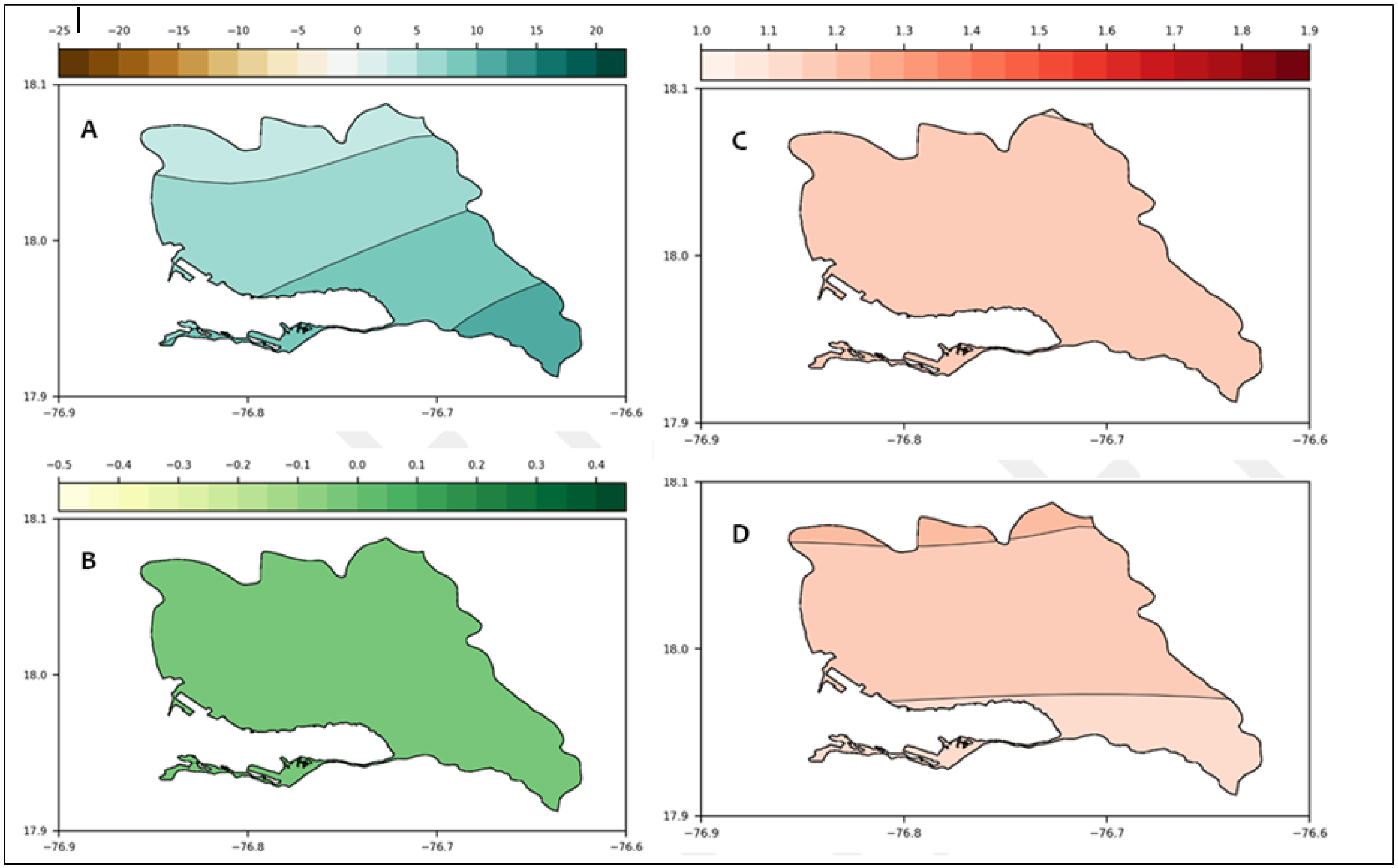


Figure 10-8: Change in annual (a) rainfall (%), (b) maximum surface wind (m/s), (c) 2m maximum temperature (°C) and (d) 2m minimum temperature (°C) for the near term (2030-39) in comparison to 1980-2003 for RCP4.5.

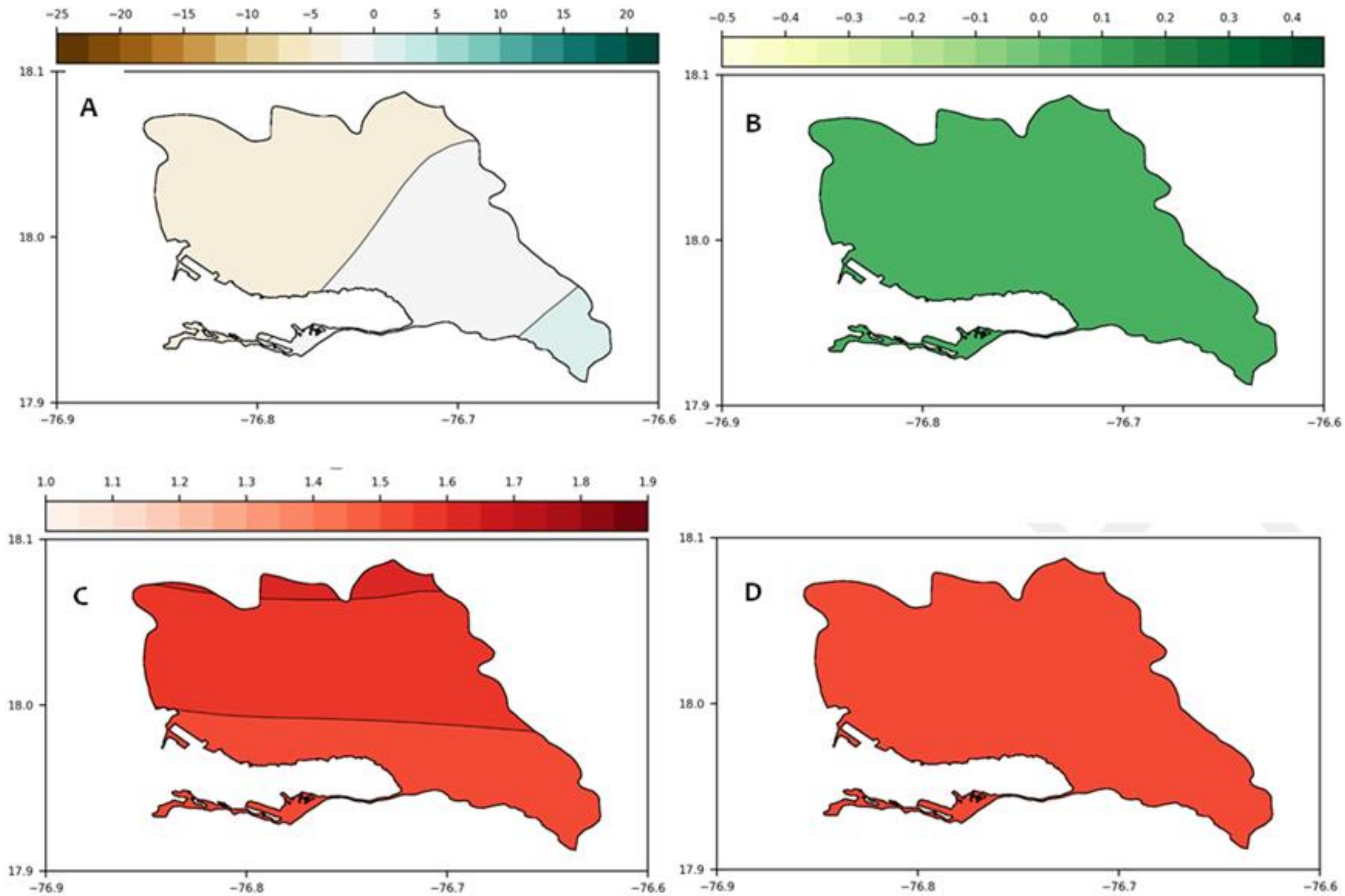


Figure 10-9: Change in annual (a) rainfall (%), (b) maximum surface wind (m/s), (c) 2m maximum temperature (°C) and (d) 2m minimum temperature (°C) for the medium term (2050-59) in comparison to 1980-2003 for RCP4.5.

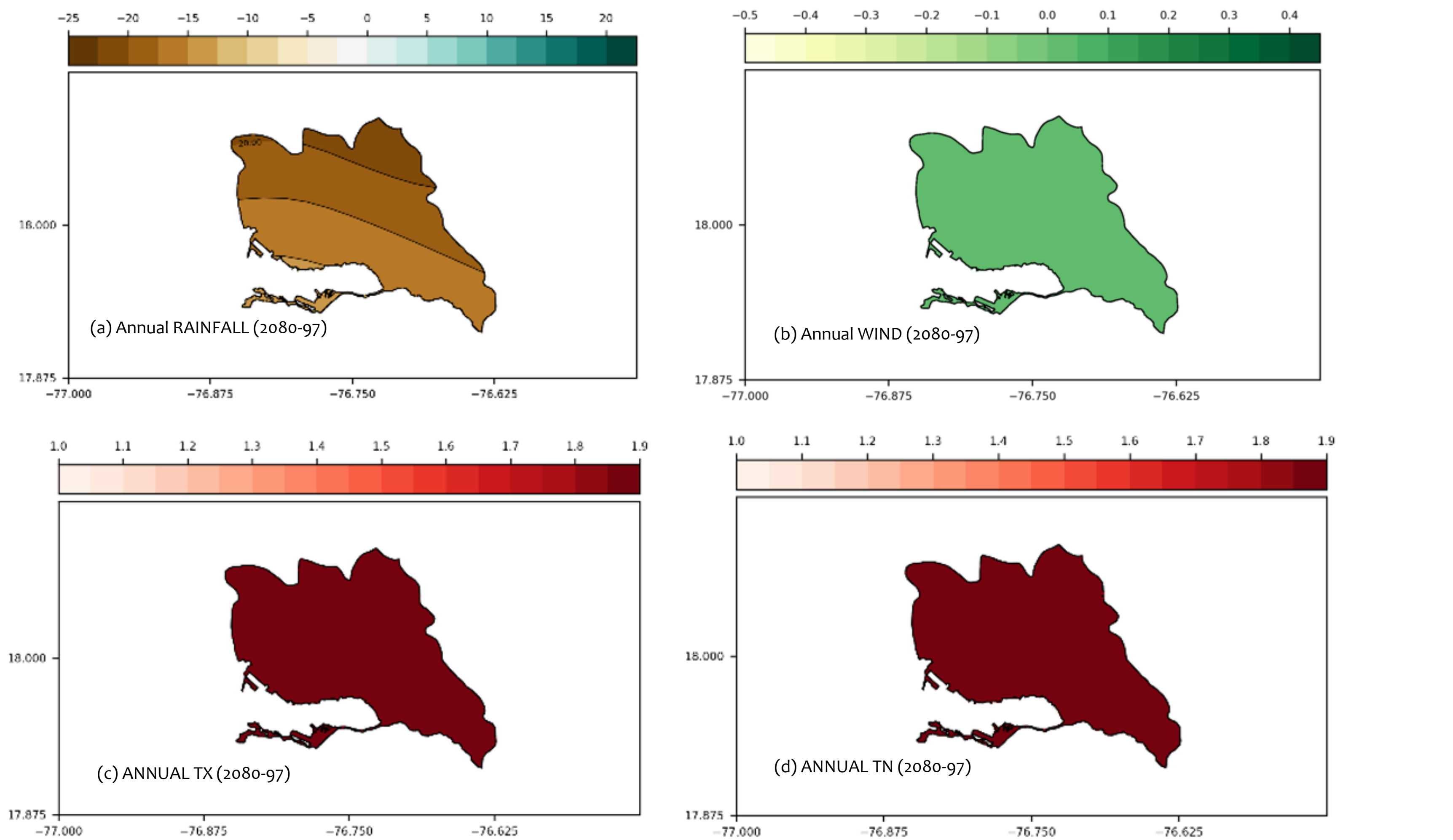


Figure 10-10: Change in annual (a) rainfall (%), (b) maximum surface wind (m/s), (c) 2m maximum temperature (°C) and (d) 2m minimum temperature (°C) for the medium term (2080-87) in comparison to 1980-2003 for RCP4.5.

10.8.2 Seasonal Changes

The projections of annual changes of rainfall changes, temperatures and wind (**Figure 10-11** and **Figure 10-12**) showed general projections of drier conditions, slightly higher wind speeds and increases in temperature for the WMU. These annual changes are not consistent throughout the year; seasonal impacts may be more pronounced than the annual changes. Under the more extreme RCP8.5 scenario the clear differences in the seasonal changes can be seen. **Figure 10-11** shows that there is an overall drying trend in the Hope River WMU during the mid-term however the seasonal breakdown shows that through April-June period it is wetter by up to 25% throughout the entire WMU. The dryness is apparent in the August-November period, the late rainfall season in Jamaica, is which is projected to see decline in up to 20% of rainfall in the northern region of the WMU. The dry season of December- March is also projected to see decreases in rainfall by up to 10% in the majority of the WMU. This suggests that while changes in the annual may be towards drier conditions by middle to end of century under intermediate and extreme emissions scenarios, some seasons still show increasing rainfall.

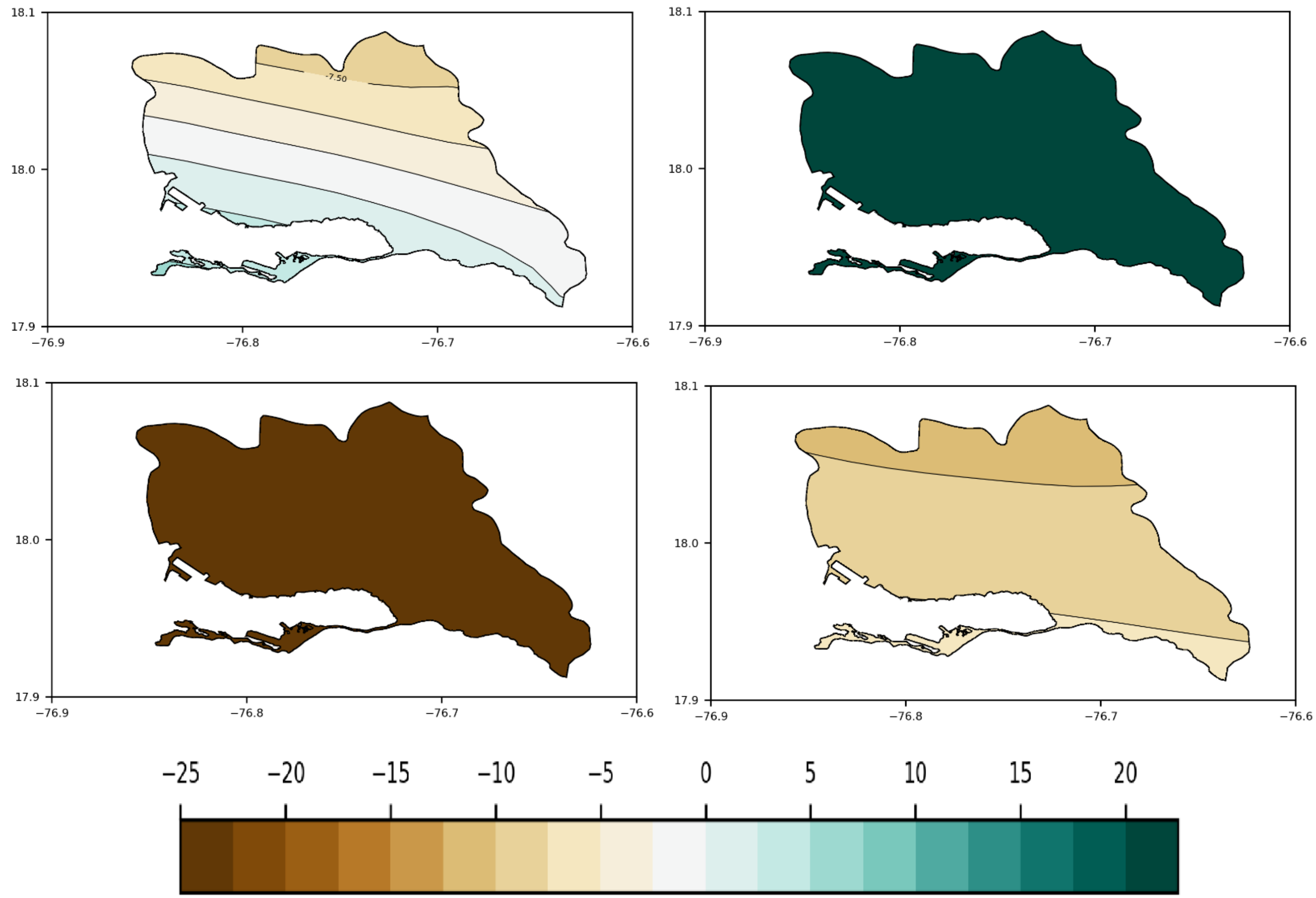


Figure 10-11: Changes in seasonal rainfall for medium term (2050-59) relative to 1980-2003 for RCP8.5 for (a) December-March (DJFM), (b) April – June (AMJ), (c) August – November (ASON) and (d) annual Units are %.

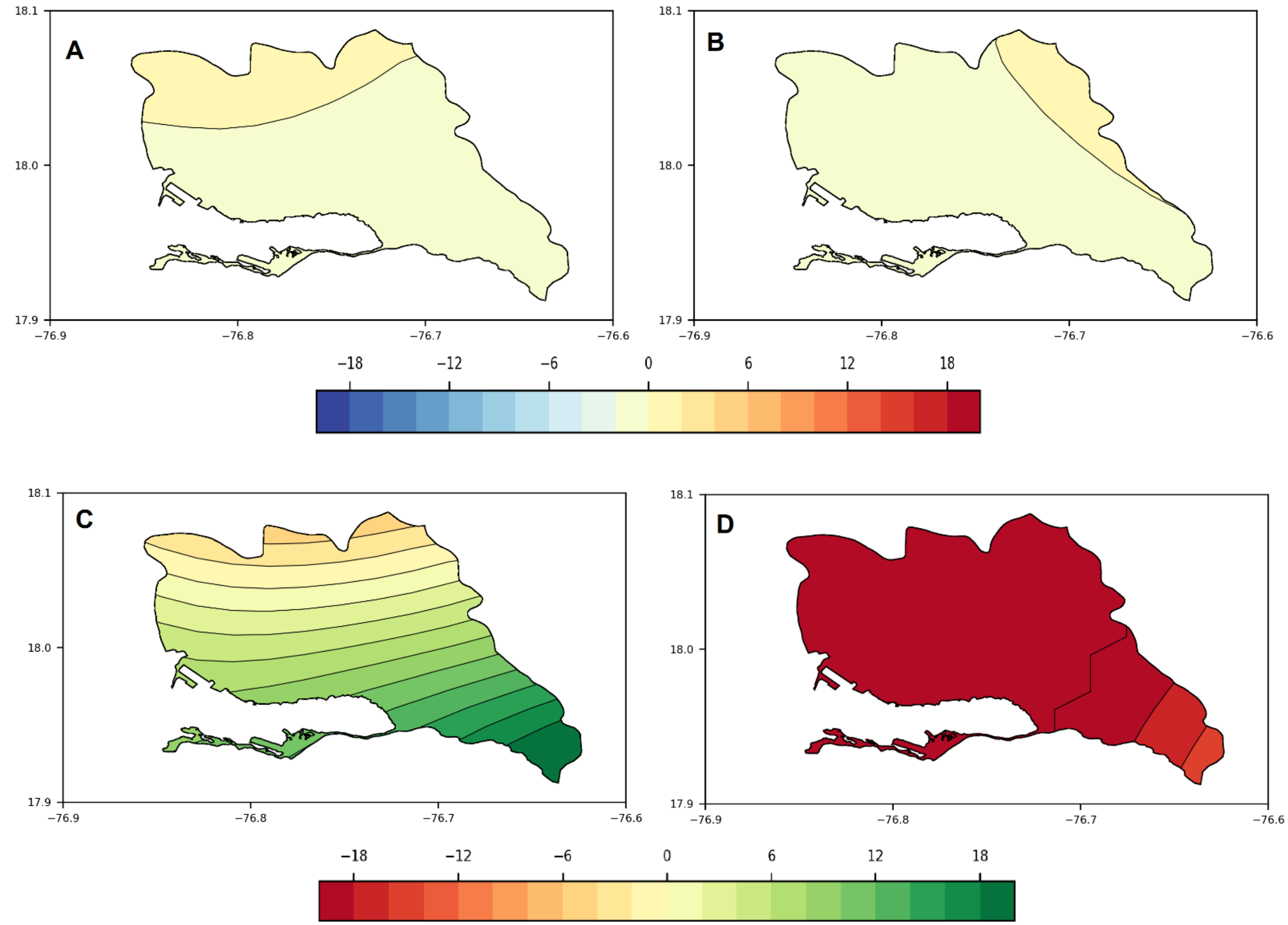


Figure 10-12: Change in annual rainfall extremes for near term (2030-39) and medium term (2050-59 relative to 1980-2003 for RCP4.5. The changes in number of consecutive dry days (CDD) and maximum one day rainfall (in percentage) are highlighted.

10.8.3 Extremes

The extreme rainfall indices such as consecutive dry days (CDD) and maximum 1-day rainfall (RX1) help to quantify projected rainfall changes. **Figure 10-12** of CDDs shows only small changes in the CDDs by 2030-39 with slight decrease in the south of the WMU, which agrees with the projections of slightly wetter conditions for this time period. The maximum one-day rainfall during 2030-39 shows increases in max day rainfall reaching 18% higher relative to 1981-2003 in this south eastern region of the WMU. These results suggest that the rainfall will be more intense in the southern area of the WMU even if it is marginally less frequent. The north sections of the WMU show a slight increase in the CDDs, by as much as +2 days during this period. These slightly wetter conditions continue into the mid-century (2050-59) where the entire WMU except a small section in the east show a slight decrease in CDD down by to -2 days. The maximum one-day rainfall during the mid-century showed decreasing rainfall of over -10% throughout the entire WMU. RX1 is projected to reduce to -18% in the majority of the western and central areas of the WMU which indicate the prevalence of drier conditions overall.

Under the extreme RCP8.5 scenario there is significant seasonal variability of CDD and RX1 throughout the WMU by 2050-59. The overall annual CDD in **Figure 10-13** shows a slight decrease in CDD for the WMU but indicates that there is a decrease of as much as -6 days in the south-eastern section of the WMU for the December-March season. While the August-September season shows an increase in CDD for the central and eastern sections of the Hope River WMU. The dynamic seasonal variability of rainfall related extremes is more pronounced in the RX1. The RCP8.5 projection for 2050-59 show decrease in RX1 by over 4% in the entire WMU with the northeastern section seeing a reduction by as much as -8% in the December-March season. This is very different from the projected increase in the RX1 by over 18% for the entire region during the early wet-season (April-June). The late wet-season (August-November) however which typically produces the most precipitation in Jamaica is projected to see reduction in RX1 by -20% for the entire Hope River WMU which suggests largely drier conditions overall (**Figure 10-14**).

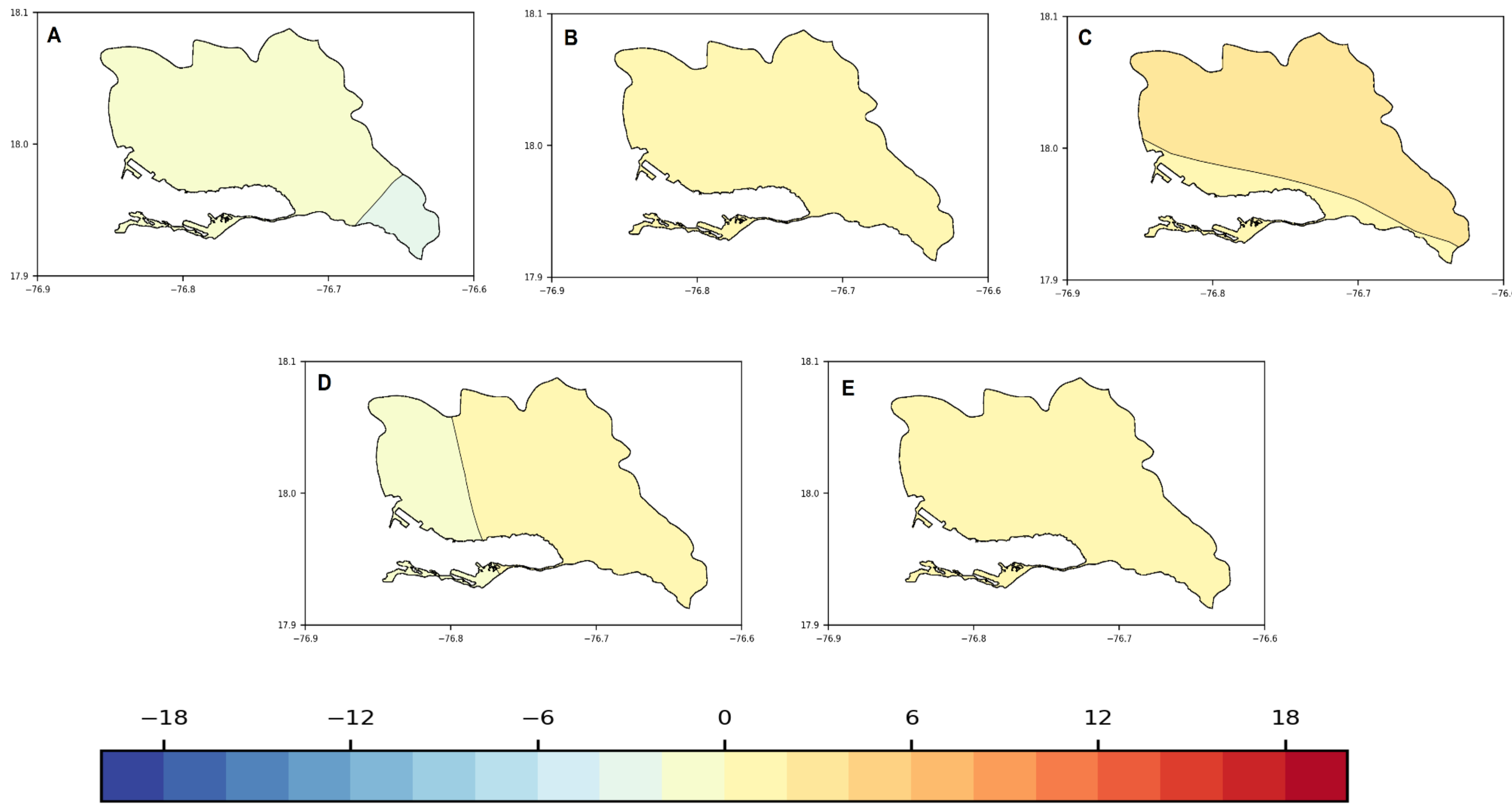


Figure 10-13: Changes in seasonal CDD for medium term (2050-59) relative to 1980-2003 for RCP8.5 for (a) December-March (DJFM), (b) April – June (AMJ), (c) July, (d) August – November (ASON) and (e) annual. Units are days.

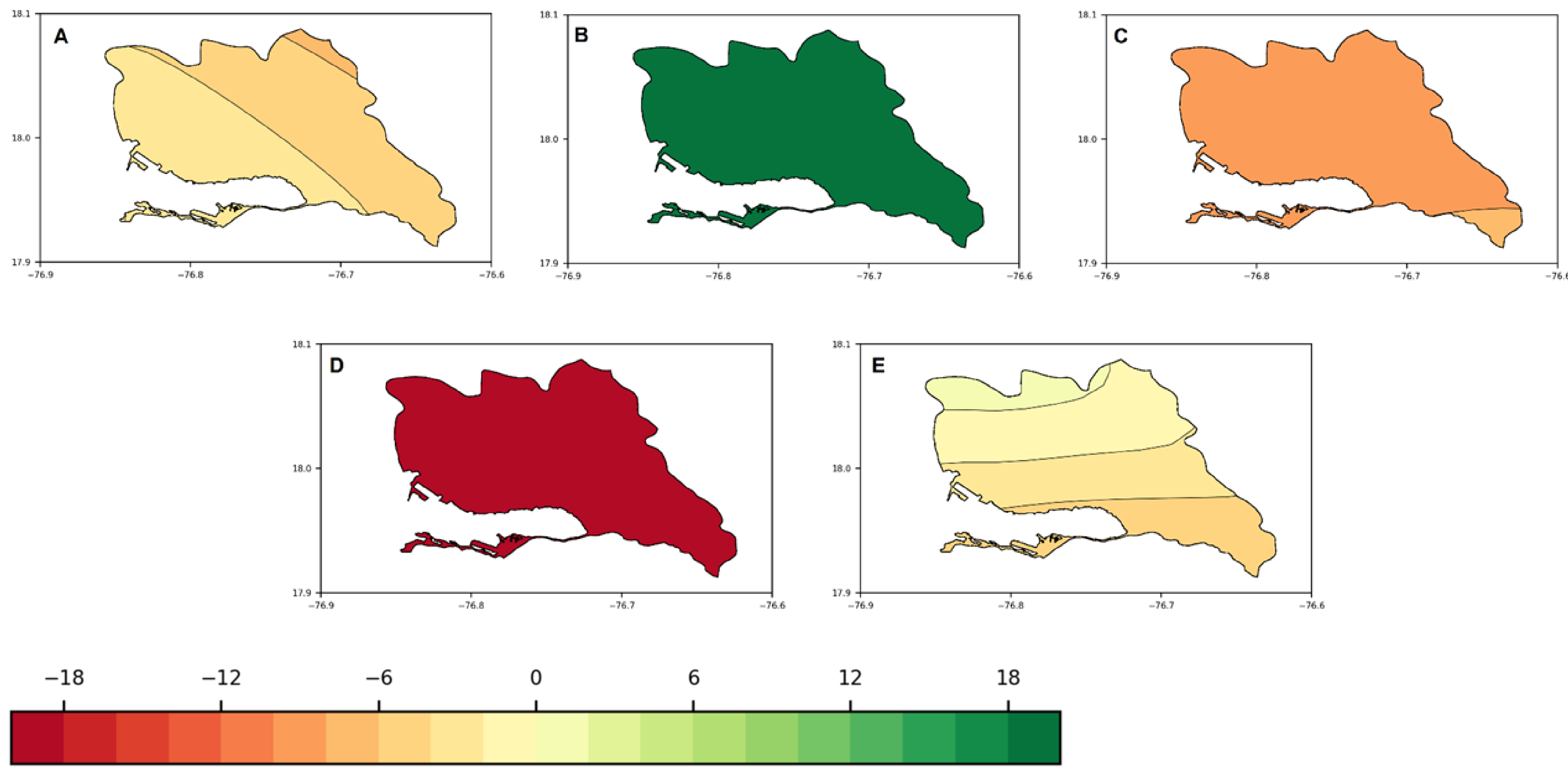


Figure 10-14: Changes in seasonal RX1 for medium term (2050-59) relative to 1980-2003 for RCP8.5 for (a) December-March (DJFM), (b) April – June (AMJ), (c) July, (d) August – November (ASON) and (e) annual. Units are %.

10.9 Impact Assessment for Three Climate Change Projections

10.9.1 RCP2.6

Under the least severe of the RCPs, RCP2.6, there is projected to be a moderate increase in the annual total of precipitation for the Hope River WMU at the end of the century. The pattern of increase has a northwest gradient with highest increases (~7.5%) seen coastally and the lowest seen in the hilly interior or the northern extents of the watershed (~2.5%). This is a similar pattern noted for both the middle of the century and the near term, however instead of increases the WMU shows a pattern of reduced rainfall totals with the northern extents of the domain projected to receive up to 12% less rainfall than the coastal areas relative its baseline. Seasonally the projected changes in rainfall for the April-May-June show the highest increases in precipitation at the end of the century with increases reaching up to and exceeding 20% coastally with a reduction in increases as the WMU is traversed northerly. However, in earlier time periods, during AMJ, there is a clear reduction in rainfall amounts with smaller reductions in the near term (-2.5% to -10%) and greater reductions in the medium term (-12.5% to -20%). Overall reductions in rainfall were greatest during the July-August period with reductions exceeding 25% coastally and averaging 20% in the northern extents of the WMU, this was almost independent of the time period under investigation. The shift from dry to wet as we traversed the medium term to the end of the century is corroborated by CSGM 2020.

The projections for the medium-term show increases in minimum temperature of up to 1.4°C and maximum temperature up to 1.6°C which by the end of century reach above 1.3°C for both the minimum temperatures and maximum temperatures.

10.9.2 RCP4.5

For RCP4.5. projection of annual rainfall for the Hope River WMU in the near-term (2030-39) shows variability within the region. The south eastern portion of the WMU is projected to receive up to 10% more rainfall during this period while the northern section is expected to receive largely the same amounts as baseline period. In the medium term (2050-59) these wetter conditions in the south east are projected to be reduced to less than 5% more rainfall than present while the northern section will experience drier conditions than present with -5% less rainfall. The projections show a shift to drier conditions for the entire WMU by the end of century (2080-97). The projections for maximum annual surface wind speed show slight strengthening of 0.05m/s (near-term), 0.1m/s (medium-term) and 0.1m/s (end of century) above the baseline period. Model projections for temperature change indicate increases in the maximum and minimum temperature in the coming decades. There is a relatively uniform increase in maximum temperatures of 1.15^{o}C in the near–term, throughout the Hope River WMU. In this same period the northern region of the WMU shows increase in minimum temperature by 1.2^{o}C while the coastal region shoes increase up to 1.1^{o}C. The projections for the medium-term show increases in minimum temperature of up to 1.5^{o}C and maximum temperature up to 1.6^{o}C which by the end of century reach above 1.9^{o}C for both the minimum temperatures and maximum temperatures.

10.9.3 RCP8.5

Under the more extreme RCP8.5 scenario there is an overall drying trend in the Hope River WMU during the mid-term however the seasonal breakdown shows that through April-June period it is wetter by up to 25% throughout the entire WMU. The dryness is apparent in the August- November period, the late rainfall season in Jamaica, is projected to see decline in up to 20% of rainfall in the northern region of the WMU. The dry season of December- March is also projected to see decreases in rainfall by up to 10% in the majority of the WMU. This suggests that while changes in the annual may be towards drier conditions by middle to end of century under intermediate and extreme emissions scenarios, some seasons still show increasing rainfall.

10.10 Discussion of analysis of findings

This assessment of the present state of the climate in the Hope River Water Management Unit shows variability in the present and in future projections.

Projections of temperatures show continued increases in both the maximum temperature (up to 1.7°C) and minimum temperatures (up to 1.6°C) in the Hope River WMU through to mid-century and beyond. The temperature increases approach 2°C by end of century. The very likely increase in temperatures will negatively impact ecosystems and the services they provide, as well as result in biodiversity loss. These will impact on settlements and infrastructure, food and water security, health, economies, culture and migration/displacement as suggested by Mycoo et al. (2022).

The near term annual rainfall will increase up to 15%, the medium-term increase will be reduced to within the region of 7.5% while by the end of the century there will be a drying of 22.5%. The December-March and seasons show decrease in seasonal maximum 1-day rainfall (increased drying) by as much as -10% and -20% respectively, by 2050-59, according to projections under RCP8.5 scenario. There is an overarching annual drying trend for the whole WMU projected for this time annually, but the April-June season will be wetter with projections showing an increase in the RX1 by as much as 20%. The consecutive dry days are projected to remain largely the same for the Hope River WMU during this time. The changes in rainfall will have implications for freshwater supply and stream flow patterns within the WMU that will impact downstream users and habitat conditions for organisms supporting a wide range of ecosystem services (Mycoo et al. 2022).

1 The IPCC (2021) suggests that with increasing global warming, the proportion of intense tropical cyclones (Category 4-5) and peak winds of most intense tropical cyclones are projected to increase at the global scale. Inferences can be made with respect to an increased risk to the WMU associated with intense winds and rains from storms and tropical cyclones. Relative to 1995-2014 Global mean sea level rise is projected to be 0.44 – 0.76 m under the intermediate greenhouse gas (GHG) emissions scenario (SSP2-4.5) and 0.63 – 1.01 m under the very high GHG emissions scenario (SSP5-8.5). Local projections of sea level rise on the south coast of Jamaica (17°N, 77°W) found using the recently released IPCC Sea Level Projection Tool (https://sealevel.nasa.gov/ipcc-ar6-sea-level-projection-tool) show that under the intermediate GHG emissions scenario (SSP2-

4.5), sea level on the north coast of Jamaica is projected to rise by 0.64 ± 0.310 m by 2100 (0.11 ± 0.060 m by 2030 and 0.24 ± 0.120 m by 2050). Under the very high GHG emissions scenario (SSP5-8.5), the total sea level rise projections are 0.85 ± 0.630 m by 2100; 0.12 ± 0.060 m by 2030 and 0.27 ± 0.120 m by 2050. These projections for 17°N, 77°W may be accessed at https://sealevel.nasa.gov/ipcc-ar6-sea-level-projection-tool?lat=17&lon=-77. SSPs are explained below.

SSPs are a new way method of assessing future scenarios which seeks to combine the knowledge of the physical sciences of climate change with the societal impacts brought on by the vulnerability caused by climate change. SSPs incorporate adaptation and mitigation research to create more holistic approach to future projections by combining them with future emission and concentration scenarios with socio-economic development pathways. SSPs were presented in AR6 and are not equivalent to RCPs however also incorporate emissions scenarios (Pörtner et al., 2022; Riahi et al.,

11 Vulnerability to Climate Change

The objective of the Vulnerability Assessment (VA) conducted in the select communities in the Hope River WMU was to evaluate the susceptibility of communities to climate related events and to identify appropriate measures for Ecosystem-based Adaptation that can be implemented at the community level. This involved identifying factors for vulnerability components exposure, sensitivity, impact and adaptive capacity.

According to the IPCC[6], vulnerability to climate change refers to the "degree to which a system is susceptible to and unable/able to cope with, adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of the character, magnitude and rate of climate change and variation to which a system is exposed, its sensitivity and adaptive capacity.”

Understanding the impacts of climate change on communities and their socio-ecological systems requires assessing their vulnerability to climate-related hazards and their capacity to adapt to future climate scenarios. Site specific vulnerability analysis can help identify hotspots or areas exposed to multiple risks and hazards.

Baseline data, specifically the output of the socio-economic surveys and the biophysical surveys have been used to identify site-specific threats, which will inform the selection of possible solutions (i.e., EbAs).

---

6 IPCC, 2007: Climate Change 2007: Synthesis Report. Contribution of Working Groups I, II and III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, Pachauri, R.K and Reisinger, A. (eds.)]. IPCC, Geneva, Switzerland, 104 pp.

11.1 Socio-environmental Vulnerability to Climate Change

The study focused on examining communities in the Hope River WMU that were representative of the upper, middle, and lower regions. The investigation looked at various aspects of the physical environment, such as geology, hydrology, climate, and the state of ecosystems and the services they provide. To evaluate the level of exposure of inhabitants, ecosystems, and associated productive systems to existing hazards, the analysis included baseline data and evaluated the adaptive capacity. The findings were used to assess the current level of vulnerability of the communities in the study. This assessment of vulnerability offers a starting point for evaluating the potential consequences of future climate scenarios and identifying appropriate solutions.

- Who or what is vulnerable?
- What they are vulnerable to?
- What is the degree of vulnerability?
- What EbAs can be implemented to reduce this vulnerability?

Figure *11-1* presents the vulnerability framework[7], which outlines the workflow for evaluating the vulnerability of communities to both existing and future hazards within the context of climate change. The framework also facilitates the assessment of adaptive capacity of these communities and the environment they inhabit to withstand these hazards.

7 (n.d.). Https://cityadapt.Com/que-es-la-adaptacion-al-cc/. What is Climate Adaptation. Retrieved November 29, 2022, from https://cityadapt.com/que-es-la-adaptacion-al-cc/

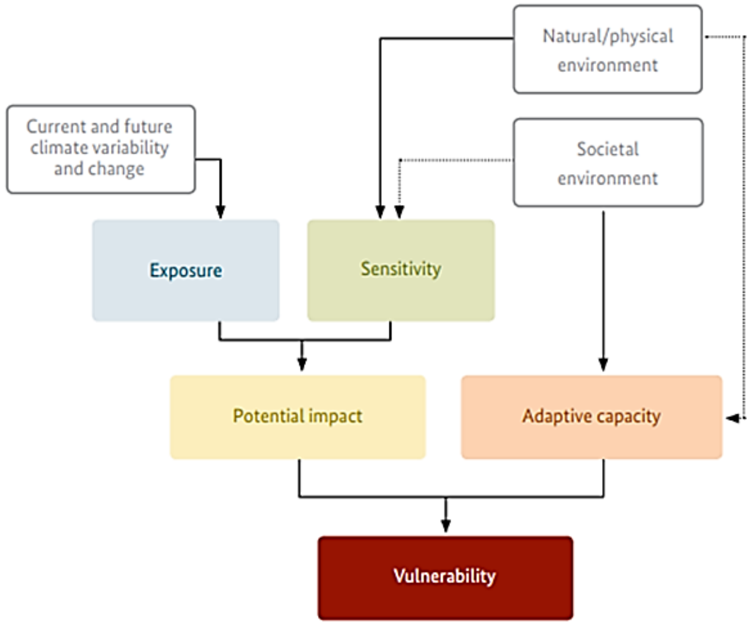


Figure 11-1. Vulnerability components [8]

***Exposure**: Factors that are directly related to climate parameters. Common parameters of exposure include temperature, precipitation, heavy rain, meteorological drought, and extreme weather events. Changes in these parameters can exert major additional stress on systems (e.g. heavy rain events, increase in temperature, shift of peak rain from June to May)*

***Sensitivity:** Factors that affect the magnitude of consequences of a hazard. Sensitivity may include social (e.g., age structure, income structure) and ecological/physical (land use, water retention capacity for flood control, building material) attributes of a system.*

***Adaptive Capacity:** Set of factors that determine the capacity of a system/community to generate and implement adaptation measures. These factors pertain to the available resources within human systems and their socio-economic, structural, institutional and technological capacities. It also considers the resilience of biophysical systems (i.e., ecosystem resilience).*

***Vulnerability:** The predisposition to be adversely affected. Vulnerability encompasses a variety of concepts and elements including sensitivity or susceptibility to harm and lack of capacity to cope and adapt.*

---

[8] Fritzsche, K., Schneiderbauer, S., Bubeck, P., Kienberger, S., Buth, M., Zebisch , M., & Kahlenborn, W. (2014). The Vulnerability Sourcebook: Concept and guidelines for standardised vulnerability assessments. (GIZ). https://adelphi.de/en/publications/the-vulnerability-sourcebook-concept-and-guidelines-for-standardised-vulnerability

11.2 Geographic Scope – Hope River Watershed Management Unit

Watershed management units are defined geographic areas across Jamaica that are managed and monitored by the NRCA/NEPA, in conjunction with other government agencies, Parish Councils, or other stakeholders to protect and manage the water resources within those areas.

The Hope River watershed Management Unit (WMU) is in the southeastern section of the island (**Figure 11-2**) covering an estimated 250 km^2. The most important watershed in the Hope River WMU is the Hope River drainage basin.

11.3 Hope River watershed

The Hope River and its tributaries (**Figure 11-2**) play a crucial role as a primary water source for the Mona Reservoir (capacity of 3.03 million cubic meters) which supplies water to the Kingston metropolitan area and surrounding communities (Hayman, 2000). Moreover, the Hope River basin serves as a vital habitat for numerous plant and animal species, including various endangered species, highlighting its ecological significance.

As is true for all of the island's watersheds, the Hope River watershed is under stress due to population growth, increased development, inadequate maintenance of roads and unsustainable farming practices. The combined effect of these stresses results in deterioration of the watersheds resulting in the increased vulnerability to the effects of drought and subsequent heavy rainfall events. These effects are expected to become more pronounced in the future due to the impacts of climate change.

The Hope River watershed has been described as extremely fragile in that years of misuse of steep slopes, rapid population growth and agricultural expansion (mainly coffee) have been contributing to reduced availability of water, deteriorating conditions due to erosion, deforestation and degrading water quality.

Small Island states like Jamaica bear a disproportionately high impact from climate change relative to their low emission of greenhouse gases. In this situation it essential to improve watershed management through strategic inventions to promote:

- Behavioral change - land use and farming practices
- Revegetation/reforestation
- Erosion control – reduce loss of topsoil

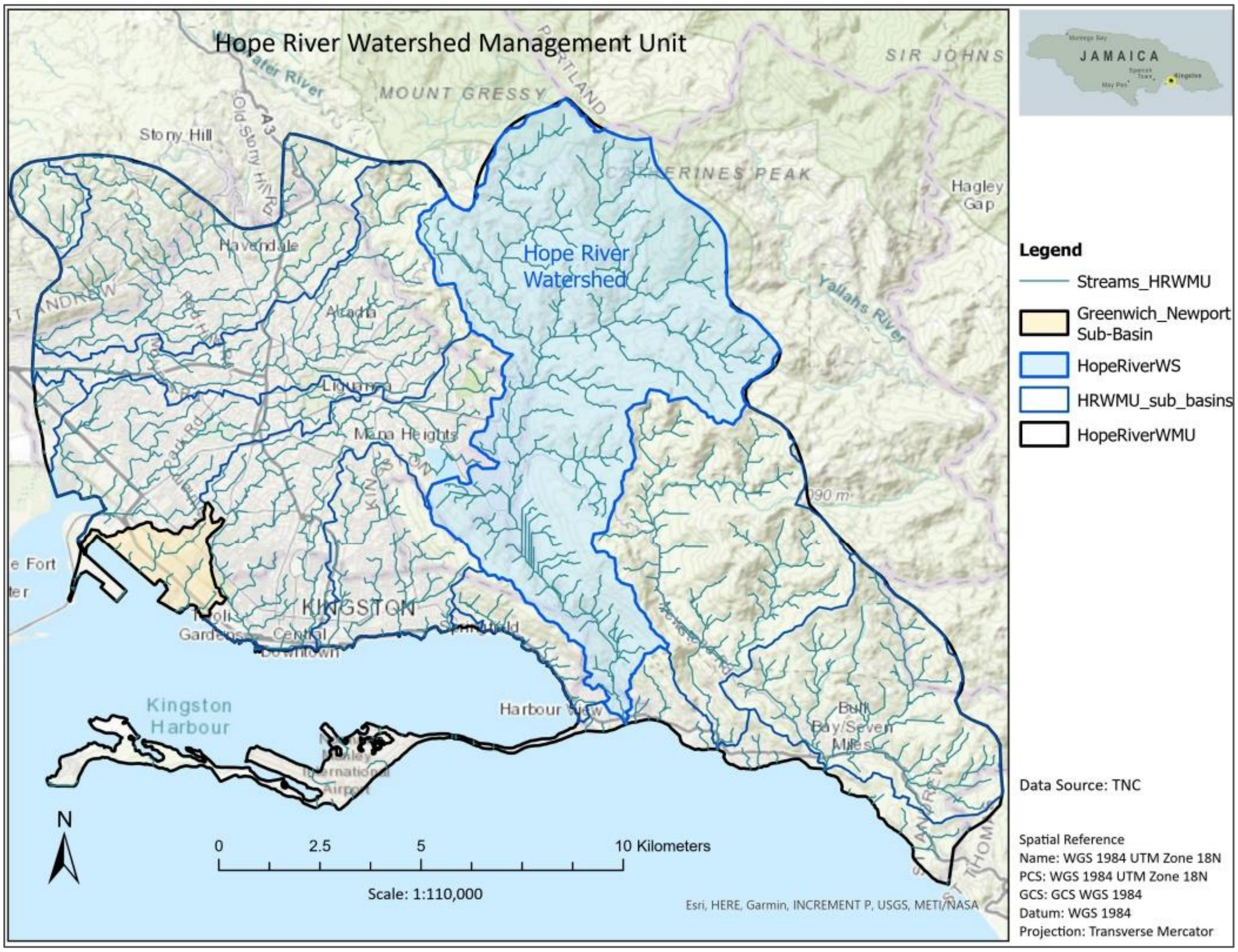


Figure 11-2. Hope River watershed (blue) and the synthetic stream channels (green)[drainage network derived from 6m Lidar data River Tools software; data source TNC]   in the broader watershed management unit(WMU in black).

11.3.1 Sub-basins

Sub-basins are typically delineated by natural features such as ridges, hills, or other topographical boundaries that separate them from adjacent areas. They can vary in size, and their boundaries may be determined by factors such as land use, soil type, and hydrology. In addition to the Hope River watershed, the Hope River watershed Management unit comprises smaller watersheds or sub-basins, each with its own unique characteristics and features.

This study focused on the upper and middle reaches of the Hope River watershed and the Greenwich-Newport sub-basins located in the lower reaches of the Kingston/Liguanea basin within the greater Hope River WMU (**Figure 11-3**).

The management of sub-basins is important because the health of each sub- watershed can affect the overall health of the larger watershed. The management of sub- watersheds involves understanding the specific characteristics and features of each sub watershed, such as its land use, soil type, and hydrological processes, and implementing appropriate management practices to protect and improve water quality and quantity in the sub watershed and downstream areas.

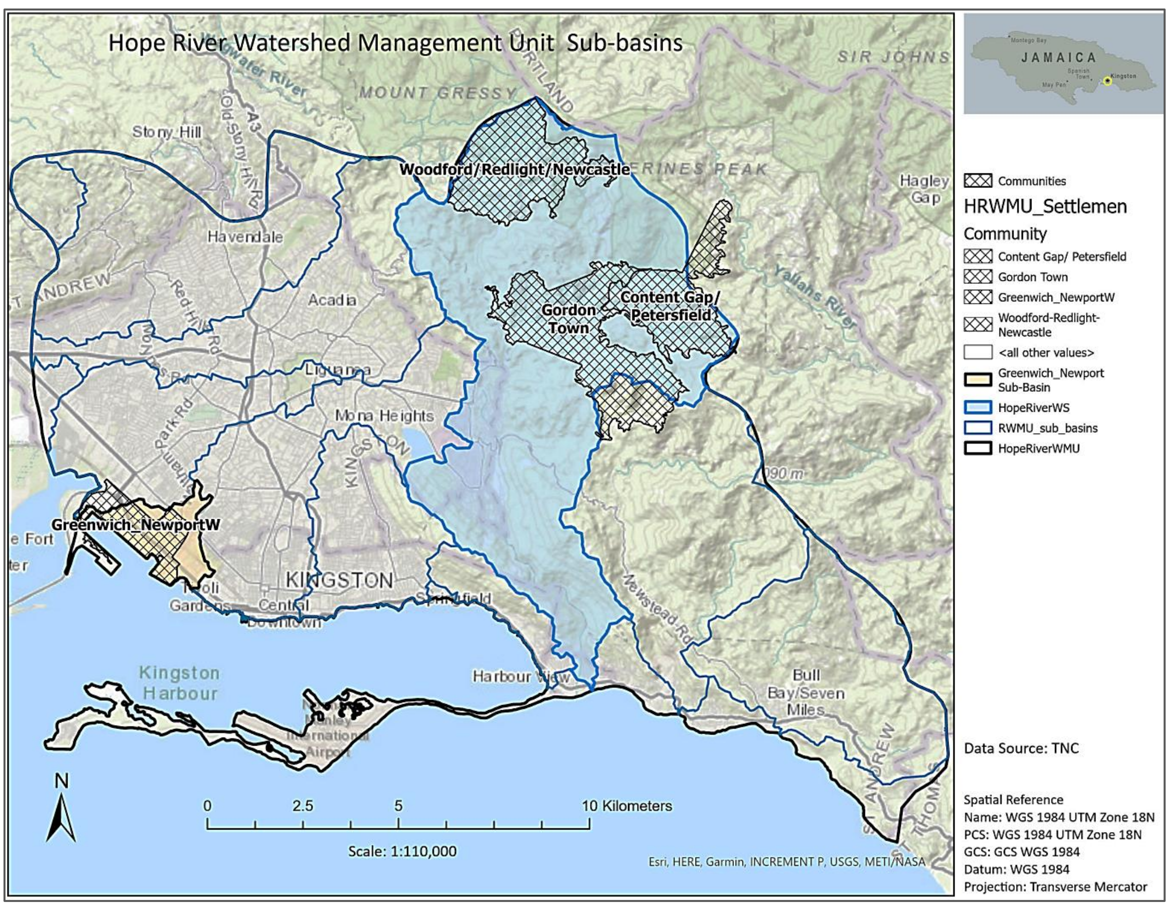


Figure 11-3. Sub-basins in the Hope River watershed Management Unit (WMU).

11.3.2 Land Cover

Land cover data, including historical time series of land cover, provided by Jamaica's Forestry Department were used to characterise the land cover in the Hope River watershed Management Unit, and document changes in land cover over time. The land cover from 2000 to 2020 incorporates time series imagery from Landsat 4, 5, 7, and 8, with a 30 m pixel resolution. The methodology, rationale and validation for land cover classification are detailed in Bowers and Ryan (2021) Land Cover Change in Jamaica.

The land cover classification was based on the Forestry Department's land cover classification scheme to distinguish between various types of land cover (Bowers & Ryan, 2021).

Table 11-1. Land cover classification scheme for land cover time series, with RGB colors in HEX format (from Bowers and Ryan 2021). For presentation purposes, the color scheme for 'settlement' was changed from red to grey, and for mining, from grey to black.

Map class	Level 1 (IPCC)	Level 2 (National*)	Map legend
0	No data	No data	#000000
11	Forest land	Dense moist forest	#006400
12		Secondary moist forest	#228B22
13		Dry forest	#9ACD32
14		Mangrove forest	#20B2AA
21	Grassland†	Pasture†	#90EE90
22		Other grassland†	#FFFF00
31	Cropland	Cultivated cropland	#FFD700
41	Settlement	Settlement	#C31400
51	Wetland	Seasonally inundated	#ADD8E6
52		Permanent water	#00008B
61	Other land	Mining	#FF8C00
62		Quarrying	#C0C0C0
63		Other bare†	#4D4D4D

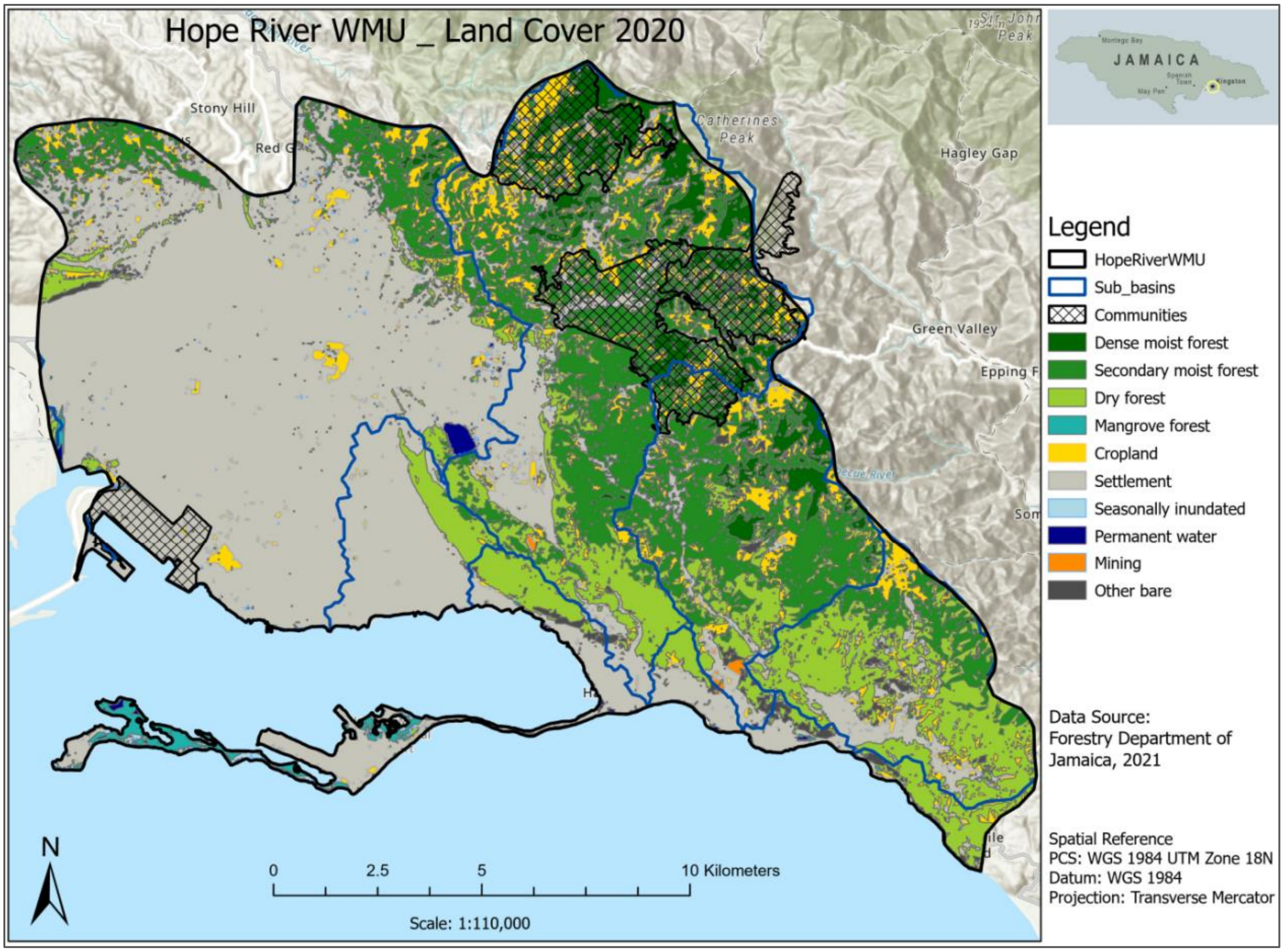


Figure 11-4. Land cover classes (based on the Forestry Department land classification scheme, for the Hope River watershed Management Unit.

Table 11-2 summarises the land cover types (i.e., % cover) in three different areas in the Hope River watershed: Woodford/Redlight/Newcastle, Gordon Town, Content Gap/Petersfield, and Greenwich. The land cover types include dense moist forest, secondary moist forest, dry forest, mangrove forest, cultivated cropland, settlement, seasonally inundated land, permanent water, mining, and other bare areas.

Table 11-2: Land cover categories in communities

Land Cover (%)	Greenwich (% cover)	Gordon Town (% cover)	Content Gap/ Petersfield (% cover)	Woodford/ Redlight/ Newcastle (% cover)
Dense moist forest	-	17.4	20.1	38.6
Secondary moist forest	-	49.8	31.2	24.5
Dry forest	0.6	6.9	7.5	0.9
Mangrove forest	-	-	0.0	0.02
Cultivated cropland	3.0	14.8	28.1	28.75
Settlement	95.9	10.4	9.1	6.46
Seasonally inundated	-	-	0.1	0.03
Permanent water	-	-	-	0
Mining	-	-	2.1	0.18
Other bare	-	-	1.6	0.52
Total area (km^2)	**3**	**10**	**6**	**8**

Woodford, Redlight, and Newcastle are small communities in Jamaica's Blue Mountains. Blue Mountain forests are part of the Blue and John Crow Mountains National Park (BJCMNP), which was established in 1992 to protect the natural and cultural resources of the area[9]. The park is also recognised as a UNESCO World Heritage Site for its cultural and natural significance[10].

The Woodford, Redlight and Newcastle communities are in the Community Buffer Zone of the Blue and John Crow Mountains. The Community Buffer Zone was established to conserve the unique biodiversity of the region while also supporting the livelihoods of local communities and promoting sustainable land use.

[9]The Blue And John Crow Mountains National Park. Jamaica Conservation and Development Trust (https://www.blueandjohncrowmountains.org/about) , Accessed, Feb 20, 2023)

[10]Blue and John Crow Mountains (https://whc.unesco.org/en/list/1356. Accessed Feb 23, 2023

In terms of land cover in and around Woodford, Redlight and Newcastle communities, the dense moist forest accounts for almost ~40% of the land cover, while the secondary moist forest covers an additional ~25%.

Dense moist forest, also known as montane rainforest, is characterised by tall trees, a closed canopy, and a high level of rainfall and humidity. According to the National Environment and Planning Agency of Jamaica, dense moist forest in the Blue Mountains is dominated by tree species such as cedar (*Cedrela odorata*), blue mahoe (*Hibiscus elatus*), and the Blue Mountain mahogany (*Swietenia mahagoni*). Other common tree species include tree ferns, bamboo, and a variety of epiphytes, such as orchids and bromeliads[11].

Secondary dense moist forest represents a forest land that has regrown after a disturbance, such as a hurricane or human activity, and has not yet reached full maturity. This forest type is characterised by a lower canopy height and a higher density of smaller trees and shrubs compared to primary or mature dense moist forests.

Both the dense and secondary dense moist forests in the Blue Mountains provide important habitat for a variety of wildlife, including birds, bats, and small mammals such as the Jamaican coney (*Geocapromys brownii*) and the Jamaican fruit-eating bat (*Artibeus jamaicensis*)[12]. These forests also play a vital role in regulating water resources, providing clean water for human and animal use.

---

[11]National Environment and Planning Agency (NEPA). (2011). Blue and John Crow Mountains National Park: Management Plan 2011-2016. Kingston, Jamaica.

[12]Kapos, V., et al. (2008). Jamaica: Biodiversity and Conservation. In R. A. Mittermeier, et al. (Eds.), Hotspots Revisited: Earth's Biologically Richest and Most Endangered Terrestrial Ecoregions (pp. 254-259). Conservation International.

Farming is an important source of livelihood for the Woodford, Redlight and Newcastle communities. An estimated ~29% of land cover is taken up by cultivation, while settlements (built-up) account for an additional ~6%.

Some of the common crops grown in the area include coffee, cocoa, banana, plantain, yam, and dasheen. Farmers may also cultivate vegetables and other fruits, such as mangoes, avocados, and citrus. Agroforestry is also practiced in the buffer zone, where crops and trees are grown together to promote biodiversity and sustainability. Shade-tolerant crops such as coffee and cocoa are grown under the shade of larger trees, which provide habitat for wildlife and help protect soil and water resources.

The land cover in Content Gap and Petersfield is primarily forest with the dense moist forest covering 20% of the land, and the secondary moist forest covering another 31%. Cultivated cropland represents 28.1% of the area, settlement covers 9.1%, and dry forest covers 7.5%. Other land cover types, such as seasonally inundated areas, mining areas, and other bare land, make up smaller percentages.

Similarly, Gordon Town and surrounding areas are dominated by secondary moist forest which represents ~50% of the land cover, and moist dense forest covering another ~17%. An estimated 15% of the area is cultivated and 10% built up (i.e., settlements, roads and other infrastructure). Dry forest and other bare land cover make up a relatively small percentage of the land cover in Gordon Town.

In contrast to the communities in the upper and middle reaches of the Hope River watershed, urban and suburban areas are primarily found in the lower reaches of the watershed, including the city of Kingston and its surrounding communities, as well as industrial zones, including cement plants and quarries. Greenwich Town has a predominantly urban landscape, with 95.9% of the area covered by settlements (built-up impervious surfaces). Cultivated cropland represents 3% of the area, while dry forest, mangrove forest, seasonally inundated land, and permanent water all have negligible coverage.

11.3.3 Forest Lands and Forest Reserves in the Hope River WMU

The Blue and John Mountains National Park is protected by the Natural Resources Conservation Authority Act, Forestry Act, and the Jamaica National Heritage Trust Act.[13] The Forest Act of 1996 outlines the role and responsibilities of the Forestry Department and the Conservator of Forests[14] in conserving the biodiversity of forest lands. The Conservator of Forests is responsible for identifying and maintaining an inventory of forests and suitable lands for development, while the Forestry Department assesses forestry lands to determine their potential for enhancing biodiversity. The Act also provides for controlled use of forest resources and the creation of forest management plans. These plans are designed to protect and conserve forests, soil, water, wildlife, and forest products. The Act also prohibits activities such as tree destruction, damage, fire lighting, axe-carrying, and killing or injuring wildlife in forest reserves or management areas. Jamaica has over 100 gazetted forest reserves, and private lands can be acquired for declaration as forest reserves under the Act, with the goal of protecting endemic flora and fauna.

Forest conservation and watershed protection are critical in the Hope River watershed (**Figure 11-5**). Forests play a vital role in maintaining the area's ecological balance and overall health by regulating the water supply, providing habitats for a variety of plant and animal species, and preventing soil erosion. They also serve as carbon sinks, which absorb carbon dioxide from the atmosphere, mitigating the effects of climate change. In terms of provisioning, forests provide important resources, such as timber and non-timber forest products, which are essential to the livelihoods of local communities. Moreover, forests have cultural significance for indigenous communities, as they are a source of traditional knowledge, spiritual practices, and cultural identity. The Forest Act of Jamaica recognises

---

13 Blue and John Crow Mountains National Park (https://www.blueandjohncrowmountains.org/about/park-management. Accessed March 2 2023)

14 Jamaica National Biodiversity Strategy and Action Plan (NBSAP) 2016-2021. (2016). Kingston, Jamaica: National Environment and Planning Agency.

the importance of forests and establishes measures to protect and conserve them for the benefit of present and future generations.

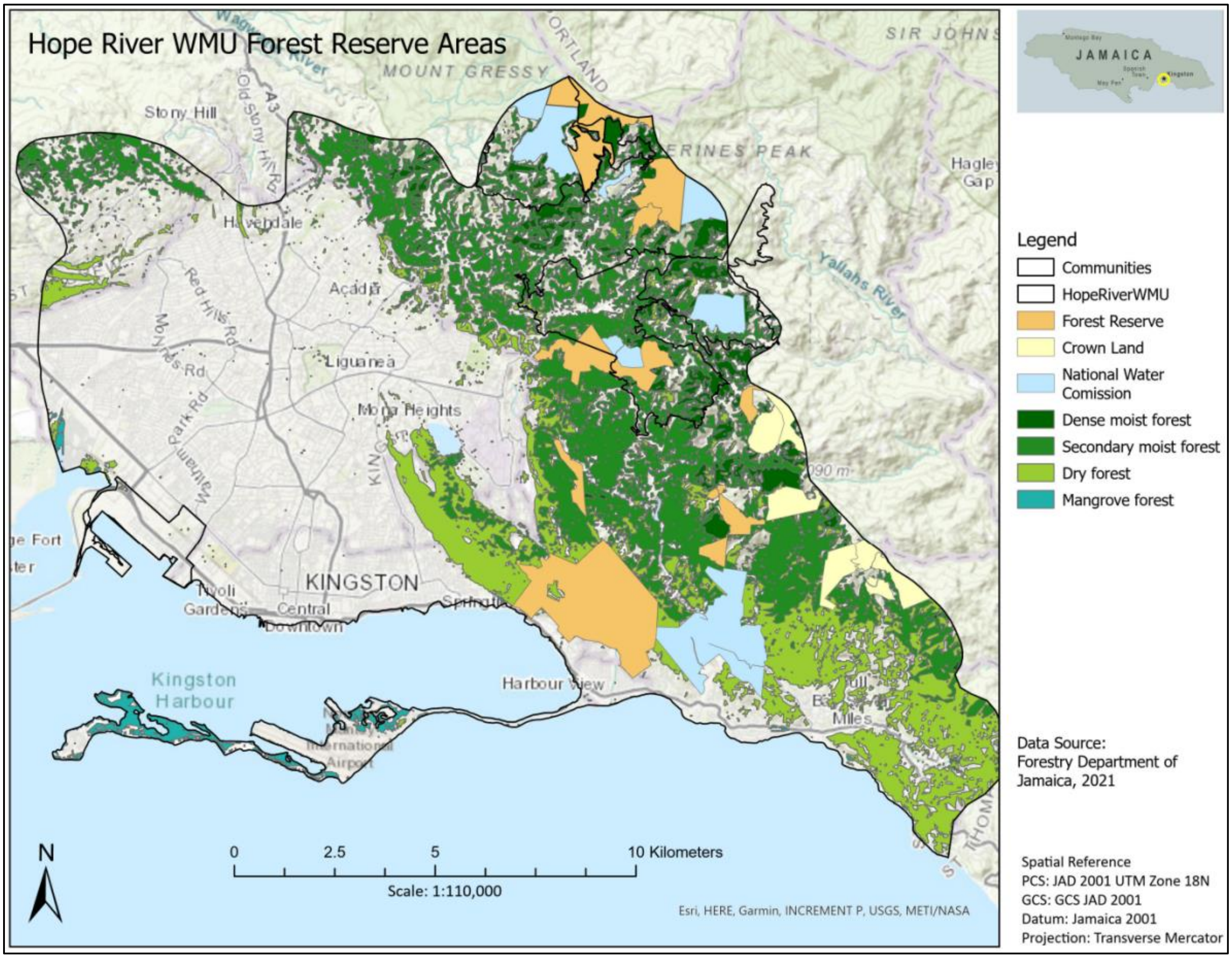


Figure 11-5. Forested land in the Hope River watershed Management Unit, highlighting the forest reserves, crown land and NWC lands that are managed for conservation and sustainable use.

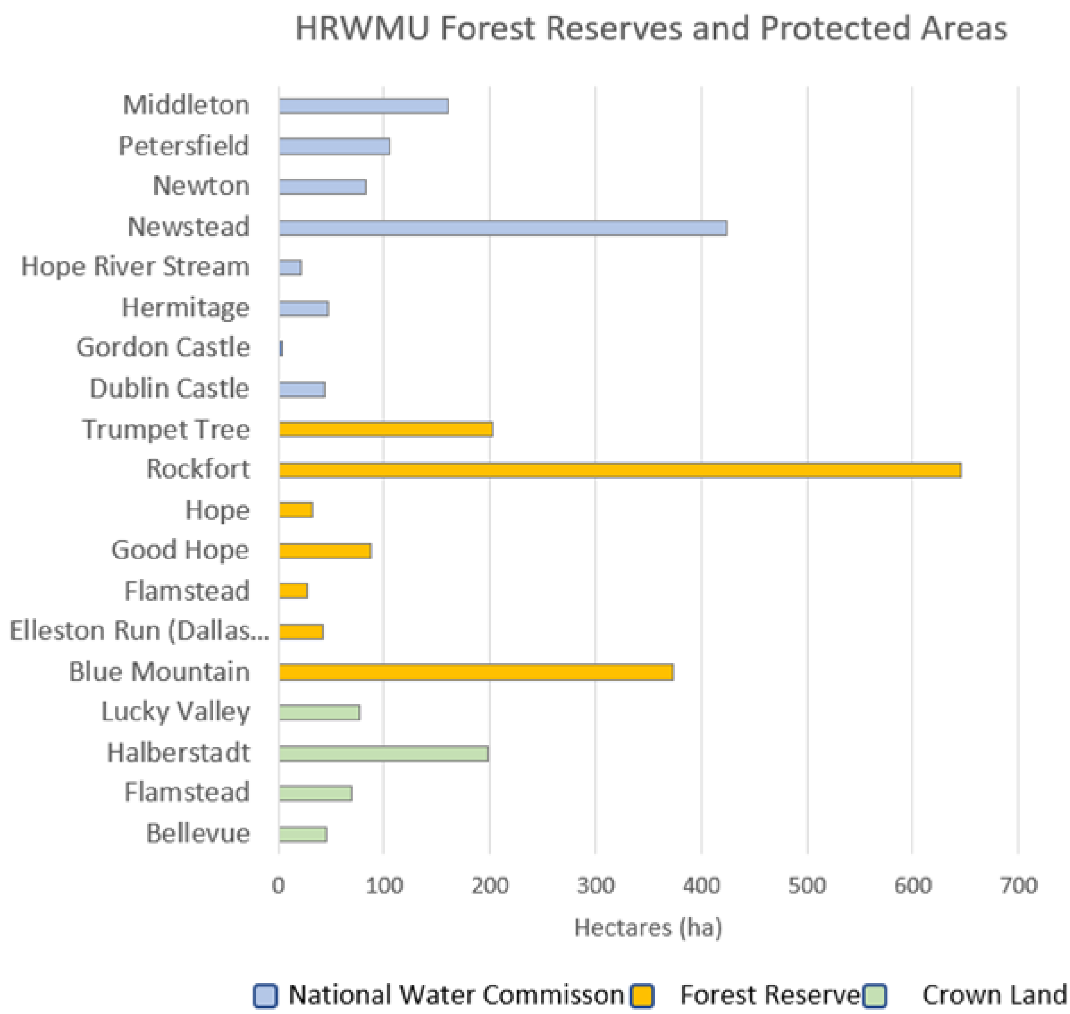


Figure 11-6. Forest reserves, crown land and NWC lands in the Hope River watershed.

The Hope River watershed in Jamaica has several forest reserves (**Figure 11-6**), including the renowned Blue Mountain Forest Reserve. These reserves cover a significant portion of the watershed and are vital for conserving the area's biodiversity and maintaining the quality and quantity of water resources. Additionally, the watershed includes crown lands owned by the government and managed by the Forestry Department for forest conservation and sustainable use. The National Water Commission (NWC) also manages land in the watershed, primarily for water supply and treatment. The protection and conservation of these lands are essential to ensure the long-term sustainability of the watershed's ecosystems and to provide a livelihood source for local communities who depend on these resources.

The Hope River watershed encompasses forest reserves and protected areas that overlap with communities in the area (**Table 11-3**).

Table 11-3. Forest reserves and protected areas in communities located in the study area.

Community	Forest Reserve/PA	Area (ha)
Woodford	Blue Mountain	175
Woodford	Middleton	160
Woodford	Hermitage	47
Content Gap	Petersfield	106
Gordon Town	Trumpet Tree	105
Gordon Town	Dublin Castle	44

In recent years, the Hope River WMU has undergone land use changes, with deforestation and transformation (**Table 11-4**) for agriculture and urbanisation leading to soil erosion, pollution, and reduced water quality. Conservation efforts are underway to protect and restore the natural habitats in the watershed and promote sustainable land use practices.

In the time series data from 2000-2020, provided by Forestry Department (2021)[15], deforestation is highlighted as any instance where a change occurs from any type of forest land cover (such as dense, secondary, dry, or mangrove forest) to any other land cover type. Conversely, forest regrowth is defined as the opposite of deforestation and is indicated by

15 Bowers and Ryan 2021, Monitoring land cover change in Jamaica (Report prepared for the Forestry Department of Jamaica)

succession from a non-forest land cover to a secondary forest cover. Secondary forest cover refers to the areas of forest that have regrown naturally or through human intervention after being cleared or disturbed by human activities such as logging, shifting cultivation, or wildfire. These areas are not as biologically diverse or structurally complex as primary forests, but they still provide important ecological and socio-economic benefits, such as carbon sequestration, soil protection, and timber and non-timber forest products. Secondary forests also serve as important habitat for many species and can contribute to the conservation of biodiversity.

Forest land is the most prominent land cover in the Hope River watershed with protected areas in the mountainous regions (stable forest) and secondary forests (regrowth) more prominent in the middle reaches of the watershed (**Figure 11-7**). The deforestation trend shows steady, moderate losses with peaks in 2006, 2013 and 2014 a declining trend since 2000. Settlement expansion and agriculture are the primary causes of deforestation (**Figure 11-8 -Graphs A** and **B**).

The forest cover in the Hope River WMU remained generally consistent between 2000 and 2020, changing at a rate of 0.03% per year[16]; however, during the same period, the dense moist forest cover decreased at a rate of -0.03%/year, while the secondary moist and dry forest areas increased at 0.02%/year and 0.004%/year, respectively (**Table 11-4**).

[16] Puyravaud. (2003, April). Standardizing the calculation of the annual rate of deforestation. Forest Ecology and Management, 177(1–3), 593–596. https://doi.org/10.1016/S0378-1127(02)00335-3

Table 11-4. Change in Forest cover in the Hope River WMU from 2000 to 2020.

Forest type (WMU)	2000 (ha)	2010 (ha)	2020 (ha)	Annual rate of change from 2000 to 2021	%Change in forest type from 2000-2020
Dense moist forest	2,678	2,447	1,560	-0.03	-42
Secondary moist forest	3,932	4,714	5,359	0.02	36
Dry forest	3,730	3,800	4,041	0.004	8
Mangrove forest	282	255	255	-0.005	-9
Total forest land (ha)	10,622	11,216	11,215	0.003	5.6

Between 2000 and 2020, the upper reaches of the Hope River watershed (Woodford, Redlight, and Newcastle) experienced a decrease in dense moist forest cover of -0.013%/year and an increase in secondary moist forest cover of 0.04%/year. Similarly, between 2000 and 2020, the dense moist forest cover in the middle reaches (Gordon Town, Content Gap, Petersfield) declined by -0.03%/year, whereas secondary forest cover rose at a rate of 0.03%/year.

The observed changes can be attributed to selective logging, landslides, forest fires, and areas cleared by slash-and-burn agriculture practices[17]. For the same 20-year period, gains in secondary moist forest can be linked to the regrowth in abandoned agricultural or barren lands, contributing to an annual increase in moist forest cover in the higher and middle reaches, respectively.

---

[17] Forrest. (2018). Jamaica: Monitoring Sustainable Forest Management. United Nations Forest Forum.

In the lower reaches (Greenwich - Newport), the area is heavily developed and largely denuded of vegetation, only with strips of mangrove stands along the coast and sparse tree cover in residential areas and nearby overgrown barren lands. Between 2000 and 2020 mangrove stands were lost at a rate of -0.05%/year, while the dry forest increased by 0.03%/year.

Figure 11-7 shows a decline in deforestation (-0.08%/year) between 2000 and 2020, with exception of increases in 2004, 2006, and subsequently in 2013 and 2014.

Between 2000 and 2008, there was a positive trend in forest regrowth, which was subsequently followed by a decrease. Over the course of 20 years, the average annual rate of forest regrowth declined by -0.02%.

Forest regrowth can be attributed to succession growth occurring on former agricultural or barren lands, as well as the growth of secondary forests. Deforestation, even at moderate levels, can have significant adverse impacts on forest ecosystems. One of the many negative effects is fragmentation, which can lead to habitat loss and degradation, changes in microclimate, and altered ecological processes including nutrient cycling and carbon storage. As a result of fragmentation, forest-dependent species may experience reduced population sizes, increased isolation, and decreased genetic diversity. Additionally, fragmentation can also lead to an increase in edge effects, which are the changes in environmental conditions and species composition that occur at the boundary between different land cover types. These effects can further disrupt ecological processes and biodiversity conservation. Therefore, it is important to minimise deforestation and prioritise forest conservation and restoration efforts to avoid or mitigate the negative impacts of fragmentation on forest ecosystems.

Various reforestation and watershed management initiatives have been implemented since the early 2000s. One notable program was the Integrated Management of the Yallahs and Hope River watershed Management Areas Project[18]. The goal of this project was to enhance the conservation and sustainable management of biodiversity and ecosystem services in the Yallahs River and Hope River watershed Management Units (WMUs). The project implementation focused on three main components: (i) enhancing capacity to incorporate biodiversity into watershed management, (ii) establishing economic and financial mechanisms to support sustainable biodiversity and watershed management, and (iii) implementing sustainable livelihoods, agriculture, and forestry practices in communities within the watersheds.

More recently there have been community-based reforestation initiatives such as the UNEP CityAdapt Project in Jamaica, where local communities were involved in planting trees in their areas (See **14.7 Appendix 7** - Forestry Department Planting Sites Under UNEP CityAdapt Project).

[18] Integrated Management of the Yallahs and Hope River watershed Management Areas Project. Dr. Alicia A. Hayman. (2018) Report submitted to NEPA. https://www.thegef.org/projects-operations/projects/4454 (Accessed April 3, 2023)

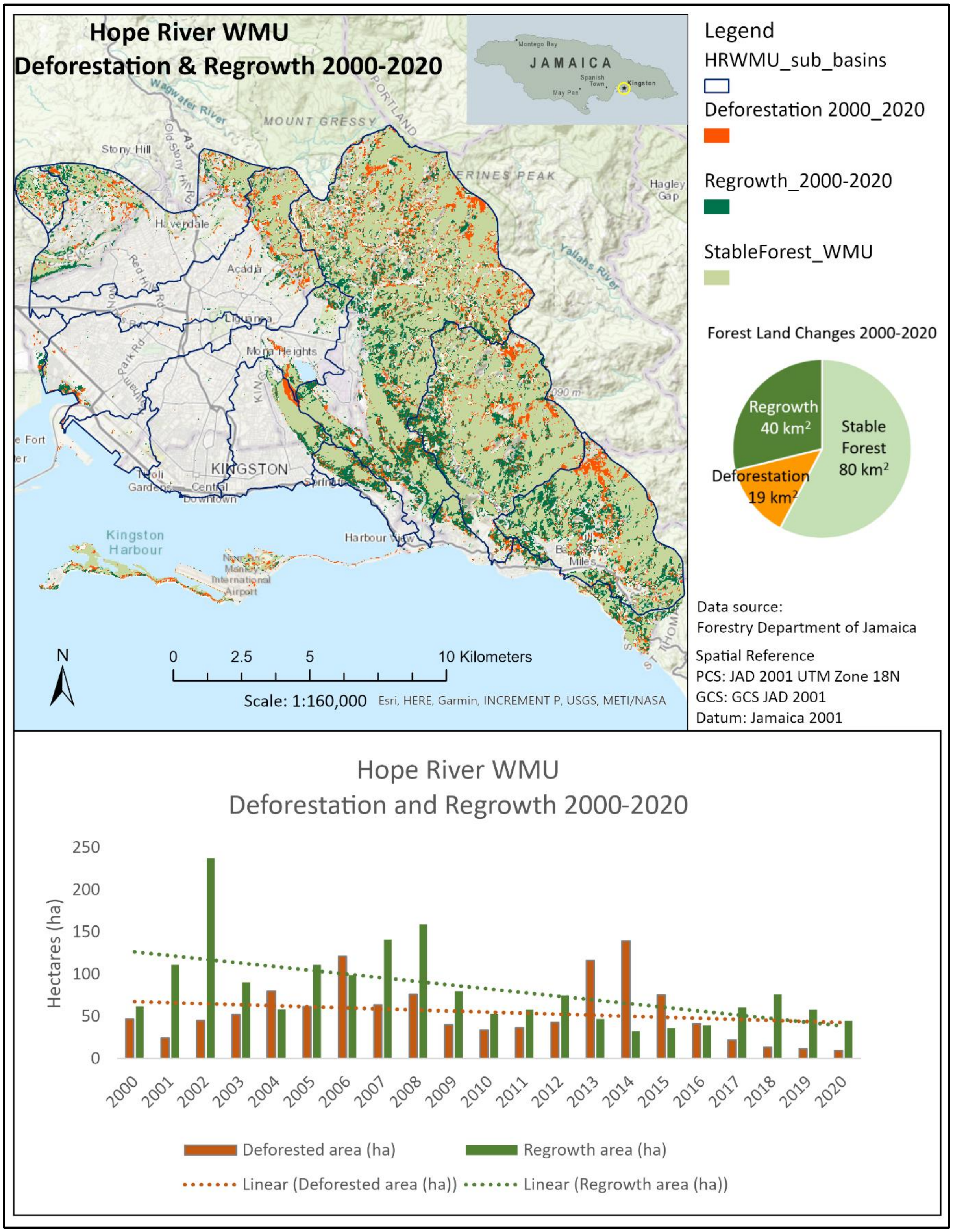


Figure 11-7. Deforestation (-0.08%/year) *and regrowth* (-0.02%/year) *trends in the Hope River watershed Management Unity from 2000 to 2020.*

11.3.3.1 Change Detection in Forest Land

Analysis of the decadal land cover data provided by the Forestry Department of Jamaica[19], focuses on changes occurring between 2000 and 2020 due to the consistency of Landsat data from 2000 onwards.

Change detection analysis was used to compare two or more temporal raster datasets to identify areas where land cover changed over time. The analysis evaluated the land cover data from 2000, 2010, and 2020 to determine the extent to which forest land in Hope River WMU had been converted into cropland, settlement, wetland, mining, and bare ground during the period between 2000 and 2020.

The land cover classification used by the Forestry Department distinguishes between dense moist, secondary moist, dry forest and mangroves. When examining the decadal changes in land cover, forested lands were amalgamated as "Forest Land" following the IPCC classification[20] since it is challenging to precisely capture a gradual natural shift from old growth to secondary forest.

Based on ecological processes[21], land cover transitions are usually gradual and rarely occur abruptly. Abandoned cropland will transition through a series of successional stages, such as cropland, abandoned land, shrubland, and then secondary forest, before reaching a stable forest state[22].

This gradual transition can be attributed to several factors, including the ecological processes in the watershed, natural disturbances, fire, climate change, and human activities

---

19 Bowers, & Ryan. (2021). Monitoring land cover change in Jamaica. Forestry Department of Jamaica. Retrieved September 19, 2022, from https://sambowers.users.earthengine.app/view/jamaicachangev0

20 Penman, J., et al. (2003). Good practice guidance for land use, land-use change and forestry. IPCC

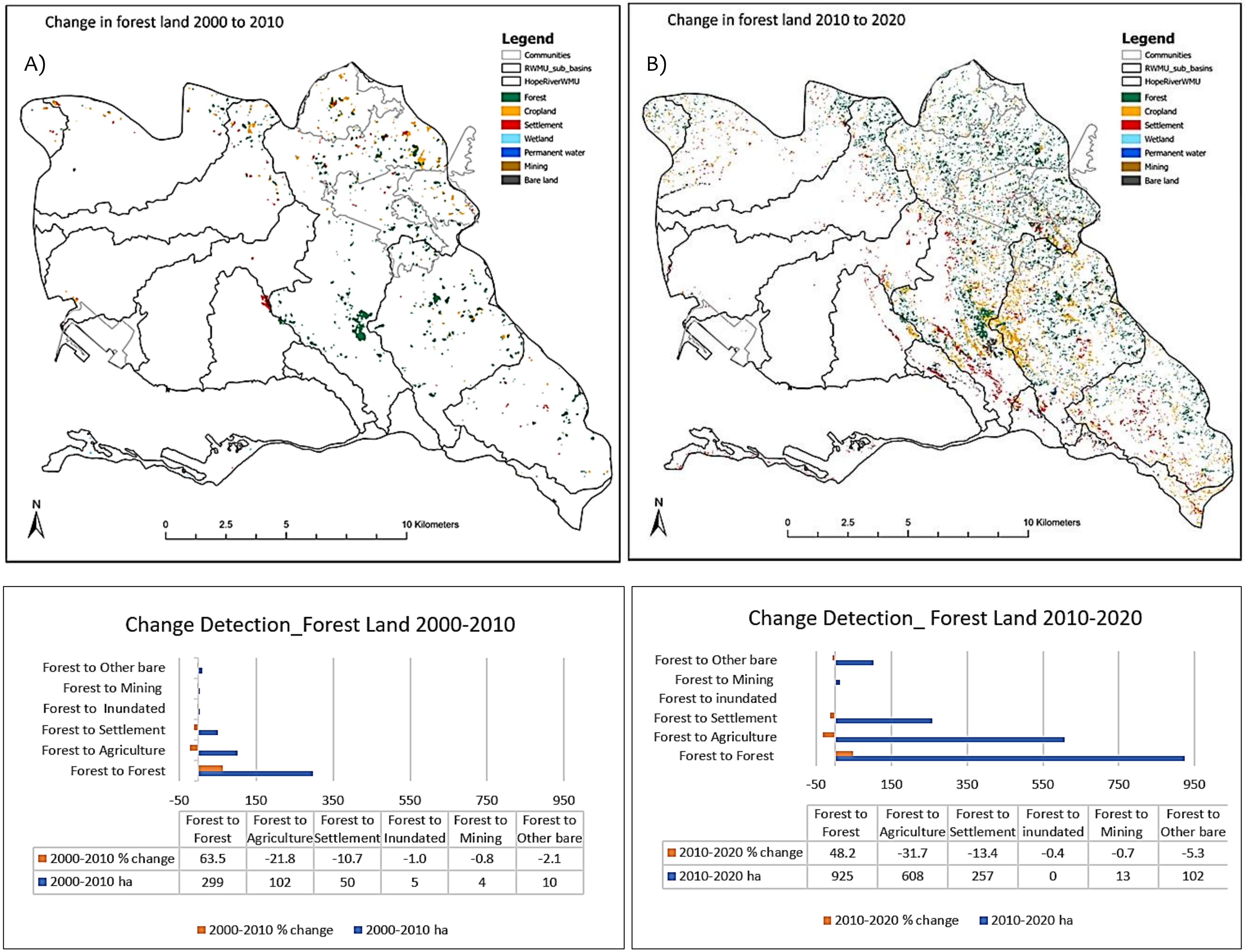
21 Mazon, M.M., et al (2020). How forest structure varies with elevation in old growth and secondary forest in Costa Rica. Forest Ecology and Management 469 (2020) 118191. https://doi.org/10.1016/j.foreco.2020.118191

resulting in land-use changes. These factors can influence the composition and structure of plant communities, creating a mosaic of different vegetation types and successional stages.

From 2000 to 2010, approximately 470 hectares (4.7 km^2) of forest land within the WMU underwent alteration or transformation to another land use (**Figure 11-8A**). Of the 470 ha, 300 ha (~64% forest to forest) of forested land were impacted by various natural or anthropogenic disturbances; still, the land retained its forest land classification. Further changes to forest land were attributed to deforestation to make room for agriculture (100 ha or ~22% forest to agriculture), new settlements (51 ha or ~11% forest to settlement), and land clearing for other purposes, including mining and barren land (7 ha or ~3% forest to other).

In contrast with the first decade, there was a four-fold increase in the amount of forest land that was altered or transformed for other land use between 2010 and 2020 (**Figure 11-8 B**). An estimated 1,918 ha (19.18 km^2) of forest land was altered and transformed. Of the 1,918 ha, 925 ha (48% forest to forest) of forest land was impacted by natural and anthropogenic disturbances, a change that reflects some form of succession growth, thus retaining the status of forest land.

The most notable changes were the 608 ha (32% forest to agriculture) of forest land that was cleared for agriculture and another 257 ha (13.4% forest to settlement) cleared for settlements; most of the deforestation occurred in the lower reaches of the watershed. Other changes included 13ha (0.7% forest to mine) cleared for mining, and 102 ha (5.3% forest to other) which were classified as 'other bare' land.



	Forest to Forest	Forest to Agriculture	Forest to Settlement	Forest to Inundated	Forest to Mining	Forest to Other bare
2000-2010 % change	63.5	-21.8	-10.7	-1.0	-0.8	-2.1
2000-2010 ha	299	102	50	5	4	10

	Forest to Forest	Forest to Agriculture	Forest to Settlement	Forest to inundated	Forest to Mining	Forest to Other bare
2010-2020 % change	48.2	-31.7	-13.4	-0.4	-0.7	-5.3
2010-2020 ha	925	608	257	0	13	102

Figure 11-8. Change detection from forest land to another land cover from (A) 2000 to 2010 and (B) 2010 to 2020.

11.3.4 Hazard Assessment

The climate risk assessment identified climate change impacts and the resulting vulnerability within the socio-ecological system. Hazards mentioned by community members included landslides, flooding, loss of infrastructure, community dwellings or livelihoods, loss of biodiversity, and potential impacts of cumulative hazards. The assessment also considered other threats such as habitat destruction like deforestation and land clearing for agriculture, mining or settlements, which could exacerbate climate-related risks and impacts (**Table 11-5**). Potential impacts were assessed based on the interaction between the sensitivity of communities and the exposure to climate-related hazards over time[23] .

Data collected during field surveys in the Hope River WMU provided the basis for the climate change impact chain, including hazards, communities and infrastructure at risk, and the underlying factors.

Table 11-5. List of potential hazards for communities in the upper, middle, and lower reaches of the Hope River watershed Management Unit identified during the community surveys.

Hazards	*Upper Reaches of HRWS*	*Middle Reaches of HRWS*	*Lower Reaches of HRWS*
Changes in the maximum 1- day intensity of rainfall	✓	✓	✓
Days with precipitation exceeding 10mm	✓	✓	✓
Higher temperatures		✓	✓
Deforestation/Land clearing for agriculture	✓	✓	
Landslides	✓	✓	
Deforestation/Land clearing for agriculture	✓	✓	
Flooding	✓	✓	✓

[23] GIZ and EURAC 2017: Risk Supplement to the Vulnerability Sourcebook. Guidance on how to apply the Vulnerability Sourcebook's approach with the new IPCC AR5 concept of climate risk. Bonn: GIZ

The Hope River WMU is vulnerable to a variety of natural hazards that can be classified into two categories: meteorological/hydrological hazards and geological hazards. Extreme weather events can cause landslides, rock falls, debris flows, floods, droughts, and fires, which fall under the former category. Floods are particularly frequent in the Hope River watershed and can occur year-round due to rainfall but are more common during heavy storms and hurricanes between June and November. The latter category includes earthquakes and earthquake-induced landslides, which can cause significant damage to infrastructure and threaten lives and property. The natural hazard profile of the Hope River watershed is diverse, and it is important to consider all potential hazards and their impacts when developing effective strategies to reduce disaster risk.

The analysis of the main hazards is presented below, and highlights communities and areas at highest risk.

11.3.4.1 Meteorological Hazards

The Hope River WMU is susceptible to various meteorological hazards due to its location and topography. Some of the hazards that the region may experience include:

11.3.4.1.1 Hurricanes and tropical storms

Jamaica is located in the hurricane belt, which means that the country is vulnerable to hurricanes and tropical storms during the Atlantic hurricane season (June to November). These storms can bring strong winds, heavy rainfall, and storm surges, which can cause flooding, landslides, and damage to infrastructure. Over the past 40 years, the area has experienced several storm events that caused significant damage to the region. Here are a few examples[24]:

[24] History of Hurricanes in Jamaica (National Library of Jamaica)(n.d.)

- Hurricane Gilbert (1988): This was one of the most powerful hurricanes to hit Jamaica in modern times. The storm caused widespread damage across the island, including in the Hope River watershed. The heavy rainfall caused severe flooding and landslides, loss of life and significant damage to infrastructure.

- Hurricane Ivan (2004) caused significant damage to the Hope River watershed. The storm brought heavy rainfall, resulting in flash floods, landslides, and erosion, which impacted local communities, infrastructure, and ecosystems. The floodwaters also carried pollutants, leading to water quality issues and further ecological impacts.

- Hurricane Dean (2007): This was another powerful hurricane that passed close to Jamaica, causing significant damage in the Hope River watershed. The heavy rainfall caused severe flooding and landslides, which destroyed homes and infrastructure and led to several deaths.

- Tropical Storm Nicole (2010): This storm caused extensive flooding and landslides in the Hope River watershed, leading to significant damage to homes and infrastructure. The heavy rainfall also resulted in several deaths and displaced thousands of people from their homes.

- Hurricane Sandy (2012): Hurricane Sandy caused extensive flooding in the Kintyre community in the lower reaches of the Hope River watershed, resulting in extensive damage to homes and critical infrastructure such as roads and bridges. The resulting physical damage left the community without access to power and clean water for several days, exacerbating the already challenging conditions. The impact of Hurricane Sandy highlights the urgent need to improve disaster preparedness and build resilience in vulnerable communities. Furthermore, these events highlight the vulnerability of Kingston and other coastal cities in Jamaica to the impacts of extreme weather events and the need for ongoing efforts to improve flood preparedness and resilience.

11.3.4.1.2 Drought

Jamaica can experience droughts during the dry season, which typically runs from December to May. Drought occurs when there is an extended period with below-average precipitation levels, which can cause water shortages, reduce crop yields, and increase the risk of wildfires.

The Hope River WMU experiences periodic drought events, which can last for weeks or months. These droughts can be caused by a variety of factors, including changes in rainfall patterns, and are exacerbated by human activities such as deforestation and land-use changes. During drought events, water scarcity can lead to competition among different water users, with potentially negative social and economic impacts. Additionally, reduced water levels in rivers and streams can have significant ecological effects, such as habitat loss for aquatic species and reduced water quality.

11.3.4.1.3 Extreme heat

The region can experience periods of extreme heat, especially during the summer months. High temperatures can cause heat stress and heat stroke in vulnerable populations, such as the elderly and young children, especially in urban areas where the island heat effect is more pronounced.

11.3.4.1.4 Flash floods

The steep terrain of the watershed can cause rainwater to accumulate rapidly, leading to flash floods during heavy rainfall events. Flash floods can be dangerous as they can occur quickly and without warning, potentially causing damage to homes and infrastructure.

11.3.4.2 Landslides

The Hope River watershed is susceptible to landslides due to its steep slopes and geological conditions, compounded by anthropogenic factors[25]. The area has steep topography, and experiences bimodal seasonal rainfall patterns from April-July and August to November, which contribute to the risk of landslides, particularly in the rugged southern region of the Blue Mountains that is prone to heavy storm activity[25].

The risk of landslides can be affected by factors such as geology, topography, climate, land use, and management practices. Slopes with angles between 20°-40° are likely to experience the most failures, with no failures on slopes less than 10°[26]. Most landslides that occurred in Jamaica between 2001 and 2011 were concentrated in the eastern parishes, including the Hope River watershed[27]. These landslides were primarily shallow slides and debris flows, triggered by heavy rainfall events. Deforestation, mining, and poor land management practices also increase the risk of landslides by reducing soil stability, altering drainage patterns, and increasing runoff [27]. Effective land management practices are needed to minimise the risk of future landslides in the Hope River watershed.

Studies in eastern Jamaica reveal a rainfall/landslide threshold relationship where shallow landslides are triggered by rainfall intensities >36mm/h for about 1hr while larger deeper landslides need lower rainfall intensities (about 3mm/h) with durations of approximately 100 hrs. Two landslide susceptibility maps for the Kingston Metropolitan Area were created using factors such as slope aspect, lithological group, distance to faults, and downslope curvature[28]. Highly weathered soils with highly fractured bedrock, steep road cuts without

---

[25] Avalon-Cullen C, Caudill C, Newlands NK, Enenkel M. Big Data, Small Island: Earth Observations for Improving Flood and Landslide Risk Assessment in Jamaica. Geosciences. 2023; 13(3):64. https://doi.org/10.3390/geosciences13030064

26 Maharaj, R. J. (1993). Landslide processes and landslide susceptibility analysis from an upland watershed: A case study from St. Andrew, Jamaica, West Indies. Engineering Geology, 34(1-2), 53–79. doi:10.1016/0013-7952(93)90043-c

27 Miller, S., Brewer, T., and Harris, N. (2009). Rainfall Thresholding and Susceptibility assessment of rainfall induced landslides: application to landslide management in St Thomas, Jamaica. Bulletin of Engineering Geology and the Environment 68:539–55

28Landslide Susceptibility Maps for the Kingston Metropolitan Area. https://www.mona.uwi.edu/uds/Land_Jam.html (Accessed Oct. 30 2022 proper drainage, and volcanic lithologies were found to have the highest landslide frequencies. Changes in land use practices, including deforestation for home construction and farming, have intensified the susceptibility of sensitive slopes to landslides. Landslide hazard is symptomatic of changing land use[29].

Climate change is expected to have a significant impact on the frequency and magnitude of landslides in the Hope River watershed. Three scenarios predicting climate change of 1.5°C, 2.0°C, and 2.5°C show higher rates of rainfall, with runoff trends of up to 20% in all cases[30]. As a result, rainfall-induced landslides are expected to become more frequent, especially in areas that are already vulnerable to landslides. In the middle to upper reaches of the watershed, moderate to high landslide susceptibility is expected, while the lower watershed is predicted to have a low susceptibility to landslides[31]. Climate change adaptation measures, such as improved land use planning and infrastructure design, will be essential to minimise the impacts of landslides in the Hope River watershed in the future.

Landslide susceptibility analysis for the study area revealed medium to high risk of landslides for the upper and middle reaches of the Hope River watershed and no risk in Greenwich.

The landslide susceptibility analysis indicates high risk of landslide for the Woodford, Redlight and Newcastle study area; 34% of the terrain has medium risk of landslides, 47% of the terrain has a medium-to-high risk of landslides, and 11% of the terrain is at high risk of landslides (**Figure 11-9**).

---

29 Ahmad, R. (1999). The management of landslides in Jamaica. Caribbean Geography, 9(2), 129-137.

30 Jamaican Meteorological Service. (2015). Jamaica's Third National Communication to the United Nations Framework Convention on Climate Change. Retrieved from https://unfccc.int/documents/83236.

31 Hope River watershed Management Unit. (2012). Watershed Management Plan. Retrieved from https://www.nepa.gov.jm/wp-content/uploads/2018/02/Hope_River_Watershed_Management_Plan_Final.pdf

Similar landslide susceptibility exists for Gordon Town and Content Gap with 39% of the terrain at medium risk of landslides, 39% at medium-to-high risk, and 8% of the terrain is at high risk respectively.

11.3.4.3 Earthquakes

Earthquakes can cause landslides and other forms of ground instability, which can damage infrastructure and threaten lives and property. The level of seismic hazard in the area is influenced by a variety of factors, including the proximity to active faults, the local geology, and the depth and intensity of the earthquakes that occur.

While earthquakes in the Hope River watershed may not be as frequent or intense as in some other regions of the world, they still pose a significant threat to the local population and infrastructure. It is important for individuals and organisations in the area to take steps to prepare for potential earthquakes and to develop strategies to mitigate their impact. This may involve measures such as retrofitting buildings to make them more earthquake-resistant, developing emergency response plans, and educating the public about earthquake safety.

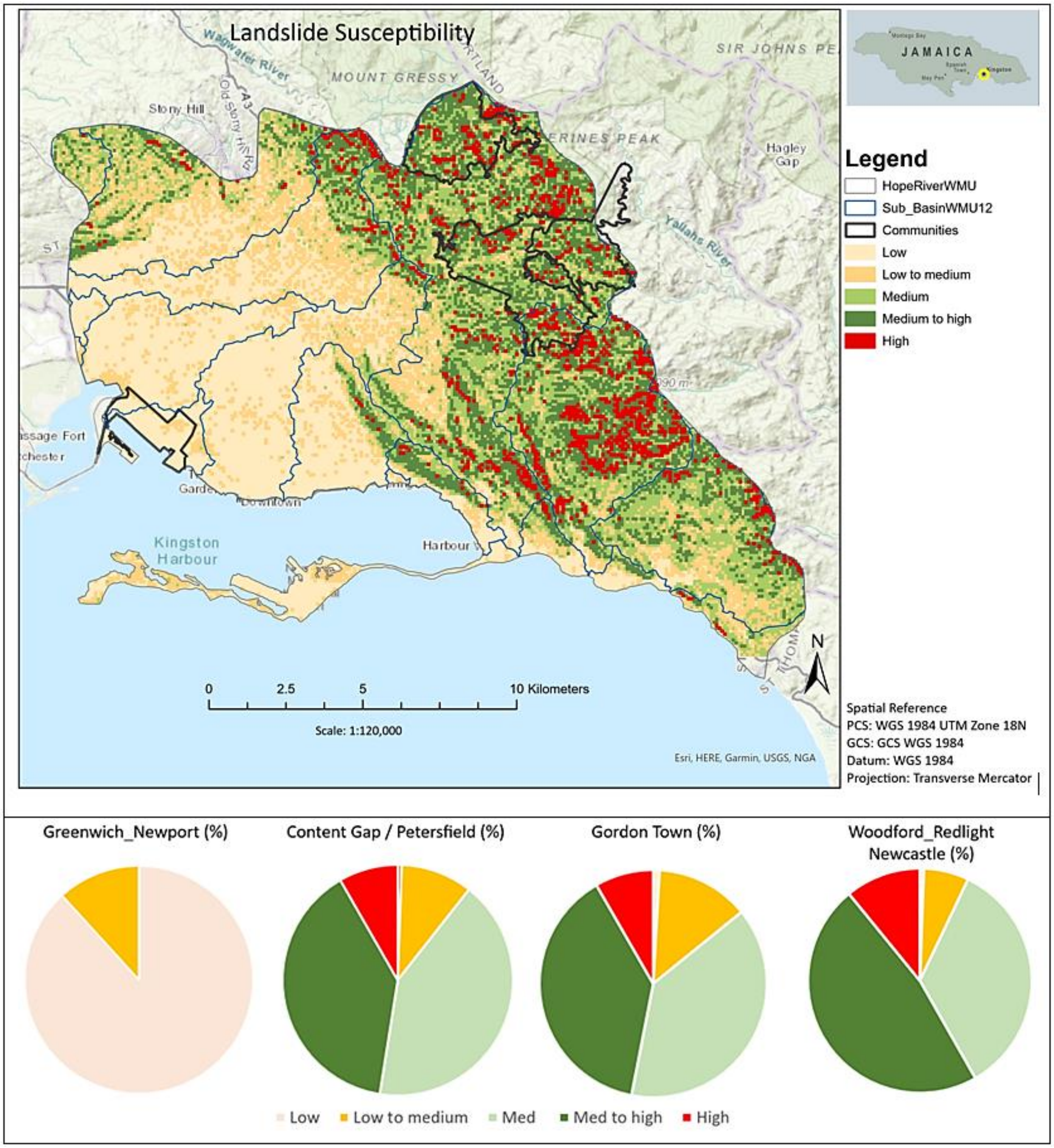


Figure 11-9. Landslide susceptibility in the Hope River watershed.

11.3.4.4 Flooding

Kingston Metropolitan and surrounding areas have faced numerous instances of flooding that have had significant and widespread effects. These impacts include property damage, disruption to infrastructure, health concerns, loss of life, economic losses, and environmental damage. Floods destroy homes, businesses, and other structures, leaving people homeless and without income. They also damage roads, bridges, and other infrastructure, making it challenging for people to travel and emergency responders to access affected areas. Furthermore, flooding can create breeding grounds for disease-carrying pests and contaminate water supplies, leading to an increased risk of waterborne illnesses. In severe cases, flooding can result in loss of life, particularly in areas with high populations or where people live in low-lying areas. Flooding can have long-term economic impacts as people are unable to work and businesses are forced to close. Environmental impacts of flooding can include erosion, soil degradation, deterioration in water quality and loss of wildlife habitat. The frequency of flooding can depend on several factors such as local weather patterns, geography, land use, and the presence or absence of infrastructure designed to mitigate the impacts of flooding.

The Hope River watershed Management Unit in Jamaica is vulnerable to various types of flooding, including coastal flooding, flash floods, and riverine flooding[32].

Coastal flooding occurs when seawater inundates coastal areas due to storm surges, high tides, and sea level rise. In the Hope River WMU, coastal flooding is a concern for communities like Greenwich located along the coast, particularly during hurricane season (**Figure 11-10**).

[32] Burgess, C.P., Taylor, M.A., Stephenson, T. et al. A macro-scale flood risk model for Jamaica with impact of climate variability. Nat Hazards 78, 231–256 (2015). https://doi.org/10.1007/s11069-015-1712-z

Flash floods, on the other hand, are fast-rising floods caused by heavy rainfall within a short period of time. Flash floods can happen anywhere in the watershed, but low-lying areas with poor drainage are particularly vulnerable.

With the Hope River being the main watercourse in the watershed, riverine flooding is a significant concern, especially during heavy rainfall events. Riverine flooding occurs when rivers and streams overflow their banks, inundating nearby communities (**Figure 11-10**). Gordon Town, Papine, August Town, Harbour View, Bull Bay, etc. are at risk of riverine flooding caused by the overflow of the Hope, Cane, Chalky, and Bull Bay rivers and their tributaries. Bull Bay has experienced flooding events in 1988 and 1995, which were attributed to debris flows resulting from the mobilisation of tailings at gypsum quarries that obstructed the channel of the Bull Bay River[31].

City drainage can also be a significant concern as impervious surfaces increase runoff, and gullies clogged with debris can lead to floods, particularly in low-lying areas with poor drainage.

Coastal communities like Greenwich and Kintyre[33] are also highly vulnerable to flooding (i.e., coastal inundation due to their low-lying elevation and proximity to the sea. In recent years, these communities have witnessed an increase in the frequency and severity of flooding, which is attributed to factors such as sea level rise and changing climate patterns (**Figure 11-10**).

The effects of climate change are expected to increase the frequency and intensity of these flooding events, exacerbating the risk to communities in the watershed and exposing them

[33] Garbage eyesore in Hope River revives Kintyre flood risk. May 23, 2022. https://jamaica-gleaner.com/article/lead-stories/20220523/garbage-eyesore-hope-river-revives-kintyre-flood-risk

to more natural disasters such as floods, landslides, storm surges, rising sea levels, and hurricanes.

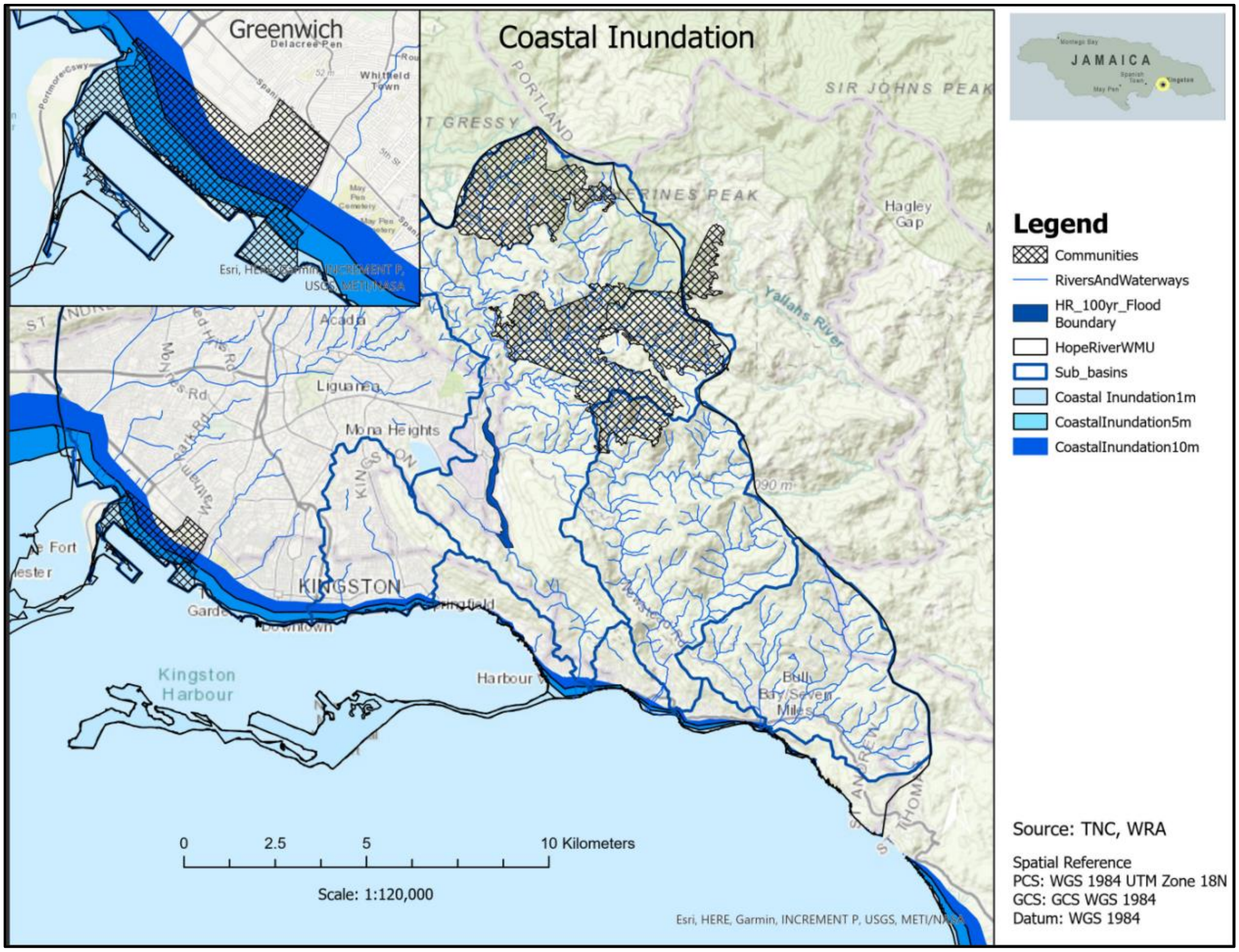


Figure 11-10. Flood zones in the Hope River WMU including areas at risk of coastal inundation and riverine flooding along the Hope River (Data source: TNC, Water Resources Authority[34])

---

[34] Water Resources Authority. Resources (GIS Flood Map) Accessed April 13, 2023. https://www.arcgis.com/home/webmap/viewer.html?webmap=645025797e0947c68388adcd8c455995&extent=-78.9494,17.2273,-75.5765,18.9166

11.3.5 Multiple Hazards

Vulnerable communities in low lying areas of the WMU are exposed to multiple hazards (**Figure 11-11**). According to the Social Development Commission's (SDC)[35] Community Profile, most residents (78%) in Greenwich Town perceive their community as susceptible to natural disasters, with hurricanes being the primary concern, followed by flooding, earthquakes, storm surges, and freak storms. Additionally, a significant proportion (20.7%) identified air pollution as the main hazard in their community, while noise pollution accounted for 13%, and flooding accounted for 9%. Other hazards mentioned were blocked drains (5.5%) and wind damage (4.8%).

The SDC profile for Gordon Town[36] revealed that 71.4% of households in the community felt vulnerable to natural hazards. Hazards cited included hurricanes/storms, with 63% of respondents citing them as a concern; mudslides/landslides with 81.2% of households considering them a potential hazard; flooding with 43.8% of households identifying it as a risk, followed by storm surges at 8.2%. A small proportion of respondents (1.2%) also mentioned freak storms as a potential hazard in Gordon Town.

According to the SDC profile for Woodford[37], the community identified the following environmental concerns: inadequate watershed protection, soil erosion, and reduced forest cover; land preparation practices involving slash and burn techniques; poor solid waste management; ground water pollution; and irregular supply of potable water. The community expressed concerns about their susceptibility to hazards such as earthquakes, landslides, and hurricanes.

---

[35] Social Development Commission. Community Profile of Greenwich Town, Kingston. 2009.

[36] Social Development Commission. Community Profile Gordon Town, St. Andrew. 2019.

[37] Social Development Commission. Community Profile Woodford, St. Andrew. 2010.

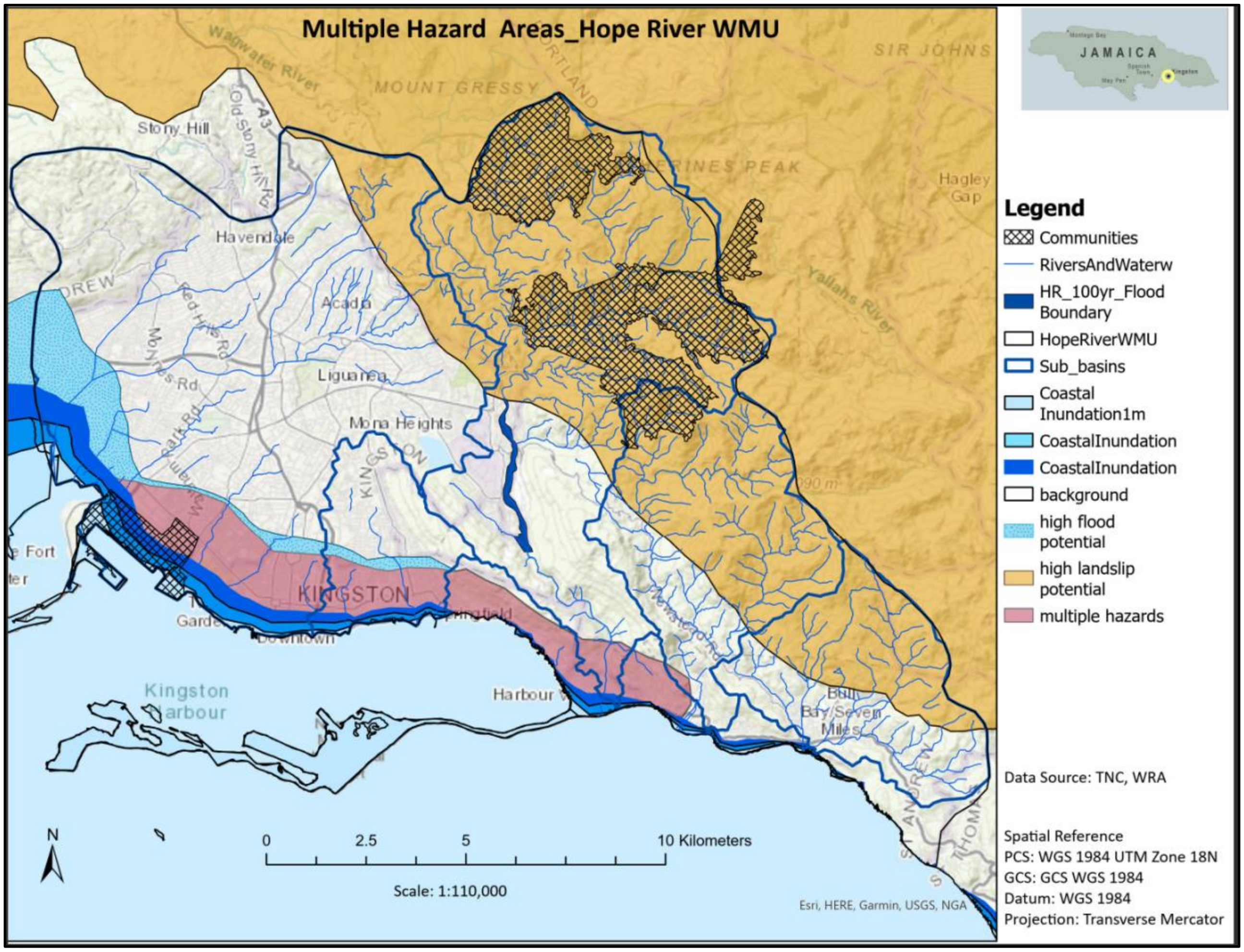


Figure 11-11. Multiple hazard risk areas in the Hope River WMU.

11.4 Aggregating indicators and vulnerability components

The objective of the Vulnerability Assessment (VA) conducted in the select communities in the Hope River WMU was to evaluate the susceptibility of communities to climate related events and to identify appropriate measures for Ecosystem-based Adaptation (EbA) that can be implemented at the community level. This involved identifying factors for vulnerability components specifically exposure, sensitivity, impact and adaptive capacity.

11.4.1 Identifying and selecting Indicators

To conduct a vulnerability assessment for each study area (lower, middle and upper reaches of WMU), the process entailed identifying factors that contribute to different vulnerability components, and the corresponding indicators. Indicators were based on findings from the study (field work, surveys, SME expertise) and literature review.

11.4.2 Data Normalization and Aggregation

Each indicator for exposure, sensitivity and adaptability was standardised using the min-max normalisation scale ranging from 0 to 1 [38].

Normalised Indicator Value Range (0 to 1)	Exposure	Sensitivity	Adaptive Capacity
0	*Climate or weather-related events do not pose a threat to the community. Optimal conditions.*	*Under normal conditions, climate or weather events have little effect on the community.*	*Optimum adaptive capacity reflecting conditions that can offset in full or in part the impacts (exposure + sensitivity)*
1	*Climate and weather events pose a major threat to the system, to the point that it seriously endangers the community's stability.*	*Social and biophysical conditions offer no protection to climate/weather events and lead to a high potential for impact even under low exposure.*	*Lack of adaptive capacity indicating social, economic, or physical conditions, that do not enable adaptation and would seriously threaten the community*

This method transforms all values to scores ranging from 0 to 1 by subtracting the minimum score and dividing it by the range of the indicator values. The following formula was used to apply min-max values for indicators with a positive direction, that is where lower values represented very positive (0) conditions and (1) very negative conditions:

[38] GIZ, EURAC & UNU-EHS (2014) The Vulnerability Sourcebook: Concept and guidelines for standardised vulnerability assessments. Bonn: GIZ. Module #5.

Equation $$X_{I,0\ to\ 1} = X_i - X_{Min} / X_{Max} - X_{Min}$$

Where:

X_i represents the individual data point to be transformed,
X_{Min} the lowest value for that indicator,
X_{Max} the highest value for that indicator, and
$X_{I,0\ to\ 1}$ the new value to calculate, i.e., the normalised data point within the range of 0 to 1.

Direction of indicators was verified to ensure that indicators values accurately represented values from very positive (0) to very negative conditions (1).

For indicators (e.g., Adaptability) where the direction of the indicator's value range was negative (i.e., vulnerability increased as the indicator value decreased), the range of the indicator was inverted so that the lowest value (i.e., negative condition) was represented by the standardised value of 1 and the highest value (i.e., negative condition) by the standardised value 0. Normalized indicator values were calculated using the following equation:

$$X_{I,0\ to\ 1} = 1 - (X_i - X_{Min} / X_{Max} - X_{Min})$$

Weighting was applied to factors that were ranked as the most significant by the community members who participated in the surveys (**Table 8-11**, **Table 8-27** and **Table 8-44**).The weighted aggregation method was used to calculate composite indicator (CI) values of vulnerability components using the following equation:

$$CI = (I_1 * w_1 + I_2 * w_{2\ +} \ldots I_n * w_n) / \Sigma w$$

Where:

CI = Composite Indicator (e.g., exposure, sensitivity, adaptability)
I = Indicator (e.g., precipitation, land use, etc.)
w = Weight assigned to the indicator

11.4.3 Exposure

Exposure, among all the factors that contribute to vulnerability, is the only one that has a direct connection to climate parameters (**Figure 11-12**). This includes the nature, magnitude, rate of change, and variability of climate, such as temperature, precipitation, and extreme events like heavy rain and meteorological drought. Changes in these parameters can significantly intensify stress on systems, such as heavy rain events, temperature increases, or shifts in peak rainfall.

Factors evaluated in determining exposure of the communities in the study are summarised in **Table 11-6** and the resulting composite indices in **Figure 11-12** .

Table 11-6. Aggregated exposure indicators and composite indices for the lower, middle and upper reaches of the Hope River WMU.

	Factor	Indicator	Direction	Weight	Greenwich Normalized values	Weight	Gordon Town Normalized values	Weight	Content Gap/ Petersfield Normalized values	Weight	Woodford Normalized values
Exposure	More frequent storm events	Maximum 1 day Precipitation	+	2	1.7	2	1.6	2	1.5	2	1.6
	Precipitation	Days where precipation exceeded 10mm	+	2	1.5	2	1.4	2	1.3	2	1.3
	Drought	Maximum # of Consecutive Dry Days	+	1	0.6	1	0.6	1	0.6	1	0.7
	Extreme Temperature /Heatwave	Experienced higher temperatures (%)	+	2	1.3	1	0.2	1	0.2	1	0.4
	Experienced more frequent storms	Changes in 1-day maximum intensity of rainfall (%)	+	1	0.1	1	0.3	1	0.3	1	0.5
	Longer lasting droughts/drying of the	Prolonged periods without rain (%)	+	1	0.1	1	0.7	1	0.7	1	0.4
	Exposure to flooding	Experienced Flooding (%)	+	2	1.9	1	0.2	1	0.3	1	0.1
	Exposure to landslide	Experienced Landslide (%)	+	-	N/A	2	2.0	2	2.0	2	1.8
	Exposure to Tropical storms/Winds/Hurricanes	Experienced Tropical Storms/ Hurricanes (%)	+	1	0.5	1	0.4	1	0.3	1	0.4
	Exposure to hurricanes/storm surges	Experienced Hurricanes/Storm surges (%)	+	2	1.7	1	0.3	1	0.3	-	-
	Composite Index for Exposure			14	**0.67**	13	**0.59**	13	**0.57**	12	**0.60**

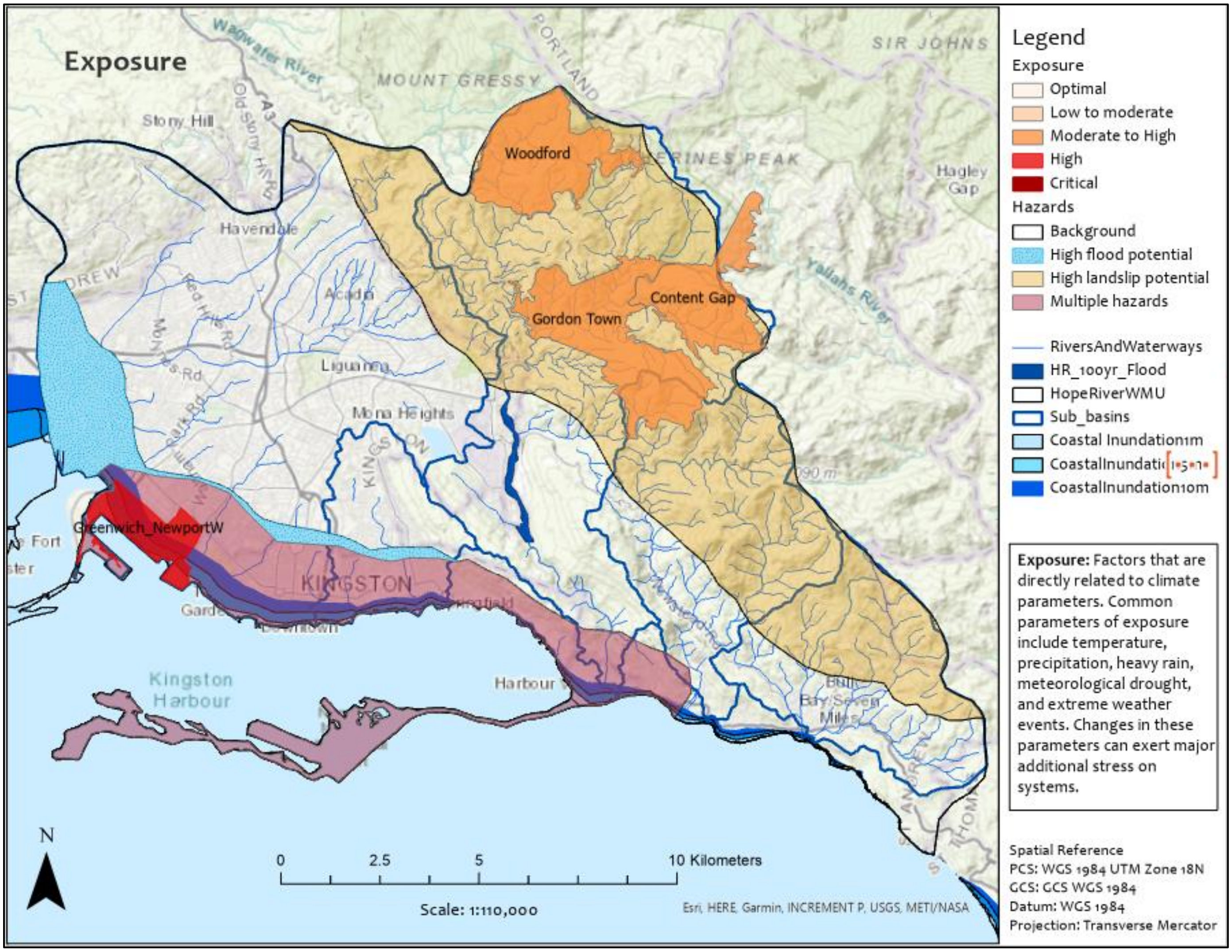


Figure 11-12. Exposure map showing the community Composite Index (CI) scores based on climate-related factors including precipitation, drought, exposure to hazards in the lower, middle and upper reaches of the Hope River WMU.

When considering the impact of climate-related factors such as precipitation and exposure to hazards, Greenwich is highly vulnerable due to its geographic location and densely populated district. The community is directly exposed to storm events such as hurricanes, which result in inundation and sea-level rise, posing significant risks to its residents and infrastructure.

The communities of Gordon Town and Content Gap, located in the middle reaches of the Hope River watershed, face exposure to climate-related factors. The rural nature of these communities and the significant forested land provide some protection against the direct impacts of climate-related events. The primary hazard they face are landslides, which tend to occur during heavy rainfall episodes. While the elevation of these communities puts them at lower risk of floods, those residing in the riparian zone, as well as cultivated lands, may be exposed to flash floods. Mudslides/landslides were identified by community members as the most significant hazard for Gordon Town, followed by flooding. The occurrence of these hazards can have a significant negative impact on livelihood groups such as farming, small business operations, trades, and craft work, which have been identified in the area.

Similarly, the communities of Woodford, Redlight, and Newcastle area experience two main wet periods in May and October, followed by periods of low rainfall and occasional drought. There are also two windy periods in July/November and January/February. These communities face adverse weather conditions such as drought, hurricanes, excessive rainfall, as well as landslides, and earthquakes, all of which pose a risk to the inhabitants, their cultivated land and the overall condition of the community.

11.4.4 Sensitivity

Sensitivity refers to the degree to which a community is vulnerable to the impacts of climate change. This includes the susceptibility of its physical and social systems to the effects of changes in temperature, precipitation patterns, sea level rise, extreme weather events, and other climate-related factors. Sensitivity can vary depending on a range of factors, such as geographic location, infrastructure, population density, and socioeconomic conditions including the lack of infrastructure and basic municipal services (e.g., lack of clean water, electricity, sewage treatment, stormwater drainage).

Factors evaluated in determining the sensitivity of the communities to climate-related factors are summarised in **Table** ***11-7*** and the resulting composite indices in **Figure 11-13**.

Table 11-7. Aggregated sensitivity indicators and composite indices for the lower, middle and upper reaches of the Hope River WMU.

	Factor	Indicator	Direction	Weight	Greenwich Normalized values	Weight	Gordon Town Normalized values	Weight	Content Gap Normalized values	Weight	Woodford Normalized values
Sensitivity	Steep slopes at risk of landslides	% of land cover classes with a high risk for erosion/slopes with a gradient greater than 25%	+	0	N/A	1	0.4	1	0.5	1	0.4
	Habitat degradation/settlements/deforestation/Land clearing/extraction)	% of forest converted to other land use (settlement+cultivated+minig + bare)	+	2	2.0	2	0.5	2	0.8	2	0.7
	Population density using ED areas for each community)	# Inhabitants /km2	+	1	0.3	1	0.1	1	0.2	1	0.1
	Vulnerable members population	% Vulnerable population (<15 and 65+)	+	1	0.3	1	0.6	1	0.3	1	0.3
	Housing quality (lack of flood resistant housing)	% Wood houses	+	1	0.1	1	0.1	1	0.1	1	0.1
	Lack of employment alternatives	% Households primarily farming/ fishing income (survey: head of houseold occupation)	+	1	0.4	1	0.0	1	0.1	1	0.2
	Dependence on ecosystem services	Dependence on provisioning ecosystem services, such as water, fisheries, livelihoods, food (crops, farming, fishing), raw material (wood for charcoal) and regulating services such as fresh air and clean water	+	2	2.0	2	0.9	1	0.4	1	0.8
	Perception of vulnerability to climate related hazards	Vulneable to climate related hazards (%)	+	1	1	1	0.4	1	0.4	2	0.9
	Perception of susceptibility to natural disasters	Susceptibility to natural disasters (%)	+	2	1.6	2	1.4	2	1.4	-	-
	Composite Index for Sensitivity			11	**0.7**	12	**0.4**	9	**0.5**	10	**0.4**

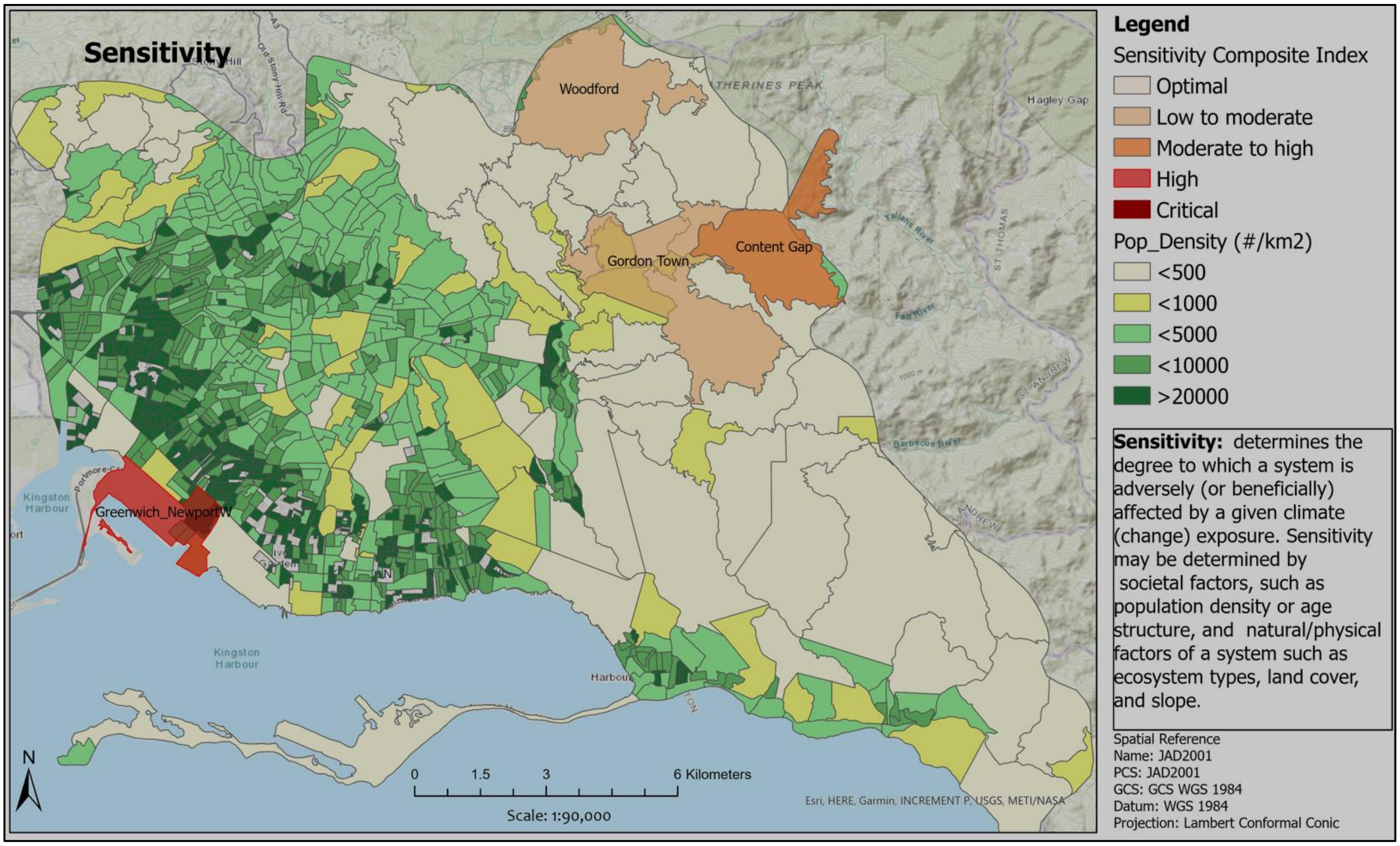


Figure 11-13. Sensitivity map showing the community Composite Index (CI) scores based on population density and vulnerability, slope, habitat degradation, dependence on ecosystem services, and predisposition to natural disasters in the lower, middle and upper reaches of the Hope River WMU. (Source: STATIN 2011 Population and Housing Census)

Social sensitivity in the Hope River watershed refers to how vulnerable communities and social systems are to climate change impacts and other stressors. It considers factors like demographics, resource access, and the impact on social and cultural values. Understanding social sensitivity is necessary for developing strategies to build resilience in vulnerable communities.

The ecological sensitivities observed in the Hope River watershed can be attributed to the biophysical characteristics, and the vulnerability of the ecosystem to changes in land use, alteration, and pollution. The interaction of these factors can affect essential ecosystem services including water regulation, carbon sequestration, and habitat provision. Notable instances of ecological sensitivities within the watershed include deforestation, degradation of riparian forests, and land clearing for agriculture and settlements. These activities elevate the risk of landslides, particularly in areas characterised by steep slopes.

Woodford, Newcastle, and Redlight are rural communities dependent on agriculture, particularly coffee cultivation, being the main source of revenue. The social vulnerability of these communities can be attributed to their remote location and lack of public services and infrastructure. The local ecology does contribute to the resilience of these communities, but the reliance on agriculture also makes them moderately susceptible to climate-related impacts.

The residents of Content Gap rely heavily on agriculture for their livelihood, which contributes to the local economy. However, this dependence on agriculture also makes them susceptible to the adverse effects of climate change on their economy, as it is largely agriculture-based. The changing climate patterns can disrupt farming practices, affecting crop yields and livelihoods of the local farmers.

The inhabitants of Gordon Town are actively involved in community work and outreach programs, demonstrating a strong sense of social responsibility. However, the community also faces challenges from improper farming practices, deforestation, bush fires for land clearing, and human encroachment, which pose risks to the local ecosystems and threaten the survival of many species. Improper waste disposal, including garbage disposal in rivers and waterways, tree cutting, and other harmful practices, further exacerbate environmental concerns in the area. It is crucial to raise awareness and promote sustainable practices to protect the natural heritage of Gordon Town and ensure a sustainable future for its inhabitants and the environment they rely upon.

Greenwich, on the other hand, is a densely populated community, with a high proportion of inhabitants living below the poverty line, making them highly vulnerable to any type of disaster. The community is exposed to environmental stressors like noise and air pollution from smoke stacks from the nearby industrial belt (e.g., PetroJam Oil Refinery, JPSCo). High unemployment rates prevail, with over half the population facing economic challenges and relying on fishing and subsistence farming for sustenance. Employment opportunities are scarce, with some individuals working as domestic workers, wholesale workers, or gardeners. The environment in the area is heavily developed and lacks green spaces. The community is highly exposed (sensitive) to hazards (e.g., hurricanes, flooding) that can further threaten their precarious existence.

11.4.5 Adaptive Capacity

Adaptive capacity is the ability of a community to prepare for, respond to, and recover from the impacts of climate change. This includes measures such as developing emergency response plans, improving infrastructure, and building community resilience through ecosystem services.

Ecosystem services contribute significantly to adaptive capacity by providing essential resources that support community well-being and cope with the impacts of climate change. For example, forest land can help reduce the impacts of floods by absorbing and storing excess water and regulating temperatures. Ecosystems also provide food, water, and other resources that are essential for human survival during times of crisis such as natural disasters or other climate-related events.

Factors evaluated in assessing the capacity of communities to adapt to climate-related factors are summarised in **Table 11-8** and **Figure 11-14.**

Table 11-8. Aggregated adaptive capacity indicators and composite indices for the lower, middle and upper reaches of the Hope River WMU.

	Factor	Indicator	Direction	Weight	Greenwich Normalized values	Weight	Gordon Town Normalized values	Weight	Content Gap Normalized values	Weight	Woodford Normalized values
Adaptive Capacity	Poverty	Incidence of Poverty %	+	1	0.4	1	0.1	1	0.1	1	0.1
	Watershed management capacity	HRWMY properly managed (% respondents)	-	1	0.6	1	0.5	1	0.5	1	0.7
	Risk reduction preparedness (Shelters/Fire Station/Police Station/Health Clinic)	Risk reduction preparedeness	-	1	0.4	1	0.2	1	0.5	1	0.4
	Capacity (ecosystem resilience)	% of forest cover(dense moist, secondary moist, dry, mangrove forests combined)	-	1	1.0	1	0.3	1	0.4	1	0.4
	Protected areas	% of forest area protected(protected area/total forest area)	-	1	1.0	1	0.8	1	0.7	1	0.3
	Composite Index for Adaptability			5	**0.7**	5	**0.37**	5	**0.44**	5	**0.36**

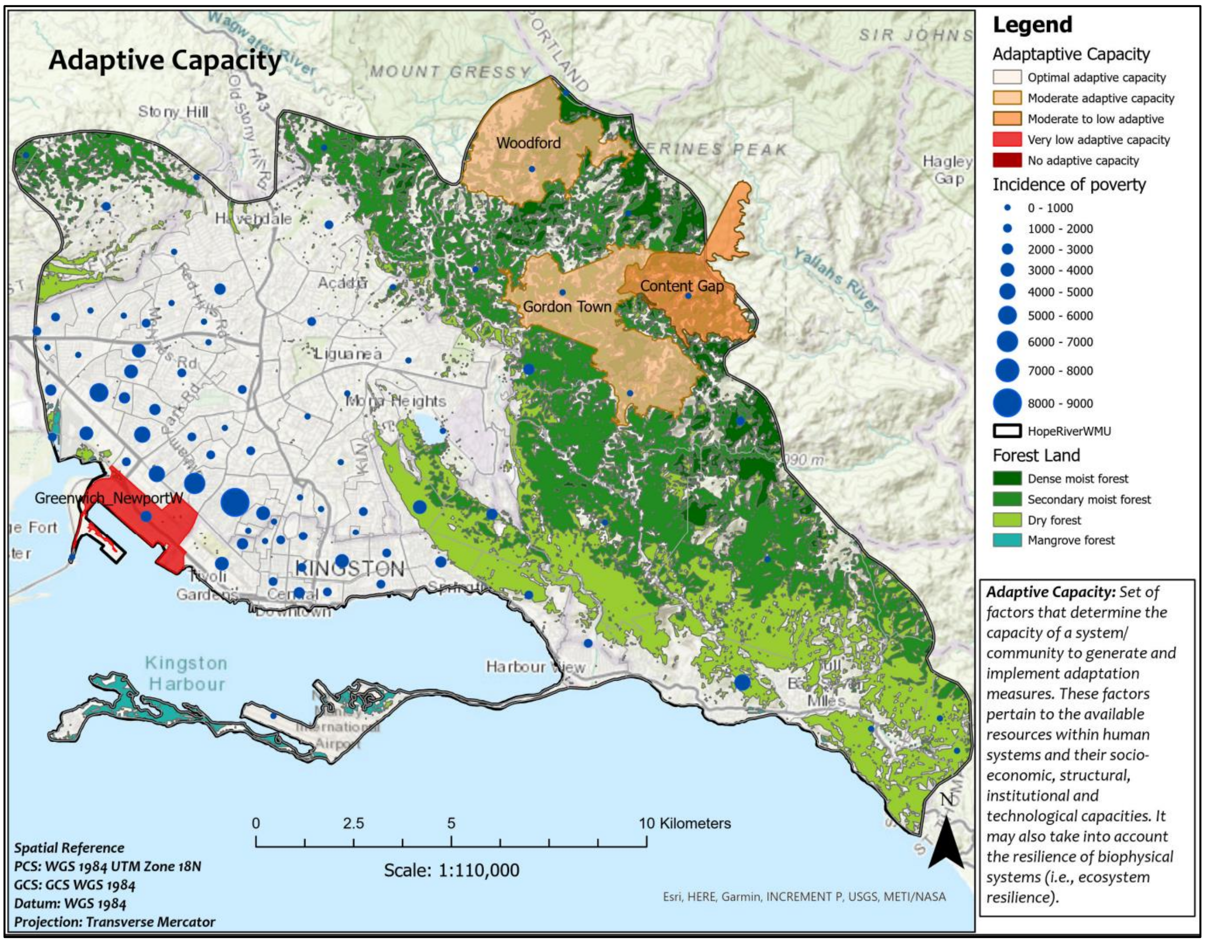


Figure 11-14. Adaptive capacity map showing community Composite Index (CI) scores based on incidence of poverty, watershed management, risk reduction preparedness, and forest cover and protected areas as indicators of ecosystem resilience in the lower, middle and upper reaches of the Hope River WMU.

11.4.5.1 Ecosystem Services

The Hope River watershed Management Unit (WMU) encompasses diverse ecosystems and multi-use areas that play a crucial role in providing various ecosystem services. These services include:

- Provisioning services such as food and water, raw materials such as timber for building and fuel, medicinal resources;
- Supporting services that are essential for the production of other ecosystem services and include biomass production, soil formation, nutrient cycling, water cycling, and the provision of habitat;
- Regulating services such as pollination, decomposition, water purification and flood control, carbon sequestration and climate regulation;
- Cultural services that hold social, recreational, and aesthetic significance to local communities.

The well-being of the communities within the boundaries of the Hope River watershed is closely linked to the essential ecosystem services it provides, which play a crucial role in supporting the health of both the people and the ecosystems within the watershed (**Table 11-9**).

Table 11-9. Ecosystem services provided by the ecosystems in the Hope River WMU.

Ecosystem Services	Provisioning	Supporting	Regulating	Cultural
Forest areas **Woodford** **Gordon Town** **Content Gap**	• *Raw materials, medicines and ornamentals* • *Wood* • *Water supply*	• *Wildlife habitat/biodiversity* • *Water infiltration and runoff reduction* • *Carbon sequestration* • *Nutrient cycling* • *Soil*	• *Microclimate regulation (temperature/ humidity)* • *Erosion and sedimentation control* • *Air quality regulation* • *Crop pollination*	• *Recreation and ecotourism* • *Spiritual* • *Existence*
Riparian corridor **Woodford** **Gordon Town** **Content Gap**	• *Raw materials, medicines and ornamentals* • *Wood* • *Water supply*	• *Wildlife habitat/ biodiversity* • *Water infiltration and runoff reduction* • *Carbon sequestration* • *Nutrient cycling* • *Soil*	• *Microclimate regulation (temperature/ humidity)* • *Erosion and sedimentation control* • *Air quality regulation* • *Crop pollination*	• *Recreation* • *Spiritual* • *Existence*
Agroecosystem **Woodford** **Gordon Town** **Content Gap**	• *Coffee, bananas, citrus fruits, pulses, vegetables* • *Raw material* • *Water supply*	• *Water infiltration and runoff* • *Carbon sequestration* • *Nutrient cycling* • *Habitat for fauna*	• *Microclimate regulation (temperature/ humidity)* • *Erosion and sedimentation control* • *Air quality regulation* • *Crop pollination*	• *Recreation and ecotourism* • *Cultural values* • *Biodiversity promotion*
Urban/Peri-urban green areas **Gordon Town** **Greenwich**	• *Food (urban gardens and fruit trees)*	• *Water infiltration and runoff* • *Carbon sequestration* • *Nutrient cycling*	• *Microclimate regulation (temperature/ humidity)*	• *Recreation* • *Urban biodiversity*

The Blue and John Crow Mountains National Park, a UNESCO World Heritage Site, spans the HRW, encompassing Woodford, Newcastle, Redlight, Gordon Town, Content Gap and other communities. This area holds significant natural and cultural heritage, providing essential ecosystem services, supporting local communities through agriculture and tourism, and offering recreational opportunities.

The Blue Mountains provide essential ecosystem services that are crucial for the well-being of the rural communities and the entire Hope River watershed. These include:

Water supply and regulation - The Blue Mountain headwaters are a critical freshwater source for the Hope River and its numerous tributaries that replenish the water supply for the Kingston Metropolitan area. These natural water resources are indispensable for human and agricultural purposes, such as providing clean drinking water and irrigation for farming, which supports local livelihoods in the watershed.

Biodiversity conservation- The Blue Mountains are an important biodiversity hotspot, with lush forests, high-elevation wetlands, and unique ecosystems that provide habitat for endemic species of birds, mammals, and reptiles. This contributes to the conservation of important plant and animal species, supporting ecological and cultural benefits.

Agriculture - The fertile soils and favorable climate support agriculture, including the cultivation of crops such as coffee, vegetables, and fruits. Agriculture is an important economic activity in the region, providing livelihoods for local farmers and contributing to the local food supply.

Soil conservation- The vegetation helps stabilise the soil, preventing erosion and protecting the area's natural resources. This contributes to soil conservation and supports sustainable agriculture in the surrounding communities. The forests help prevent soil erosion and nutrient depletion.

Climate regulation- Forests ecosystems play a crucial and multifaceted role in regulating air quality and climate at local and regional scales through processes such as photosynthesis, gas absorption, and temperature modulation. Trees provide shade, absorb carbon dioxide, and release oxygen, while forests also influence rainfall patterns and water availability. Urban trees have been shown to lower local temperatures, mitigate the urban heat island effect, and contribute to cleaner air by absorbing pollutants.

Recreation and tourism - The Blue Mountains offer a range of recreational opportunities for local and international tourism, including hiking, birding, and nature tours, which provide economic benefits and contribute to the local economy.

Cultural values– The natural surroundings of the Blue Mountains and forest reserves hold deep cultural value, as they have been used and cherished by local communities for generations, forming an integral part of their way of life and cultural heritage.

11.4.5.2 Institutional Capacities/Regulatory Framework

The legislative framework for watershed management comprises several Acts including:

- The Watershed Protection Act
- The National Environment and Planning Agency (NEPA)
- The Forest Act
- The Water Resources Authority Act
- The National Water Commission Act
- The Local Governance Act 2015
- Rural Agricultural Development Agency

The **Watersheds Protection Act (1963)** is the law governing watersheds in Jamaica and is administered by the Natural Resources Conservation Authority through the National Environment and Planning Agency. The primary focus of the Act is to recommend to the Minister programs and regulations for ensuring the proper, efficient and economic use of watershed areas with a view of promoting the conservation of water resources.

The Forestry Department, as mandated by the **Forest Act (1996)**, is responsible for the management of forest reserves (including mangrove) in Jamaica. Forest management encompasses a range of functions, which include, among others:

- protection and preservation of watersheds in forest reserves, protected areas and forest management Areas; and
- developing programs for proper soil conservation

The Water Resources Authority's duty is the regulation, allocation, conservation and management of the water resources of Jamaica. The authority is also charged with the drafting of the Water Resources Master Plan and Water Quality Control Plan.

The National Water Commission Act designates the National Water Commission as responsible for supplying public water supply throughout the Island. The Commission has a vested interest in the protection and management of watershed areas.

The Local Governance Act gives the Kingston and St. Andrew Municipal Council (KSAMC) the responsibility for regulating building within its area of jurisdiction which includes the entire Hope River WMU.

The Rural Agricultural Development Agency (RADA) is Jamaica's chief agricultural extension and rural development agency. Among its functions are:

- Promoting Climate Smart innovations to safeguard the environment and protect livelihood.
- Adopting Climate Smart practices by promoting the use of Water Harvesting and Water Use Efficiency.

RADA is a key agency engaged in outreach to farmers. The recent launch of the 'Climate-Smart Land Husbandry in Jamaica: A Manual for Extension Officers' is recognises the importance of understanding how watersheds function and how practices such as deforestation, and improper land preparation contribute to soil loss – especially on farms with steep slopes.

11.4.5.3 The Community Initiatives

Woodford, Redlight, Newcastle and Gordon Town communities demonstrate good adaptive capacity (**Figure 11-14**) with proactive community organisations that have been actively engaged in practical efforts to address various environmental concerns. The communities have been advocating for public collection and proper disposal of solid waste in the area. Additionally, they have taken steps to educate local farmers on alternative farming techniques, such as the use of greenhouse technology, land preparation by slash and burn, reduced forest cover and the need for better watershed protection. The community has also been focused on addressing problems related to poor solid waste management, ground water pollution, irregular supply of potable water, and community sensitivity to hazards.

Content Gap and Petersfield are rural farming communities with some community organisations that are deemed not as effective (i.e., medium adaptive capacity). There is a general appreciation of the role healthy ecosystems play in mitigating natural disasters, however, institutional initiatives that provide training pertaining to agricultural practices, and reforestation programs are required to effect change (**Figure 11-14**).

Greenwich Town is situated in an area that is prone to multiple hazards. Despite the presence of certified emergency shelters in the community, the level of training for emergency preparedness is limited, with less than 25% of the population having received proper training.

There are several community organisations including church groups, Jamaican Agricultural Society, Civic Organisation and the Citizens Association but no environmental wardens. The community relies on government and NGO initiatives for dealing with hazards and disasters. The community has very low adaptive capacity in the face of climate change (**Figure 11-14).**

11.4.6 Potential Impacts

Potential impacts of climate change on cities are determined by the combination of exposure and sensitivity.

Exposure refers to the degree to which an area is likely to be exposed to the physical impacts of climate change, such as rising temperatures, extreme weather events, sea level rise, or changes in precipitation patterns. This can depend on factors such as geographic location, proximity to coastlines or rivers, elevation, and climate projections for the region.

Sensitivity refers to susceptibility of a region or city, its populations and infrastructure, to the impacts of climate change. In the Hope River WMU, low-income communities are more sensitive to the impacts of climate change due to social, economic, or health-related factors. Similarly, communities in the watershed management unit with lack of, or outdated critical infrastructure and services such water supply systems, energy infrastructure, and emergency services are more sensitive to the impacts.

Figure 11-15 illustrates the combination of exposure and sensitivity to risk events. In the Hope River WMU, two distinct regions can be identified: the eastern part of the watershed, which is primarily prone to landslides during heavy rain due to steep terrain, improper land clearing, and land use practices; and the low-lying coastal area, where there is a high risk of impacts from coastal inundation, hurricanes, flashfloods, and socio-economic sensitivity of the communities (i.e., multiple hazards).

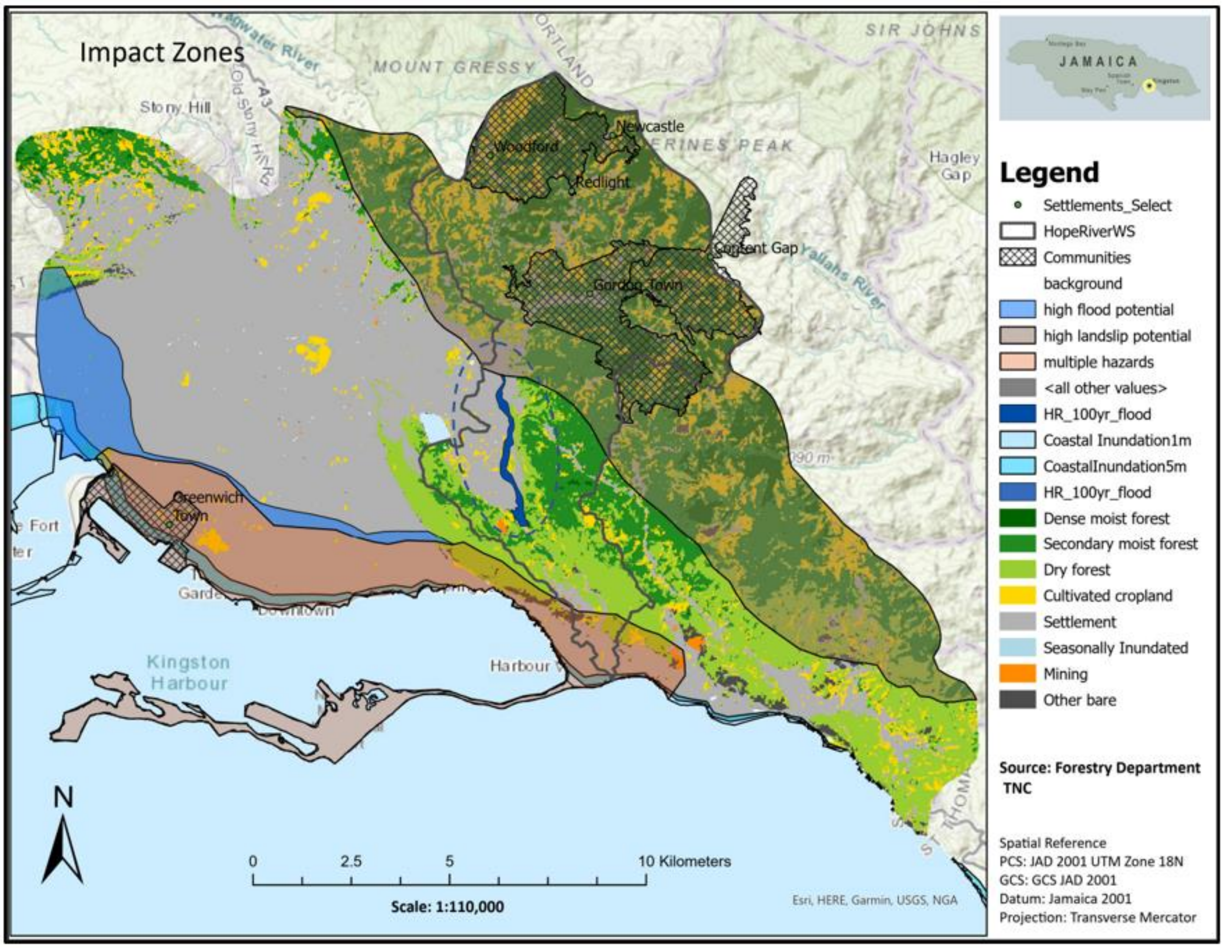


Figure 11-15. Impact zones in the Hope River watershed where communities and infrastructure are in high flood potential, high landslide potential areas, or are exposed to multiple hazards.

11.4.7 Outcomes of the Vulnerability Assessment

Vulnerability refers to the combined assessment of both the potential impacts of climate change and the adaptive capacity of an area. It considers the susceptibility of the area to the adverse effects of climate change, such as sea level rise, extreme weather events, and temperature changes, as well as the ability of the communities to cope with, adapt to, and recover from these impacts. Adaptive capacity includes factors such as infrastructure, resources, governance, social systems, and economic capabilities that enable a city to effectively respond to and mitigate the effects of climate change. A community with low adaptive capacity may be more vulnerable to the impacts of climate change, while communities with high adaptive capacity may be better equipped to withstand and recover from these impacts. Understanding vulnerability is critical for developing effective climate adaptation strategies and policies that can enhance the resilience and sustainability of communities in the face of climate change.

There are two aspects to vulnerability: a) socioeconomic vulnerability, which reflects vulnerable conditions of the population and their in/ability to respond to the disastrous events; and b) biophysical vulnerability, which identifies areas or ecosystems with characteristics that make them susceptible to certain hazards, such as proximity to the coastline or areas in the upper reaches of the watershed with steep slopes that are more prone to landslides.

Figure 11-16 illustrates how coastal areas, such as Greenwich, are highly vulnerable because they are exposed to multiple hazards including coastal inundation, hurricanes, wind, flashfloods, pollution from nearby Petrojam, and lack sufficient resources to adapt to the increased risks.

Content Gap is vulnerable to hazards such as landslides due to heavy rain events, flash floods near rivers, and brushfires from land clearing for agriculture. What exacerbates their vulnerability is the limited availability of resources within these communities to cope with the heightened potential for exposure to hazards resulting from climate change.

Gordon Town, Woodford, Redlight, and Newcastle communities are also situated in areas with complex topography and unregulated land use. Despite being remote from urban centers, these communities tend to come together and collaborate to identify potential solutions to mitigate the impacts of climate change in their areas. The resilience of these communities is largely bolstered by their community organisations. However, due to the biophysical and socioeconomic conditions, these communities are moderately vulnerable to the impacts of climate change. They face certain risks and limited adaptive conditions, which emphasise the need to identify and implement necessary actions to preserve and protect these areas, particularly the highlighted ecosystems. Under this category are ecosystems-unique forest lands, that need to be preserved for the stability in the provision of ecosystem services.

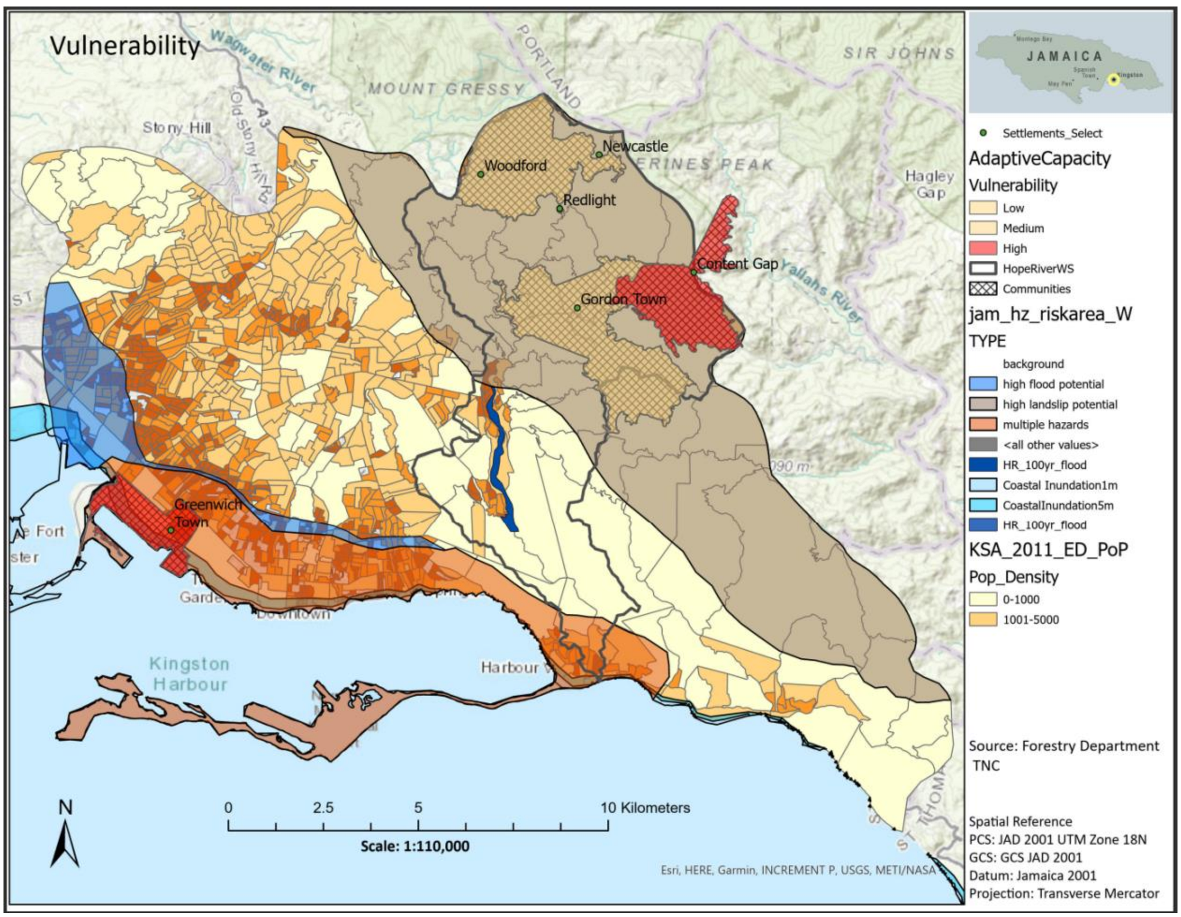


Figure 11-16. Vulnerability of communities reflects the level of impacts and their capacity to absorb the impacts and recover from them.

Table 11-10 lists some of the communities located within the 'multiple hazard' that are vulnerable because of their geographic location, the state of or lack of proper urban infrastructure (water supply, sanitation systems, and energy networks). Aging or inadequate infrastructure can be vulnerable to climate-related hazards such as extreme weather events, leading to service disruptions and impacts on the quality of life for urban residents.

Vulnerable populations within cities, such as low-income communities, marginalised groups, and those with limited access to resources and services, may be more affected by climate change. These populations may have less capacity to adapt due to factors such as limited financial resources, inadequate access to information and decision-making processes, and social inequalities.

Areas categorised as highly vulnerable often suffer from inadequate infrastructure, services, and social organisations necessary to effectively address the negative impacts of climate change. Despite these challenges, interventions can still be implemented in these areas to improve their conditions and reduce their risk of the negative impacts associated with climate change. It is important to identify and implement measures that can enhance resilience, adaptation, and sustainability in these vulnerable areas, even with limited resources, in order to mitigate the risks and reduce the vulnerability of these communities to the adverse effects of climate change.

Effective governance and urban planning are crucial for climate change adaptation in urban, peri-urban and rural communities. Cities with limited capacity for comprehensive planning, coordination, and implementation of climate adaptation measures may be more vulnerable to the impacts of climate change.

Table 11-10. Some vulnerable communities in the Hope River WMU that are located in high (hazard) impact zones.

Towns /Communities	***Impact***
Washington Gardens	*Coastal inundation*
Seaview Gardens	*Coastal inundation*
Majesty Gardens	*Coastal inundation*
Delacree Pen	*Coastal inundation*
Whitefield Town	*Coastal inundation*
Rose Town	*Coastal inundation*
Greenwich Newport East	*Coastal inundation*
Tivoli Gardens	*Coastal inundation*
Kingston – Central Downtown	*Coastal inundation*
Delacree Pen	*Coastal inundation*
Springfield	*Coastal inundation*
Rockfort	*Coastal inundation*
Harbour View	*Coastal inundation*
Port Royal	*Coastal inundation*
August Town	*Fluvial flooding*
Papine	*Fluvial flooding*
Kintyre	*Fluvial flooding*
Gordon Town	*Fluvial flooding, flash floods, landslides*
Content Gap / Petersfield	*Flash floods, landslides*
Craigton	*Flash floods, landslides*
Irish Town	*Flash floods, landslides*
Hopewell	*Flash floods, landslides*
Redlight	*Flash floods, landslides*
Happy Gate	*Flash floods, landslides*
Woodford	*Flash floods, landslides*
Newcastle	*Flash floods, landslides*

11.4.8 Impacts of climate change on ecosystem services under IPCC emission scenarios

Potential climate change under the three IPCC emission scenarios can have significant impacts on various aspects of the environment, thereby putting vulnerable communities in high impact zones at greater risk (**Figure 11-17**).

One key area of concern is water resources, as changes in precipitation patterns can result in droughts or flooding, affecting the availability of water for drinking and irrigation.

Additionally, climate change can lead to the loss of biodiversity, with changes in temperature and precipitation affecting the distribution and abundance of species. This can result in a reduced provision of ecosystem services such as pollination, pest control, and nutrient regulation, which are essential for maintaining healthy ecosystems.

Another consequence of climate change is the increased risk of invasive species outcompeting native species, leading to further loss of biodiversity and disruption of ecosystem functions. Changes in phenology, or the timing of seasonal events, can also be affected by climate change, which can disrupt ecological interactions and reduce the provision of ecosystem services such as pollination. Coastal ecosystems are particularly vulnerable to climate change impacts, with rising sea temperatures resulting in declines in marine biodiversity.

The impacts of climate change on various aspects of the environment can have significant consequences for communities in the Hope River WMU and their ability to adapt to changing conditions. It is essential for the leaders in communities to consider these impacts in their adaptation strategies to ensure the sustainability and resilience of their ecosystems and communities.

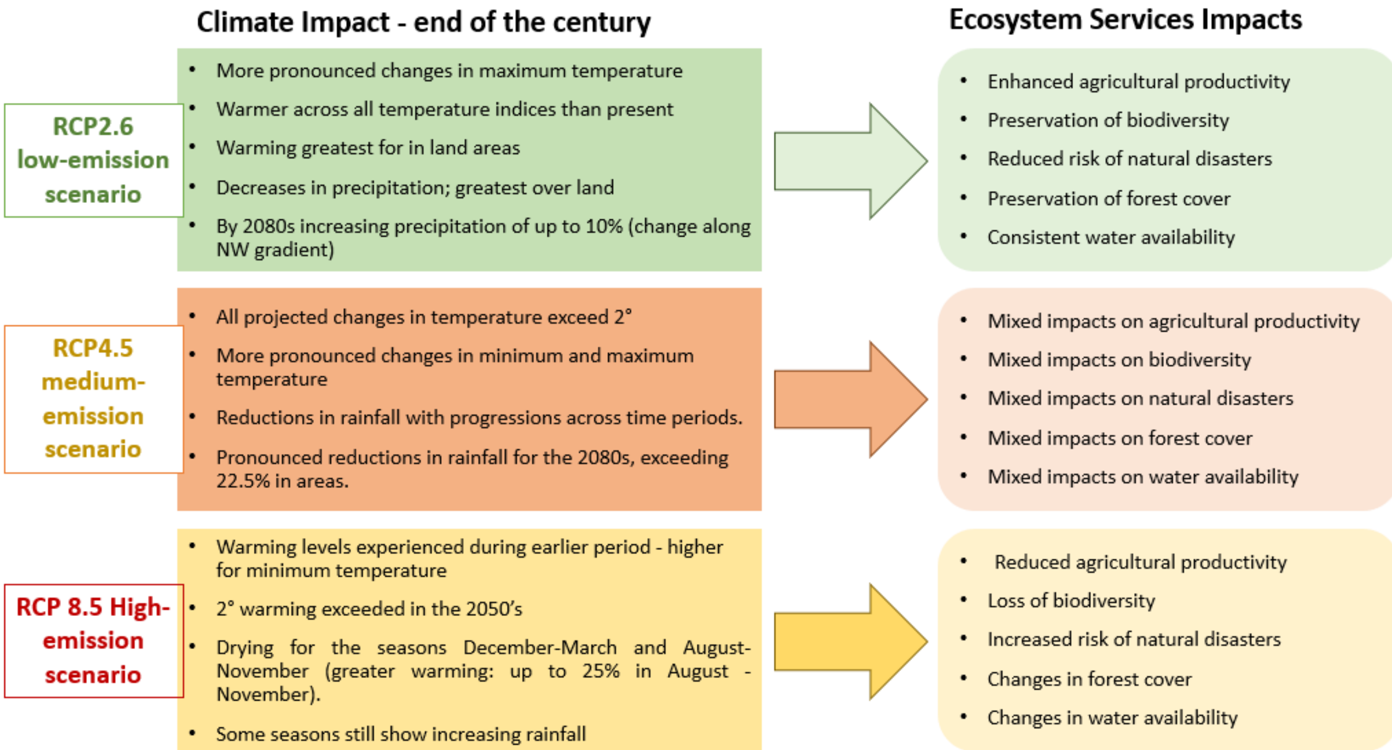


Figure 11-17. Impacts of climate change on ecosystem services under IPCC emission scenarios by the end of the century.

12 Ecosystem Based Adaptation (EbA)

Ecosystem-based adaptation (EbA)[39] is a strategy that conserves, manages, and restores ecosystems to help communities adapt to climate change impacts, by reducing vulnerability and increasing resilience. EbA recognises that ecosystems provide valuable services, such as coastal protection, water regulation, food and income generation, which can help communities to adapting to climate change. EbA addresses loss of biodiversity, impacts of climate change, food security, and human welfare. Investing in EbA measures can be cost-effective and sustainable compared to traditional infrastructure-based approaches (Secretariat of the Convention on Biological Diversity, 2016).

12.1 Social Benefits

Ecosystem-based adaptation (EbA) provides social benefits such as improved livelihoods, improved health, social inclusion, education and capacity building. EbA involves accessing ecosystem services for food, fuel, and income, reducing vulnerability to extreme weather events, involving local communities in adaptation efforts, capacity building through education and skills training. This holistic approach highlights the inclusive nature of EbA, making it a valuable strategy for climate change adaptation that considers the well-being and empowerment of local communities.

12.2 Ecosystem Benefits

The conservation and restoration of ecosystems through EbA can provide a wide range of benefits. These include conserving biodiversity by protecting and restoring ecosystems, maintaining important ecosystem services such as water regulation and carbon sequestration, restoring degraded habitats, conserving soil through erosion control and

[39] FEBA (Friends of Ecosystem-based Adaptation). (2021). Climate Justice for People and Nature through Urban Ecosystem-based Adaptation (EbA): A Focus on the Global South. Vidal Merino, M., Kang, Y. H., Arce Romero, A., Pahwa Gajjar, S., Tuhkanen, H., Nisbet, R., DeMaria-Kinney, J., Min, A.K., Atieno, W. C., Bray, B. (authors). PlanAdapt, Berlin, Germany and IUCN, Gland, Switzerland. 43 pp. https://doi.org/10.5281/zenodo.5187945

sustainable land use practices, regulating climate by reducing greenhouse gas emissions and providing shading, and controlling erosion by stabilising slopes and riverbanks. Specific benefits of EbA can vary depending on the type of ecosystem, region, and scale of implementation.

12.3 Adaptive Benefits

The findings of the socioeconomic surveys and the vulnerability assessment indicate that a considerable proportion of communities are exposed to and vulnerable to climate-related impacts. The high reliance on ecosystem services for provisioning, regulating, supporting, and cultural ecosystem services highlights the need for nature-based solutions (NbS) and ecosystem-based adaptation (EbA) to protect, restore and enhance ecosystems within and surrounding the communities in Hope River WMU. Ecosystem-based adaptation (EbA) provides a range of adaptive benefits, including increased resilience of human and natural systems to climate change impacts, risk reduction through natural buffers against disasters, and cost-effectiveness through multiple ecosystem services, sustainability through long-term maintenance of ecosystem services, and synergy with other adaptation measures.

12.4 Community-proposed Solutions

In addition to EbAs, the survey participants from the lower, middle and upper reaches of the Hope River WMU provided several non-EbA recommendations for protecting the watershed:

- As a priority, emphasis on sanitation and waste management (e.g., provision of skips), particularly more frequent and consistent garbage collection to prevent garbage from littering the communities and entering waterways and drains/gullies (this was a key proposal from all communities surveyed)
- Improving the drainage systems and conducting regular cleaning of drains and gullies to prevent flooding during heavy storm events
- Special protection/status of riparian buffer zones along riverbanks to prevent the construction of houses and discourage squatting. Policies and enforcement of setbacks

from the “100-year flood” water levels would protect houses, productive systems and infrastructure from future flood events.

- Adopting better land use and farming practices, such as zoning for specific purposes and promoting conservation
- Encouraging community action and establishing partnerships to promote conservation, reforestation/afforestation,
- Education, training, and community outreach to enhance environmental practices and management in communities
- Monitoring, enforcement, and regulations to safeguard ecosystems and impose penalties on polluters. Hiring rangers/wardens was put forth as an idea.

12.4.1 EbAs for Lower Reaches of the Hope River watershed

Urban and peri-urban Ecosystem-based Adaptation (EbA) strategies involve the conservation, management, and restoration of ecosystems to help people and their environment adapt to the adverse effects of climate change. **Table 12-1** proposes EbA strategies for building up the resilience of coastal communities in the Hope River WMU. Each proposed EbA is further discussed with proposed locations in each community.

Table 12-1. EbA interventions for Lower Reaches of the Hope River watershed

EbA Strategy	Ecological Benefits	Adaptive Benefits	Social Benefit
Mangrove wetland restoration	• *Re-establish coastal habitat* • *Increase biodiversity of flora and fauna* • *Provide nursery grounds for fish and rookeries for marine birds*	• *Reduce coastal erosion* • *Coastal protection from storm surges* • *Reduce the impacts of extreme weather events, such as floods and droughts, by storing and slowly releasing water*	• *Protect coastal properties from flooding* • *Reduce replacement cost of coastal infrastructure from storm surges*
Urban forestry-establishing green areas/treed parks/liner parks	• *Increase urban biodiversity* • *Establish connectivity*	• *Reduce urban heat island effect*	• *Provide recreational areas for people to gather* • *Community gardens*
Green infrastructure such as green roofs, green walls,	• *Establish urban vegetation* • *Attract pollinators* • *Increase urban biodiversity*	• *Reduce runoff or rainwater from impervious surfaces* • *Reduce heat island effect in urban areas*	• *Subsistence gardening in urban environment*
Rainwater harvesting	• *Water availability during drought conditions*	• *Supplement water supply and reduce the impacts of drought* • *Source of non-potable water for irrigation and toilet flushing*	• *Alternative source of water during drought periods*
Drainage management such as vegetative swales check dams, pervious surfaces and retention ponds	• *Swales or ditches, to redirect excess water away from vulnerable slopes and reduce the buildup of water*	• *Prevent excessive saturation of soil* • *Redirect excess water away from vulnerable slopes*	• *Reduce cost associated with coastal flooding and loss of property*
Outreach, education and capacity building – water management,	• *Sustainable land, groundwater management practices*	• *Water availability during drought conditions*	• *Building programs for local communities, landowners, and educating relevant stakeholders on value of EbA mitigation*

12.4.2 Greenwich Fishing Beach

12.4.2.1 Clearing drainage ways and gullies

During the site visit, the residents lamented that neighborhoods around Greenwich were being upgraded and that they, too, would benefit from such upgrades in their neighborhood. Access to running water, efficient sewage treatment, and regular waste collection were just some of the suggestions made.

For any EbA to be effective in Greenwich area, the first step would be to address the gully that leads to the Greenwich fishing beach (**Figure 12-1**). Outreach and programs that promote individual and community-based responsibility for rubbish disposal would foster a culture of environmental stewardship.

Figure 12-1. Littered gully leading to the Greenwich fishing beach.

12.4.2.2 Mangrove Restoration

An ecosystem-based adaptation approach for Greenwich Fishing Beach involves the implementation of coastal wetland restoration and protection measures. The strategy includes clearing the gully that runs from the road to the fishing beach, which carries debris from upstream drainage systems, and subsequently restoring mangroves. There are two potential sites for this restoration:

1. The east and west banks of the gully at the entrance to the inlet, where a pigsty currently exists (**Figure 12-2**). Restoration efforts can focus on this area to establish mangroves and enhance the wetland ecosystem, providing valuable protection against storm surges.
2. The shoreline along the Petrojam boundary (**Figure 12-3**). Once restored, this site would serve as a protective barrier, safeguarding the fishing beach from the impacts of storm surges. A similar initiative was implemented by NEPA and the University of the West Indies in the Palisadoes-Port Royal Protected Area (P-PRPA) and Ramsar Site, where 450 saplings were planted along the Palisadoes strip[40].

By implementing coastal wetland restoration and protection measures, the Greenwich Fishing Beach could benefit from enhanced resilience to coastal hazards and improved ecological health.

---

[40] NEPA (2022, June 24). *450 Mangroves Saplings Replanted Along The Palisadoes Strip To Support Ecosystem Restoration*. Www.Nepa.gov.jm. Retrieved June 1, 2022, from https://www.nepa.gov.jm/450-mangroves-saplings-replanted-along-palisadoes-strip-support-ecosystem-restoration

Figure 12-2. Potential mangrove restoration site 1: Eastern (left) and the western (right) bank of the inlet at the inlet at the Greenwich fishing beach.

Figure 12-3. Potential mangrove restoration site 2 along the Petrojam Oil Refinery shoreline and sites for vegetative buffers between Petrojam and the Greenwich fishing beach.

12.4.3 Greenwich Town

12.4.3.1 Urban green structures and spaces

Urban green structures refer to green spaces and vegetation in urban areas, such as parks, gardens, green roofs, and trees. These structures can provide a range of ecosystem services, including improving air quality, reducing urban heat island effects, promoting biodiversity, carbon sequestration and enhancing the overall quality of life for urban residents. In the context of climate change adaptation, urban green structures are increasingly recognised as a valuable strategy for mitigating the impacts of extreme weather events and other climate-related risks[41].

The opportunity should be taken to expand upon the success of the CityAdapt Pilot project[42], which involved the planting of tree seedlings across the communities in Greenwich and Petersfield. Further tree planting efforts can be undertaken to sustain the initiative. With proper, long-term funding, green space/landscape maintenance can create job opportunities for community members and foster environmental stewardship.

Some challenges that may hinder the implementation of urban green structures in a densely populated community like Greenwich Town may include limited space available for green infrastructure, and the cost of implementing and maintaining green structures. In addition, there may be conflicts between different stakeholders over the use of urban space, and concerns about safety and security in green areas. There may also be challenges associated with ensuring that green structures are accessible and inclusive for all members of the community.

---

[41] Schmidt K, Walz A (2021) Ecosystem-based adaptation to climate change through residential urban green structures: co-benefits to thermal comfort, biodiversity, carbon storage and social interaction. One Ecosystem 6: e65706. https://doi.org/10.3897/oneeco.6.e65706

[42] Forestry Department (2021, September 30). Jamaica to benefit from CityAdapt project. Www.Forestry.gov.jm. Retrieved June 1, 2022, from https://www.forestry.gov.jm/newsDetails?newsID=59

12.4.3.2 Urban forestry

Urban forestry has gained a lot of attention in recent years especially with the Forestry Department's National Tree Planting Initiative which was launched in 2019 and set a goal to plant 3 million trees in 3 years[43].

Urban forestry can help to promote resilience in the context of climate change by offering a variety of ecosystem services that can help to mitigate and adapt to the effects of climate change. Urban woodlands and other green infrastructure can help to lessen the urban heat island effect, which is of concern to the residents of Greenwich, by lowering the incidence of heat-related illnesses and other health concerns. Urban forests can also help to enhance air and water quality, thereby mitigating the effects of climate change on human health and the environment. Furthermore, by absorbing and storing precipitation, lowering runoff, and stabilising soil, urban trees can help to lessen the danger of flooding and other natural disasters which were listed as primary impacts of concern for the residents of Greenwich Town.

An area that would benefit from green structures and urban forestry would be the Greenwich fishing beach that is immediately adjacent to the Petrojam Oil Refinery (**Figure 12-4, Figure 12-5**). An ecosystem-based solution would entail enhancing the existing stands of vegetation by designing substantive vegetative/tree buffer zone to mitigate the potential negative impacts of industrial activities on the coastal ecosystem. The vegetation in the buffer zone can absorb and filter pollutants, reducing the risk of air pollution reaching the fishing beach and its surrounding areas. Planting vegetative buffers (i.e., air quality buffers[44]) (**Figure 12-3**) can reduce concentrations of several common air pollutants, such as

---

[43] 3 Million Trees in 3 Years: Urban Forestry in Jamaicahttps://www.linkedin.com/pulse/3-million-trees-years-urban-forestry-jamaica-island-city-lab/

[44] Dee, R. (n.d.). 6.3 Air Quality Buffers. 6.3 Air Quality Buffers. https://www.fs.usda.gov/nac/buffers/guidelines/6_aesthetics/3.html

ozone (O_3), particulate matter (PM), nitrogen oxides (NO_X), sulfur dioxide (SO_2), and carbon monoxide (CO)[45].

Designing a successful buffer would depend on developing a clearly defined project goal and ensuring that the available resources (e.g., funding and staffing) and design plans (e.g., width, rows, species, size, density, etc.) are appropriate for the location. This initiative would require cooperation and support from Petrojam and relevant Government agencies.

Appendix 7 - Forestry Department Planting Sites Under UNEP CityAdapt Project provides a lists tree species (fruit, ornamental and timber) that can be used to enhance tree cover in Greenwich Town and surrounding areas. Working with the Forestry Department to create a nursery in Greenwich could create a supply of tree seedlings for the community and for sale to the larger community providing jobs and income diversification.

---

[45] Fienstein, Susannah, Abigail Orrick, Chris Owen, Ben Stacey, Rebeca Villegas, Larissa Larsen, Nick Leonard, O'Day Salim, Stephanie Fitzgerald. (2018) Vegetative Buffers and Tree Canopy: Promoting the use trees to improve local air quality with local policy Retrieved from https://graham.umich.edu/media/files/dow/Dow-Masters-2018-Vegetative-Buffers-Tree-Canopy.pdf

Figure 12-4. The Petrojam refinery emits air pollutants through the combustion of fuel and the flaring of unwanted refinery gases. The Greenwich community has expressed ongoing concerns regarding the effects of emissions from the refinery on their health and the health of the ecosystems they rely upon.

12.4.3.3 Urban gardens

Urban gardens[46] can be integrated into green infrastructure networks, including green roofs, vertical gardens, and rain gardens. In addition, to temperature regulation (i.e.,

[46] Thomas, Graeme & Taguchi, Makiko. (2014). Growing Greener Cities in Latin America and the Caribbean - An FAO report on urban and peri-urban agriculture in the region.

reduction in heat island effect), vegetation and soil help to absorb and retain rainwater, thereby reducing stormwater runoff. Urban gardens can also provide habitat and food for a variety of species, including pollinators, birds, and beneficial insects. Developing green corridors and interconnecting garden spaces supports urban biodiversity, boosting ecological resilience in the face of climate change.

The most important aspect of urban gardens is promoting self-reliance and food security. Growing fruits and vegetables has cost benefits for households by reducing reliance on market-bought produce and ensuring access to fresh and healthy foods.

With effective outreach, training, and capacity building for home garden cultivation, Greenwich residents can develop climate resilient home gardens while promoting urban biodiversity. Urban gardening, with its co-benefits, offers valuable opportunities for community engagement and capacity building through skill-training. These efforts work towards strengthening community resilience in the face of climate-related challenges.

Accessed at chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://www.pseau.org/outils/ouvrages/fao_growing_greener_cities_in_latin_america_and_the_caribbean_2014.pdf

12.4.3.4 Rain harvesting

Climate change patterns are predicted to bring about changes in rainfall patterns and increased frequency and duration of extreme weather events, including drought conditions. Rain harvesting[47] presents a cost-effective climate change adaptation strategy by enabling community members to collect and store water during heavy rain events and store it for use during dry periods.

Greenwich frequently experiences water shortages, especially during prolonged periods of drought. To alleviate periodic water shortages, rain harvesting can provide a means of building drought resilience. Rain harvesting provides an additional source of water for non-potable uses (e.g., washing, irrigation, industrial uses) thereby reducing the demand on existing water infrastructure. In addition, rain harvesting represents a cost-saving alternative to the reliance on costly water truck deliveries thereby lowering water bills for households and businesses in the community.

12.4.3.5 Replacing Impervious Spaces

Implementing green infrastructure[48] that reduces impervious surfaces in the Greenwich community, such as permeable pavement and rain gardens or bioswales, can significantly contribute to mitigating localised flooding issues. By replacing traditional asphalt or

---

[47] Handbook on Rainwater harvesting for the Caribbean: A practical guideline featuring best practices for rainwater harvesting in small island Caribbean environments. Prepared by the Caribbean Health Institute (UNEP 2009). PDF accessed at chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://carpha.org/saintlucia/Rain/Rainwater%20Harvesting%20Toolbox/Media/Print/RWH_handbook.pdf

[48] Balcostics (2020, October 20). Green Strategies to Reduce Flooding in the Caribbean. Www.Forestry.gov.jm. Retrieved June 1, 2022, from https://balcostics.com/2020/10/20/green-strategies-to-reduce-flooding-in-the-caribbean/

concrete with permeable pavement in areas like car parks and walkways, excess stormwater runoff can be minimised as water can infiltrate through the surface and into the soil, naturally draining away. Additionally, the incorporation of rain gardens and bioswales strategically placed along streets and sidewalks allows for the capture and redirection of stormwater. These landscaped features with native vegetation act as filters, absorbing and slowly infiltrating rainwater, thereby reducing the burden on drainage systems and alleviating the risk of flooding in the community. By embracing these infrastructure solutions, Greenwich can enhance its resilience to climate-related challenges and foster a more sustainable and flood-resilient environment.

The combined implementation of urban green spaces, rainwater harvesting along with increasing and reducing impervious spaces, has the potential to mitigate impacts of flashfloods, storm surges and stormwater runoff which can cause flooding and can carry pollutants and rubbish into coastal ecosystems.

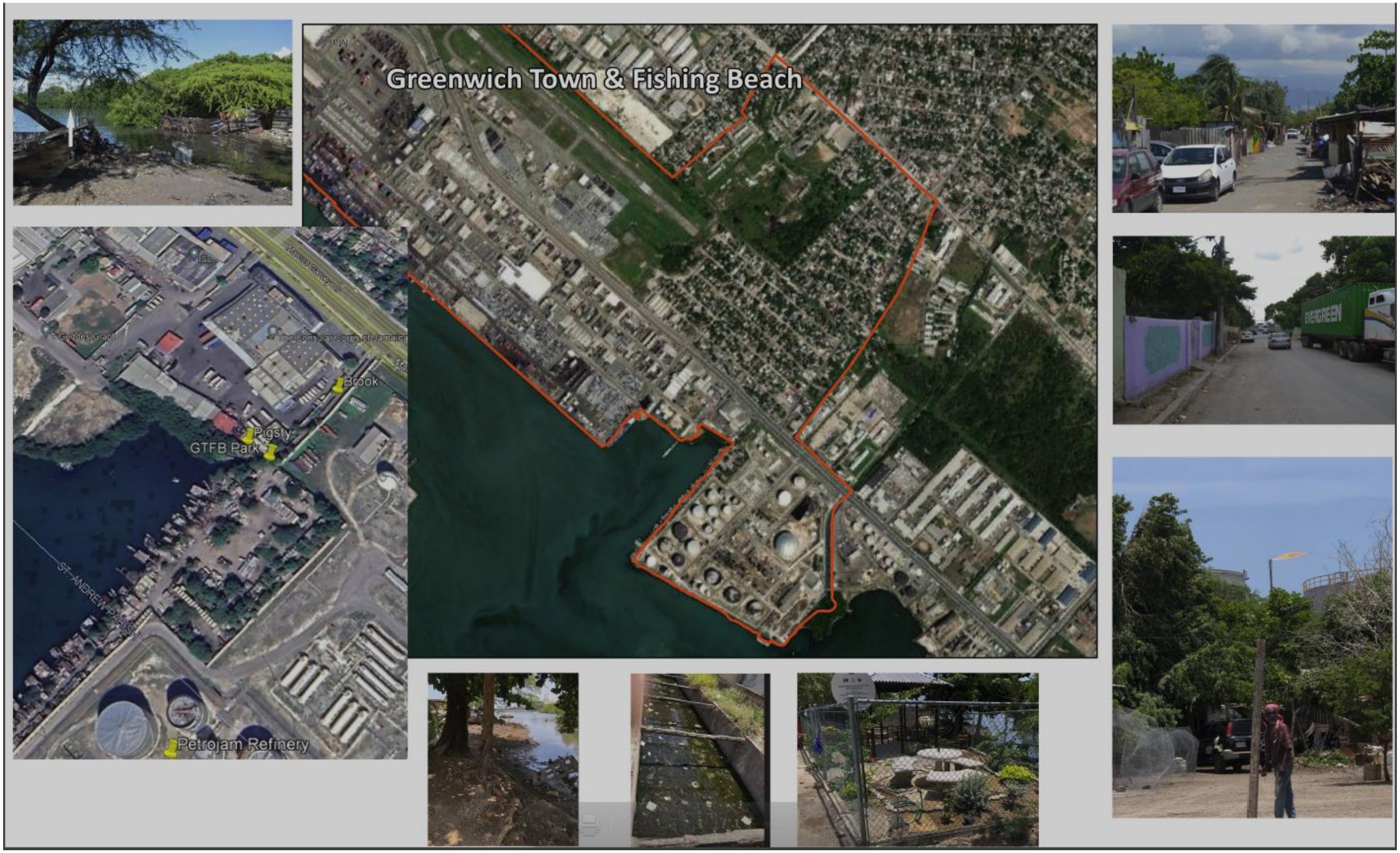


Figure 12-5. Proposed areas in Greenwich Town and Fishing Beach where ecosystem-based measures can be implemented to mitigate the impacts of climate change and foster community resilience.

12.4.4 EbA for Middle and Upper Reaches of the Hope River watershed

Effectiveness of EbA (Ecosystem-based Adaptation) measures proposed for the upper and middle reaches of the Hope River WMU would require a tailored approach that accounts for site-specific conditions including landscape, hydrology, and geological conditions. Local community engagement, participation, and knowledge should also be considered in the planning, implementation, and monitoring of EbA measures to ensure their effectiveness and sustainability.

For any EbA efforts to be successful in the middle and upper reaches of the Hope River WMU, the initial focus should be on improving municipal services, especially waste management practices (e.g., provision of skiffs, regular waste collection). It is essential to establish outreach initiatives and programs that encourage both individuals and communities to take responsibility for proper waste disposal. These efforts would promote a culture of environmental stewardship, and cooperation in caring for the natural surroundings.

Table 12-2 presents a suite of EbA solutions that may be suitable for rural areas, in the middle and upper reaches of the Hope River watershed.

*Table 12-2. EbA interventions for Middle and Upper Reaches of the Hope River watershed (**Figure 12-9**).*

EbA Strategy	Ecological Benefits	Adaptive Benefits	Social Benefit
Establish forest reserves to protect existing forest land (Collaboration with the Forestry Department and other initiatives currently underway in the WMU)	• *Maintain and enhance exiting ecosystem services* • *Protect native flora and fauna (biodiversity)* • *Soil retention*	• *Reduce risk of landslides on steep slopes in the upper and mid reaches of HRW* • *Regulate water flow through absorption, filtration*	• *Sustainable ecotourism (employment & income)* • *Fee for ecosystem services* • *Provisioning ecosystem services (subsistence and income)*
Reforestation and slope stabilisation	• *Restore native flora* • *Prioritise flora with root systems that bind soil* • *Water regulation*	• *Slope* • *Reduce soil erosion* • *Reduce surface runoff* • *Reduce habitat fragmentation and edge effect* • *Reduce impacts from drought (moisture retention)*	• *More cost effective than concrete retaining walls*
Restoration of riparian corridors using native tree species	• *Increase biodiversity of flora and aquatic fauna*	• *Improve the stability of riverbanks* • *Reduce riverine flooding* • *Reduce erosion* • *Improve water quality*	• *Protection of properties near flood plain*
• *Soil conservation using terracing, checkdams, contour ploughing, and cover cropping*	• *Prevent soil loss and desertification* • *Maintain integrity of soil composition*	• *Reduce the need for fertilisers* • *Reduce soil erosion*	• *Increased crop yield*

EbA Strategy	Ecological Benefits	Adaptive Benefits	Social Benefit
• *Agroforestry – integration of trees and shrubs into farming landscapes*[49]	• *Improved ecological landscape functioning* • *Improved nutrient cycling* • *Biodiversity conservation*	• *Land use alternative* • *Carbon sequestration* • *Soil health enrichment*	• *Increased crop yield*
• *Crop diversification*	• *Drought resistant crops* • *Crop rotation*	• *Buffering crop production from the effects of greater climate variability and extreme events*	• *Increased crop yield*
• *Building with nature (e.g., gabion baskets*[50]*, coconut fiber logs*[51]	• *Natural building materials can be easily integrated into ecosystem*	• *Using natural materials such as stone, wood, and vegetation to stabilise slopes and reduce the risk of landslides*	• *Locally sourced, sustainable building material*

[49] Climate Smart Land Husbandry in Jamaica: A manual for Extension. chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://www.fao.org/3/br873e/br873e.pdf (Accessed April 2, 2023)

[50] Gabion retaining wall. https://enviro-mesh.com/portfolios/city-view-gabion-retaning-wall-cladding/ (Accessed April 2, 2023)

[51] Coconut coir logs for biodegradable erosion control. https://www.clarionmunicipal.com/coconut-coir-logs.html(Accessed April 2, 2023)

12.4.4.1 Forest Reserves and Crown Lands

Forest lands and especially forest reserves and Crown Lands (managed by the Forestry Department) provide critical ecosystem services that contribute to maintaining healthy hydrology and building resilience to climate change impacts in the Hope River watershed. These reserves serve as vital components of the watershed's ecosystem, providing a range of benefits for both the environment and communities.

The dense moist and secondary moist forest cover in the upper and middle reaches of the watershed play a critical role in regulating waterflow, reducing the risk of floods and droughts, and preventing soil erosion by stabilising the soil with their intertwined root system. This is particularly important in steep slope areas, where forests act as natural barriers, reducing the likelihood of landslides and sediment runoff into streams and rivers. Preserving and increasing forest cover helps maintain the balance of the local ecosystem that ensures the survival of various species, including endangered ones.

To safeguard the existing forest land and its ecological functions in the Hope River WMU, protection, maintenance and potential expansion of forest reserves to preserve connectivity is recommended. This can be achieved through ongoing collaborative efforts with the Forestry Department, National Environment and Planning Agency (NEPA), the University of the West Indies (UWI), United Nations Environment Program (UNEP), NGOs and other organisations and initiatives that are currently active in the Hope River and neighboring watersheds.

By maintaining existing, and designating additional areas as forest reserves, these collaborative efforts can effectively protect and manage the forest ecosystems, ensuring their long-term sustainability. Through coordinated planning and implementation, the protected areas provide the basis for preserving biodiversity, maintaining healthy hydrology in the watershed, and building resilience to climate change impacts.

The Forestry Department's Climate Change Adaptation and Disaster Risk Reduction Report (2014) [52] recommends specific reforestation measures that could inform future reforestation efforts in the upper and middle reaches of the WMU, including:

- Planting of seedlings in degraded areas of the Hope River WMU
- Planting tree species that provide additional benefits such as bird feeder trees (nutrient enrichment of soils, leaf litter to enhance water retention, slow erosion and carbon sequestration)
- Establishment and/or strengthening of Local Forest Management Committees continued support and capacity building (LFMC)
- Reforestation, including the establishment, maintenance of nurseries, production of seedlings for reforestation
- Promotion of agroforestry

A collaborative and participatory approach recognises the importance of outreach and capacity building, involving multiple stakeholders, combining scientific expertise, local knowledge, and community engagement to achieve effective forest conservation and management in the Hope River region.

The following are examples of ecosystem-based adaptation measures aimed at enhancing resilience of the forest ecosystem in the Hope River WMU.

12.4.4.2 Reforestation

To enhance the resilience of the forest ecosystem in the Hope River WMU, reforestation projects should focus on re-establishing vegetation cover in areas that have experienced degradation due to clearcutting, fires, or abandoned croplands. It is essential to prioritise

---

[52] (2014). Forestry Department Final Report- Climate Change Adaptation & Disaster Risk Reduction Project. *Forestry Department*. Accessed June 5 2023. chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://www.forestry.gov.jm/resourcedocs/fd_finalreport_eu_ccadrr_apr2014.pdf

the use of native tree species to foster biodiversity and enhance the quality of habitats and ranges for native fauna.

12.4.4.3 Slope Stabilisation

To promote stability on steep slopes that have been cleared, modified, ecosystem-based solutions would see slope stabilisation implemented through revegetation/reforestation using native species of flora. This would involve strategically planting native trees and vegetation to effectively bind the soil, minimise runoff, and enhance soil texture and water retaining capacity (**Figure 12-9**).

12.4.4.4 Restoring Riparian Buffer Zones

Riparian forests are at the interface between terrestrial and freshwater habitats, and provide essential ecosystem services including water purification, flood control, erosion prevention, and habitat provision for a wide range of plant and animal species. Riparian forests are particularly important for biodiversity preservation, as they provide habitat for a variety of species, including many that are threatened or endangered[53].

Increasing the protection and restoration of ecosystems in the upper and middle reaches of Hope River watershed, especially dense moist forests, wetlands, and particularly riparian corridors, can positively impact downstream water quality and availability, for both agricultural irrigation and human consumption. The presence of intact riparian corridors along the Hope River and its tributaries helps to regulate the water flow, stabilise banks, and water infiltration, resulting in a more reliable water supply downstream. However, there are stretches along the waterways that are heavily impacted by settlements and other

[53] Tockner, K.; Stanford, J.A. Riverine flood plains: Present state and future trends. Environ. Conservation. 2002, 29, 308–330.

anthropogenic activities, as evidenced by degraded vegetation and rubbish, that would benefit from restoration (**Figure 12-6**).

Bioengineering[54,55] provides a low-cost nature-based approach for restoring eroded and degraded riparian habitats. The key components of bioengineering for riparian bank restoration include:

- Selecting native site-specific plant species with deep root systems to stabilise the soil by binding the soil, enhancing the habitat diversity and with time, reducing water flow velocity.
- Using live cuttings or stakes of native site-specific woody plants to further consolidate the riverbank. These living pegs can take root and expand, strengthening the soil structure.
- Using support structures like fascines (bundles of live cuttings) or gabion baskets to redirect the water flow and prevent erosion[56].

Successful restoration of riparian forests requires site-specific planning and implementation, and regular monitoring, and maintenance. As with any restoration project, the involvement of local communities and stakeholders is a must.

---

[54] Mira, E., Evette, A., Labbouz, L., Robert, M., Rousteau, A., & Tournebize, R. (2021). Investigation of the asexual reproductive characteristics of native species for soil bioengineering in the west indies. Journal of Tropical Forest Science, 33(3), 333-342. https://info.frim.gov.my/infocenter_applications/jtfsonline/jtfs/v33n3/333-342.pdf

[55] Conservation Buffers: Design Guidelines for Buffers, Corridors, and Greenways. (2008). USDA National Agroforestry Center. Retrieved July 11, 2023, from https://www.fs.usda.gov/nac/buffers/index.html

[56] Richet, J.-B., et al., The role of vegetative barriers such as fascines and dense shrub hedges in catchment management to reduce runoff and erosion effects: Experimental evidence of efficiency, and conditions of use. Ecol. Eng. (2016), http://dx.doi.org/10.1016/j.ecoleng.2016.08.008

Figure 12-6. Heavily impacted riparian corridor in Gordon Town.

12.4.4.5 Agroecology and Agroforestry

Agroecology and agroforestry are critical components of ecosystem-based adaptation to climate change. EbA practices, that incorporate agroecology, agroforestry, conservation agriculture, and drought-tolerant crops, enhance soil health, reduce erosion, and increase crop resilience to climate change.

Agroecology[57] is an ecological approach to agriculture that emphasises understanding the relationships between crops, animals, humans, and the environment. It aims to produce resilient and sustainable farming systems by mimicking natural processes and ecosystem dynamics. Agroecology plays an important role ecosystem-based adaptation by promoting the use of polyculture (growing multiple crops at the same time) and crop rotation. These practices contribute to climate change resilience by lowering the risks associated with single-crop reliance and improving the system's ability to adapt to changing conditions.

Agroforestry is a holistic approach to farming that combines tree crops with vegetable or mixed crops. Trees provide shade for other crops, contribute to water regulation and soil health through nutrient cycling. According to the Rural Agricultural Development Authority (RADA[58]), agroforestry practices in Jamaica commonly include the use of fruit trees such as mango, guava, cocoa, soursop, avocado, otaheiti apple, ackee, breadfruit, rose apple, lime, citrus, June Plum or naseberry, as well as timber trees such as mahogany, blue mahoe, cedar, or other wood species that are highly valued for timber.

Recommended climate-smart land husbandry practices[59] that can be promoted in the Hope River WMU, where not already in use, include:

- Contour farming on steep slopes

---

[57] Agroecology: Making Ecosystem-based Adaptation Work in Agricultural Landscapes. (2023, June 27). Retrieved July 9, 2023, from https://www.adaptationcommunity.net/publications/agroecology-making-ecosystem-based-adaptation-work-in-agricultural-landscapes/

[58] Rural Agricultural Development Authority Bigi, & Protz. (2014). Climate-Smart Land Husbandry in Jamaica: A Manual for Extension. Retrieved July 4, 2023, from https://www.fao.org/publications/card/en/c/5ce17fd1-b2ef-4b36-802b-9abaf6dde777/

[59] Bigi, & Protz. (2014). Climate-Smart Land Husbandry in Jamaica: A Manual for Extension. Retrieved July 4, 2023, from https://www.fao.org/publications/card/en/c/5ce17fd1-b2ef-4b36-802b-9abaf6dde777/

- Alley cropping using trees or shrubs between crops, and the clippings from the shrubs as mulch. In addition to improving soil nutrient levels, this approach also stabilises soil and controls erosion.
- Forest gardening by growing a variety of trees, shrubs, and perennial plants together to simulate the structure and function of a real forest. This method increases biodiversity, enhances soil fertility, and produces a long-term food production system.
- Planting drought resistant crops
- Planting barriers
- Low impact tillage
- Rainwater harvesting
- Land conservation and restoration (i.e., abandoned crop fields)

Agroforestry has gained a lot of attention because the approach mimics natural systems and increases resilience to climate change. It is considered an environmentally friendly and economically viable approach to sustainable land management. Working with local farmers in the Hope River watershed can help to identify best practices appropriate for the area by:

- Identifying practices that need to be discouraged or replaced with better options
- Providing training to help farmers adopt new practices and technologies
- Developing a list of technology options to be promoted for in-field pilot testing (e.g., precision farming)
- Identifying farm areas, with a focus on subsistence farmers, in the upper and middle reaches that would benefit from agro-EbA strategies

12.4.4.6 Green Infrastructure

Landslides are a common feature of the Hope River watershed (**Figure 12-7**). There are numerous slope stabilisation methods that can contribute to ecosystem-based solutions for slope stabilisation. The use of site-specific native plants in conjunction with wood, stone, and wire constructions such as planted pole walls, live slope grids, live timber walls, vegetated stone walls, and vegetated gabions provide a suite of options that can be scaled up depending on the site-specific requirements (**Figure 12-8**, **Figure 12-9**). A variety of factors, including slope, terrain, and available material determines the best approach. Gabion retaining walls[60] represent a green- engineering solution that can be placed strategically along steep slopes (e.g., along roadways) for:

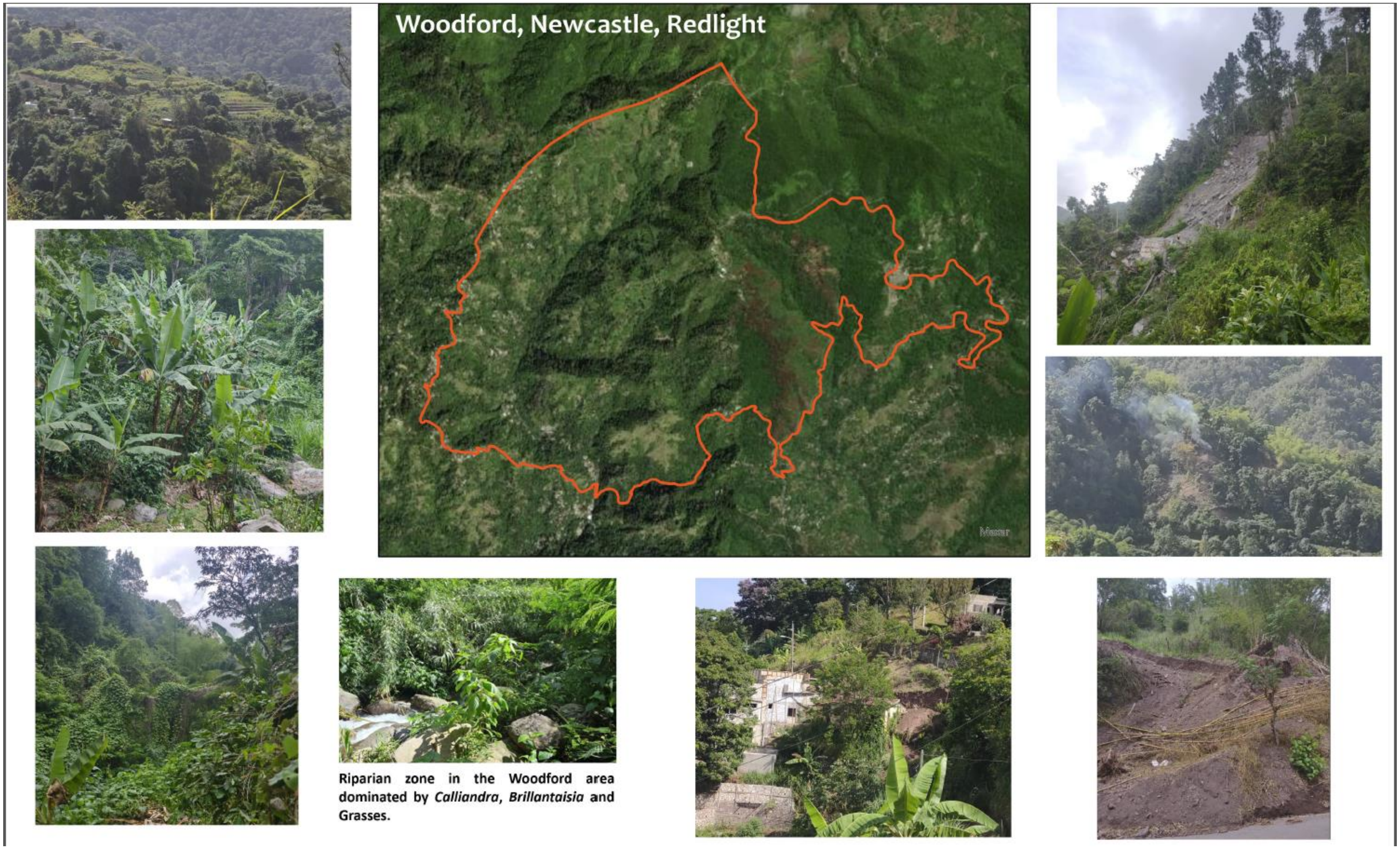
- **Slope stabilisation**: Gabion walls act as a barrier against soil movement by holding the slope in place. The weight of the boulders or stones within the baskets increases structural stability and prevents dirt from slipping or slumping downhill.
- **Erosion control**: Steep slopes are prone to erosion, especially during heavy rainfall. Gabion walls and check dams slow the flow of water, allowing it to slowly sink into the soil. This prevents soil erosion and decreases the risk of landslides.
- **Water drainage**: Gabion walls can be constructed with drainage systems. The walls help to limit excess water runoff and minimise the collection of water behind the walls by allowing water to travel through the wire mesh.
- **Habitat preservation**: The use of gabion retaining walls allows for the preservation of existing ecosystems. The wire mesh structure provides habitat niches for plants and small animals, allowing vegetation to grow and wildlife to thrive in the protected areas.

---

[60] The Science of Gabions Towards Erosion Control (https://gabionsupply.com/the-science-of-gabions-towards-erosion-control/). (n.d.). Retrieved July 9, 2023, from https://gabionsupply.com/the-science-of-gabions-towards-erosion-control/

Figure 12-7. Hollywell landslide in the upper reaches of the Hope River watershed

Figure 12-8. Examples of potential candidate sites in the middle reaches of the Hope River watershed for EbA interventions like reforestation, slope stabilisation, and the restoration of the riparian the corridor.



Riparian zone in the Woodford area dominated by *Calliandra*, *Brillantaisia* and Grasses.

Figure 12-9. Examples of potential restoration sites in the upper reaches of the Hope River watershed where ecosystem-based measures like reforestation can be implemented to mitigate the impacts of climate change and foster community resilience.

13 REFERENCES

Agroecology: Making Ecosystem-based Adaptation Work in Agricultural Landscapes. (2023, June 27). Retrieved July 9, 2023, from https://www.adaptationcommunity.net/publications/agroecology-making-ecosystem-based-adaptation-work-in-agricultural-landscapes/

Ahmad et al (1999). Landslide hazard mitigation and loss-reduction for the Kingston Jamaica Metropolitan Area. Publication No.7 Unit for Disaster Studies Department of Geography and Geology, University of the West Indies Mona, Kingston 7 Jamaica.

Avalon-Cullen C, Caudill C, Newlands NK, Enenkel M. Big Data, Small Island: Earth Observations for Improving Flood and Landslide Risk Assessment in Jamaica. Geosciences. 2023; 13(3):64. https://doi.org/10.3390/geosciences13030064

Balcostics (2020, October 20). Green Strategies to Reduce Flooding in the Caribbean. Www.Forestry.gov.jm. Retrieved June 1, 2022, from https://balcostics.com/2020/10/20/green-strategies-to-reduce-flooding-in-the-caribbean/

Bigi, & Protz. (2014). Climate-Smart Land Husbandry in Jamaica: A Manual for Extension. Retrieved July 4, 2023, from https://www.fao.org/publications/card/en/c/5ce17fd1-b2ef-4b36-802b-9abaf6dde777/

Bowers and Ryan 2021, Monitoring land cover change in Jamaica (Report prepared for the Forestry Department of Jamaica). Land cover data provided by the Forestry Departmet and Change Maps 2000-2020 retrieved October 19, 2022 from https://sambowers.users.earthengine.app/view/jamaicachangevo

Burgess, C.P., Taylor, M.A., Stephenson, T. et al. A macro-scale flood risk model for Jamaica with impact of climate variability. Nat Hazards 78, 231–256 (2015). https://doi.org/10.1007/s11069-015-1712-z

Climate Studies Group, Mona (CSGM), 2014: Near-Term Climate Scenarios for Jamaica (Technical Report). Produced for the Planning Institute of Jamaica (PIOJ). Kingston Jamaica. Climate Studies Group, Mona.

CSGM (2017): State of the Jamaican Climate 2015: Information for Resilience Building (Summary for Policy Makers). Produced for the Planning Institute of Jamaica (PIOJ), Kingston, Jamaica. 41 pp. ISBN 978-976-8103-72-7.

Climate Studies Group, Mona (CSGM), 2022: State of the Jamaican Climate (Volume III): Information for Resilience Building. Produced for the Planning Institute of Jamaica (PIOJ), Kingston Jamaica.

Climate Studies Group Mona (Eds.). 2020. "The State of the Caribbean Climate". Produced for the Caribbean Development Bank.

Climate Smart Land Husbandry in Jamaica: A manual for Extension. (Accessed April 2, 2023)
chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://www.fao.org/3/br873e/br873e.pdf

Conservation Buffers: Design Guidelines for Buffers, Corridors, and Greenways. (2008). USDA National Agroforestry Center. Retrieved July 11, 2023, from https://www.fs.usda.gov/nac/buffers/index.html

Dee, R. (n.d.). 6.3 Air Quality Buffers. 6.3 Air Quality Buffers. https://www.fs.usda.gov/nac/buffers/guidelines/6_aesthetics/3.html

FEBA (Friends of Ecosystem-based Adaptation). (2017). Making Ecosystem-based Adaptation Effective: A Framework for Defining Qualification Criteria and Quality Standards (FEBA technical paper developed for

UNFCCC-SBSTA 46). Bertram, M., 1 Barrow, E.,2 Blackwood, K.,3 Rizvi, A.R.,3 Reid, H.,4 and von Scheliha-Dawid, S.5 (authors). GIZ, Bonn, Germany, IIED, London, UK, and IUCN, Gland, Switzerland.

FEBA (Friends of Ecosystem-based Adaptation). (2021). Climate Justice for People and Nature through Urban Ecosystem-based Adaptation (EbA): A Focus on the Global South. Vidal Merino, M., Kang, Y. H., Arce Romero, A., Pahwa Gajjar, S., Tuhkanen, H., Nisbet, R., DeMaria-Kinney, J., Min, A.K., Atieno, W. C., Bray, B. (authors). PlanAdapt, Berlin, Germany and IUCN, Gland, Switzerland. 43 pp. https://doi.org/10.5281/zenodo.5187945

Fienstein, Susannah, Abigail Orrick, Chris Owen, Ben Stacey, Rebeca Villegas, Larissa Larsen, Nick Leonard, O'Day Salim, Stephanie Fitzgerald. (2018) Vegetative Buffers and Tree Canopy: Promoting the use trees to improve local air quality with local policy Retrieved from https://graham.umich.edu/media/files/dow/Dow-Masters-2018-Vegetative-Buffers-Tree-Canopy.pdf

Garbage eyesore in Hope River revives Kintyre flood risk. May 23, 2022. https://jamaica-gleaner.com/article/lead-stories/20220523/garbage-eyesore-hope-river-revives-kintyre-flood-risk

GIZ, EURAC & UNU-EHS (2014) The Vulnerability Sourcebook: Concept and guidelines for standardised vulnerability assessments. Bonn: GIZ.

https://adelphi.de/en/publications/the-vulnerability-sourcebook-concept-and-guidelines-for-standardised-vulnerability

GIZ and EURAC 2017: Risk Supplement to the Vulnerability Sourcebook. Guidance on how to apply the Vulnerability Sourcebook's approach with the new IPCC AR5 concept of climate risk. Bonn: GIZ

Graeme, Thomas & Taguchi, Makiko. (2014). Growing Greener Cities in Latin America and the Caribbean - An FAO report on urban and peri-urban agriculture in the region. Accessed at chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://www.pseau.org/outils/ouvrages/fao_growing_greener_cities_in_latin_america_and_the_caribbean_2014.pdf

Forrest. (2018). Jamaica: Monitoring Sustainable Forest Management. United Nations Forest Forum.

Forestry Department Final Report- Climate Change Adaptation & Disaster Risk Reduction Project. *Forestry Department*. (2014). Accessed June 5 2023. chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://www.forestry.gov.jm/resourcedocs/fd_finalreport_eu_ccadrr_apr2014.pdf

Forestry Department (2021, September 30). Jamaica to benefit from CityAdapt project. Www.Forestry.gov.jm. Retrieved June 1, 2022, from https://www.forestry.gov.jm/newsDetails?newsID=59

Hayman, A. (2018) Integrated Management of the Yallahs and Hope River watershed Management Areas Project. Report submitted to NEPA. https://www.thegef.org/projects-operations/projects/4454 (Accessed April 3, 2023)

Henry, C. (2021, October 21). Kingston And St. Andrew to Benefit From CityAdapt Project. Jamaica Information Service. https://jis.gov.jm/kingston-and-st-andrew-to-benefit-from-cityadapt-project/

History of Hurricanes in Jamaica (National Library of Jamaica)(n.d.) Accessed Jan 12, 2023 https://www.nlj.gov.jm/history-notes/History%20of%20Hurricanes%20and%20Floods%20in%20Jamaica.pdf

Hoegh-Guldberg O, Jacob D, Taylor M, Bindi M, Brown S, Camilloni I, Diedhiou A, Djalante R, et al. (2018). Chapter 3: Impacts of 1.5 °C global warming on natural and human systems. In: Global Warming of 1.5 °C -

An IPCC special report on the impacts of global warming of 1.5 C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change. Intergovernmental Panel on Climate Change

Hayman, Alicia A. The Effects of Land Use Practices on Water Quality and Quantity in the Hope River watershed, Jamaica. MSc Thesis, University of British Colombia, October 2000.

Hope River watershed Management Unit. (2012). Watershed Management Plan. Retrieved from https://www.nepa.gov.jm/wp-content/uploads/2018/02/Hope_River_Watershed_Management_Plan_Final.pdf

IPCC (2007): Climate Change 2007: Synthesis Report. Contribution of Working Groups I, II and III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, Pachauri, R.K and Reisinger, A. (eds.)]. IPCC, Geneva, Switzerland, 104 pp.

IPCC (2003): Good practice guidance for land use, land-use change and forestry. Penman, J., et al.

IPCC (2021): Summary for Policymakers. In: Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [Masson[1]Delmotte, V., P. Zhai, A. Pirani, S. L. Connors, C. Péan, S. Berger, N. Caud, Y. Chen, L. Goldfarb, M. I. Gomis, M. Huang, K. Leitzell, E. Lonnoy, J. B. R. Matthews, T. K. Maycock, T. Waterfield, O. Yelekçi, R. Yu and B. Zhou (eds.)]. Cambridge University Press. In Press.

Jamaican Meteorological Service. (2015). Jamaica's Third National Communication to the United Nations Framework Convention on Climate Change. Retrieved from https://unfccc.int/documents/83236.

Landslide Susceptibility Maps for the Kingston Metropolitan Area. https://www.mona.uwi.edu/uds/Land_Jam.html (Accessed Oct. 30 2022)

Maharaj, R. J. (1993). Landslide processes and landslide susceptibility analysis from an upland watershed: A case study from St. Andrew, Jamaica, West Indies. Engineering Geology, 34(1-2), 53–79. doi:10.1016/0013-7952(93)90043-c

Mandal et al. Rainfall-runoff simulations using the CARWIG Simple Model for Advection of Storms and Hurricanes and HEC-HMS: Implications for Hurricane Ivan over Jamaica Hope River watershed, 2016.

Mazon, M.M., et al (2020). How forest structure varies with elevation in old growth and secondary forest in Costa Rica. Forest Ecology and Management 469 (2020) 118191. https://doi.org/10.1016/j.foreco.2020.118191

McLean, N. M., Stephenson, T. S., Taylor, M. A., & Campbell, J. D. (2015). Characterization of future Caribbean rainfall and temperature extremes across rainfall zones. Advances in Meteorology, 2015. https://doi.org/10.1155/2015/425987

McLean, N. M., Stephenson, T. S., Taylor, M. A., & Campbell, J. D. (2015). Characterization of future Caribbean rainfall and temperature extremes across rainfall zones. Advances in Meteorology, 2015. https://doi.org/10.1155/2015/425987

Miller, S., Brewer, T., and Harris, N. (2009). Rainfall Thresholding and Susceptibility assessment of rainfall induced landslides: application to landslide management in St Thomas, Jamaica. Bulletin of Engineering Geology and the Environment 68:539–55

3 Million Trees in 3 Years: Urban Forestry in Jamaicahttps://www.linkedin.com/pulse/3-million-trees-years-urban-forestry-jamaica-island-city-lab/

Mira, E., Evette, A., Labbouz, L., Robert, M., Rousteau, A., & Tournebize, R. (2021). Investigation of the asexual reproductive characteristics of native species for soil bioengineering in the west indies. Journal of Tropical Forest Science, 33(3), 333-342. https://info.frim.gov.my/infocenter_applications/jtfsonline/jtfs/v33n3/333-342.pdf

Mycoo, M., M. Wairiu, D. Campbell, V. Duvat, Y. Golbuu, S. Maharaj, J. Nalau, P. Nunn, J. Pinnegar, and O. Warrick, 2022: Small Islands. In: Climate Change 2022: Impacts, Adaptation, and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [H.-O. Pörtner, D.C. Roberts, M. Tignor, E.S. Poloczanska, K. Mintenbeck, A. Alegría, M. Craig, S. Langsdorf, S. Löschke, V. Möller, A. Okem, B. Rama (eds.)]. Cambridge University Press. In Press.

National Water Commission https://www.nwcjamaica.com/publication.php Published 2015.

NEPA (2022, June 24). *450 Mangroves Saplings Replanted Along The Palisadoes Strip To Support Ecosystem Restoration*. Www.Nepa.gov.jm. Retrieved June 1, 2022, from https://www.nepa.gov.jm/450-mangroves-saplings-replanted-along-palisadoes-strip-support-ecosystem-restoration

Puyravaud. (2003, April). Standardizing the calculation of the annual rate of deforestation. Forest Ecology and Management, 177(1–3), 593–596. https://doi.org/10.1016/S0378-1127(02)00335-3

Richet, J.-B., et al., The role of vegetative barriers such as fascines and dense shrub hedges in catchment management to reduce runoff and erosion effects: Experimental evidence of efficiency, and conditions of use. Ecol. Eng. (2016), http://dx.doi.org/10.1016/j.ecoleng.2016.08.008

Rural Agricultural Development Authority Bigi, & Protz. (2014). Climate-Smart Land Husbandry in Jamaica: A Manual for Extension. Retrieved July 4, 2023, from https://www.fao.org/publications/card/en/c/5ce17fd1-b2ef-4b36-802b-9abaf6dde777/

Schmidt K, Walz A (2021) Ecosystem-based adaptation to climate change through residential urban

green structures: co-benefits to thermal comfort, biodiversity, carbon storage and social interaction. One Ecosystem 6: e65706. https://doi.org/10.3897/oneeco.6.e65706

Social Development Commission. Community Profile of Greenwich Town, Kingston. 2009.

Social Development Commission. Community Profile Gordon Town, St. Andrew. 2009.

Social Development Commission. Community Profile Woodford, St. Andrew. 2010

The Science of Gabions Towards Erosion Control. Retrieved July 9, 2023, from https://gabionsupply.com/the-science-of-gabions-towards-erosion-control/

Tockner, K.; Stanford, J.A. Riverine flood plains: Present state and future trends. Environ. Conservation. 2002, 29, 308–330.

van Vuuren, D.P., Edmonds, J., Kainuma, M. et al. (2011) The representative concentration pathways: an overview. Climatic Change 109, 5. https://doi.org/10.1007/s10584-011-0148-z

UNEP (2009) Handbook on Rainwater harvesting for the Caribbean: A practical guideline featuring best practices for rainwater harvesting in small island Caribbean environments. Prepared by the Caribbean Health Institute. PDF accessed at chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://carpha.org/saintlucia/Rain/Rainwater%20Harvesting%20Toolbox/Media/Print/RWH_handbook.pdf

UNEP (2021). Nature-based Solutions for Latin American and Caribbean cities - Methodological Guidelines. United Nations Environment Programme, Office for Latin America and the Caribbean, Panama.

Water Resources Authority. Resources (GIS_Flood Map) Accessed April 13, 2023. https://www.arcgis.com/home/webmap/viewer.html?webmap=645025797e0947c68388adcd8c455995&extent=-78.9494,17.2273,-75.5765,18.9166

14 APPENDICES

14.1 Appendix 1 – Terms of Reference

Terms of Reference

Consultancy to carry out Rapid Ecological Assessment and Socio-economic Survey for the Building Climate Resilience of Urban Systems Through Ecosystem-Based Adaptation (Eba)" In Latin America and the Caribbean.

Summary

Purpose	To undertake a Rapid Ecological Assessment and Socio-economic Survey within sections of the Hope River watershed with a focus on: ecosystems and ecosystem services, environmental change, as a result of human activities and climate change, local livelihoods and climate vulnerability, environmental governance, climate adaptation needs and identification of resource availability.
Expected fee	**Capped at US$ 70,000**
Location	Jamaica
Duration	5 months
Estimated start date	March 2021
Reporting to	Natainia Lummen

Background

Rapid urbanisation and unplanned expansion of cities is reducing urban and peri-urban ecosystems – including wetlands, green spaces and forests – that provide a wide range of ecosystem services that contribute considerably to the well-being of urban communities. These problems are exacerbated by the existing climate change impacts, and it is expected that there will be more impacts with the predicted effects, both of which include the increased frequency and intensity of floods and droughts as a result of increased temperature and rainfall variability.

Furthermore, the effects of future climate change will exacerbate many of the current problems affecting urban communities. For example, urban expansion has replaced ecosystems and green areas at the watershed, urban and household scale with concrete infrastructure and asphalt, a process called "catchment hardening". During periods of extreme rainfall, these hardened catchments cannot absorb large amounts of water. Consequently, rainwater remains on the hardened surfaces and results in flooding within the city, particular in areas with poor communities who have limited access to financial and natural resources to adequately respond to such extreme rainfall.

The **CityAdapt Project**, funded by the Global Environment Facility (GEF) and executed by the Regional Office for Latin America and the Caribbean of the United Nations Environment Program (UNEP) is being implemented in Kingston to reduce the vulnerability of urban communities to the current and future effects of climate change. This will be achieved by the project through: i) mainstreaming urban Ecosystem based Adaptation (EbA) into medium- and long-term urban development planning; ii) implementing urban EbA interventions to reduce the vulnerability of local communities; and iii) acquiring knowledge and raising awareness of urban EbA throughout the region.

The goal of CityAdapt is to build the capacity of government and local communities to adapt to the effects of climate change through the integration of Ecosystem-based Adaptation (EbA) into urban planning. EbA provides a cost-effective way to reduce climate change vulnerability of urban and peri-urban communities while providing multiple co-benefits to these communities and the environment, by protecting, maintaining and rehabilitating ecosystems. The Nature Conservancy, through a Small Scale Funding Agreement (SSFA) between the United National Environment Programme, will be implementing local activities under two components. To that end, the Conservancy seeks to hire a contractor to undertake activities related to the achievement of Component 2:

Component 2: Demonstration of EbA in Kingston to increase the capacity of urban and peri-urban communities to adapt to the effects of climate change.

The specific objectives and tasks to be performed under this consultancy are articulated below under the Objectives and Activities section of this TOR.

Purpose of contract

The main objective of the consultancy is to carry out a Rapid Ecological Assessment and Socio-economic Survey within sections of the Hope River watershed with a focus on ecological conditions and potential impacts on ecosystems and ecosystem services and environmental change (anthropogenic and natural phenomena, including climate change), local livelihoods and climate vulnerability, environmental governance, climate adaptation needs and identification of resource availability. These will inform the preparation of scenario maps, a report detailing climate risk and vulnerability assessment, adaptation and mitigation potential, as well as the costs and appropriate operation and maintenance plans for proposed ecosystem-based adaptation plans and interventions. Based on the results of the assessment and scenarios, it is expected that draft EbA measures will be proposed, and recommendations made for their incorporation into policy, planning and other strategy documents for urban spaces such as Kingston, Jamaica.

This consultancy is a part of a larger project with outputs from a team of other specialist. The contractor/ team hired to undertake this component will work collaboratively with three other contractors (a Policy Strategist, a Training Specialist and an Upscaling Strategist) under the guidance of the TNC team. The products generated under this consultancy will be used as inputs for the deliverables to be produced by above-mentioned contractors.

Objectives and Scope of Work

The contractor is required to work closely with TNC experts to ensure that the final report document meets UNEP requirements and quality. They will work with relevant stakeholders, with technical guidance from the TNC's Climate Adaptation Specialist to achieve the objectives outlined in the section below.

Objectives:

A. Undertake Rapid Ecological Assessment (REA) guided by RiVAMP methodology in sections of the Hope Watershed. The assessment should be done for three communities drawn from the upper, mid area and lower level of the watershed. The communities will be identified in collaboration with the TNC team and the Technical Advisory Group for the project. The lower watershed community should be located within the boundaries of Kingston. The REA will include the following activities:

- Collect primary and secondary baseline data on natural habitats (all ecosystems) within the project sites: spatial extent, biodiversity and threats (sources and attributing factors) and potential indicators of biodiversity health where applicable in coordination with TNC. This should include:
- Historic/other data from relevant ministries, departments and

agencies (WRA, RADA, Forestry Department, NEPA, Ministry of Local Government and Community Development, STATIN, National Spatial Data Management and Services (LICJ) etc.)

- Local surveys should be done where needs are identified
- Conduct a change detection of the spatial extent, health, condition, composition, and threats to the ecosystems and natural resources

- Design recommendations on abatement of threats and identify potential areas for restoration activities

- Evaluate the feasibility of different habitat restoration techniques to identify the most appropriate adaptation actions (within identified zones)

- Develop indicators and their thresholds that trigger evaluation and adaptation so systems can be managed for ecosystem resilience

- Forecast future ecological health based on current management and evaluate alternative management options and their consequences (improve community interactions with surrounding ecosystems)

B. Undertake Socio-economic Assessment in sections of the Hope Watershed. This will include three communities drawn from the upper, mid area and lower level of the watershed. Each community within the watershed zones will be identified in collaboration with TNC and the Technical Advisory Group.

Collect primary and secondary baseline data on factors that will most likely affect well-being of local communities, including livelihood characteristics, population growth, planned economic activities, urban development plans, disaster risk, and land-use change. For land use change assessments, contractor must work with information from the Forestry and other relevant government entities and Departments to ensure alignment with national efforts.

C. Spatially combine the REA, the socio-economic data and analyse against the three climate trajectories – best, middle and worst-case - to map the Hope Watershed and create scenario maps and analytical report. The climate trajectories should be linked to local climate data, which when combined with the socio-economic and ecosystems data informs and frames vulnerability scenarios and analysis, inclusive of future forecasts. In this analysis, include:

- climate-related risks
- ecological health based on current management and evaluate alternative management options and their consequences (improve community interactions with surrounding ecosystems)
- urban development (including a scenario on unplanned growth of the city)
- resource availability under conditions of climate change

D. For the city of Kingston, Jamaica

- Collate spatial data on climate trajectories at the city level for Kingston, Jamaica. Input data should be the most recent and representative one (sound data considering IPCC recommendations) e.g., 30 years of data record on climate variables, consideration of the RCP 2.6, 4.5 and 8.5.
- Collate and analyse REA and Socio-economic data and other relevant information and develop high level and detailed recommendations where applicable for a proposed Ecosystem based Adaptation (EbA) strategy for the city of Kingston.

E. Assist TNC with a workshop designed to share the results of this study with local experts and key community groups for review and feedback. (TNC will host and facilitate the workshop, contractor will be expected to present the results of the REA, Socio economic assessment, overall analysis of combined data and recommendations.)

Activities to be carried out:

Specifically, the Contractor must perform the following activities for each of the project sites:

i. Develop and submit and inception report with a detailed methodology and work plan outlining the activities to be performed and proposed timeline. This work plan will be used to coordinate activities in the field, as well as activities and consultations with other experts and the implementing partner - TNC, including workshops with the communities.

ii. Conduct field trips, hold expert interviews and focus group discussions to gather and update (if applicable) the necessary information on habitats.

iii. Identify, locate, and map the major threats, vulnerabilities and pressures to the ecosystem and biodiversity by anthropogenic and natural phenomena (including climate change) within the three identified communities. The causes, sources, effects and impacts as well as the actors related (if applicable).

iv. Conduct a socio-economic survey (including a high-level gender analysis) to identify factors that will most likely affect well-being of local communities, including population growth, planned economic activities, livelihood activities, urban development plans, disaster risk and land-use change,

v. Provide an analysis of climate trajectories at the city level and associated impacts on the urban communities located within the Hope Watershed, Kingston, Jamaica

vi. vi. Conduct an inventory of the socio-economic and natural resource data

vii. Undertake analysis to determine the best, middle and worst-case scenarios related to urban development, unplanned growth of the city, climate-related risks and resource availability under conditions of climate change,

viii. Develop recommendations for the protection, restoration, and conservation actions to increase the ecosystem services provided by the studied habitats, to abate threats, especially as they relate to climate change adaptation, coastal protection, disaster risk reduction, and livelihood provision.

ix. Propose at least five Ecosystem based Adaptation actions for Kingston. We know that to reduce climate impacts, some solutions are socio-economic, some hard infrastructure, some at the governance level and as such we encourage you to include other recommendations beyond EbA.

x. Produce a draft, final and summary technical report of the assessments incorporating listed items above.

xi. Assist TNC in the design of a workshop and present the results of the combined report (REA and Socio-economic Analysis) to local experts and key community groups for review and feedback. (TNC will host and facilitate the workshop.)

xii. Work collaboratively with the Policy Strategist, Training Strategist and the Upscaling Strategist to review all products developed and participate in workshops associated with those deliverables as required.

14.2 Appendix 2 – Laboratory Analysis Certificate

SCIENTIFIC RESEARCH COUNCIL
(An Agency of the Ministry of Science, Energy & Technology)
P.O. Box 350, Hope Gardens, Kingston 6, Jamaica
Telephone: (876) 927-1771-4, 977-2190-1
www.src.gov.jm

ANALYTICAL SERVICES DEPARTMENT
REPORT SHEET

Reference #: A22188

Customer's Name: TEM Network
Address: 190 Mountain View Avenue, Kingston 6
Date of receipt: 2022/10/05 @ 12:35 pm
No. of samples submitted: 6
Sample Description: Fresh Water

Date of sampling: 2022/10/05 @ 7:32 am – 12:18 pm
Samples collected by: Delroy Blairgrove
Condition of sample: Cold
Location of sampling: Not Applicable
Location of test: SRC

RESULTS OF ANALYSIS

Method	Parameter	Date of Analysis	TEM HRW #1	TEM HRW #1A	TEM HRW #2
HACH Method 8043	Biological Oxygen Demand mg/L	2022/10/05	0.99	0.81	1.05
SMEW Method 9221	Faecal Coliform MPN/100mL	2022/10/05	46	49	240
HACH Method 8048	Available Phosphate mg/L	2022/10/06	0.18	0.17	0.14
HACH Method 10020	Nitrate mg/L	2022/10/06	<0.9	<0.9	22
EPA Method 180.1	Turbidity, NTU	2022/10/12	1.17	1.12	1.13
SMEW Method 2540D	Total Suspended Solids mg/L	2022/10/11	<2.5	<2.5	<2.5

Method	Parameter	Date of Analysis	TEM HRW #3	TEM HRW #4	TEM HRW #5
HACH Method 8043	Biological Oxygen Demand mg/L	2022/10/05	0.46	0.51	0.25
SMEW Method 9221	Faecal Coliform MPN/100mL	2022/10/05	350	240	540
HACH Method 8048	Available Phosphate mg/L	2022/10/06	0.14	0.14	0.19
HACH Method 10020	Nitrate mg/L	2022/10/06	3.74	3.64	4.4
EPA Method 180.1	Turbidity, NTU	2022/10/12	1.03	0.83	1.54
SMEW Method 2540D	Total Suspended Solids mg/L	2022/10/11	<2.5	<2.5	<2.5

SRC-QSF-262 Revision No. 7 Date Effective: May 3, 2021 Page 1 of 3

SCIENTIFIC RESEARCH COUNCIL
(An Agency of the Ministry of Science, Energy & Technology)
P.O. Box 350, Hope Gardens, Kingston 6, Jamaica
Telephone: (876) 927-1771-4, 977-2190-1
www.src.gov.jm

ANALYTICAL RESULT – REF. #A22188

Certified by

Signature: ____________________
(Laboratory Analyst)

Name: Shermaine McKenzie

Date: 2022/10/21

Issued/Authorized by

Signature: ____________________
(Technical Manager)

Name: Ray-Anne Shaw Phillips

Date: 2022/10/21

- END OF REPORT –

14.3 **Appendix 3 -** Plant Checklist of the Greenwich Town Fishing Village and Community.

	FAMILY	GENUS	SPECIES	AUTHORITY	COMMON NAME	HABIT	STATUS	DAFOR STATUS	IUCN STATUS	USES/NOTES	GTFV	GTC
1	Acanthaceae	*Ruellia*	*simplex*	C. Wright	Petunia	Herb	Native	Occasional	Not listed	Ornamental		√
2	Acanthaceae	*Sanchezia*	*nobilis*	Hook.	Zebra plant	Shrub	Exotic	Rare	Not listed	Ornamental		√
3	Amaranthaceae	*Achyranthes*	*aspera var. aspera*	L.	Devil's horsewhip	Herb	Naturalized	Occasional	Not listed	Ecological	√	
4	Amaranthaceae	*Amaranthus*	*viridis*	L.	Calalu	Herb	Exotic	Occasional	Not listed	Food	√	√
5	Anacardiaceae	*Mangifera*	*indica*	L.	Mango	Tree	Introduced	Abundant	Data deficient	Food	√	√
6	Annonaceae	*Annona*	*squamosa*	L.	Sweetsop, Sugar apple	Tree	Cultivated	Occasional	Least concern	Food		√
7	Apocynaceae	*Adenium*	*obesum*	(Forrsk.) Roem. & Schult.	Adenium	Shrub	Exotic	Rare	Least concern	Ornamental		√
8	Apocynaceae	*Allamanda*	*blanchetii*	A. DC.	Purple allamanda	Vine	Exotic	Rare	Not listed	Ornamental		√
9	Apocynaceae	*Calotropis*	*procera*	(Aiton) W.T. Aiton	French Cotton	Shrub	Exotic	Frequent	Not listed	Ecological	√	√
10	Apocynaceae	*Catharanthus*	*roseus*	(L.) G. Don	Periwinkle	Herb	Exotic	Occasional	Not listed	Medicinal		√
11	Apocynaceae	*Nerium*	*oleaner*	L	Oleander	Shrub	Exotic	Frequent	Least concern	Ornamental	√	
12	Apocynaceae	*Pentalinon*	*luteum*	(L.) B.F. Hansen & Wunderlin	Nightshade	Vine	Native	Rare	Not listed	Ornamental	√	
13	Apocynaceae	*Plumeria*	*pudica*	Jacq.	Wild plumeria	Tree	Exotic	Rare	Least concern	Ornamental		√
14	Apocynaceae	*Tabernaemontana*	*divaricata*	(L.) R. Br. ex Roem. & Schult.	Coffee rose	Shrub	Exotic	Rare	Least concern	Ornamental		√
15	Araceae	*Dieffenbachia*	*seguine*	(Jacq.) Schott	Dumb cane	Herb	Native	Rare	Not listed	Ornamental		√
16	Araliaceae	*Polyscias*	*guilfoylei*	(W. Bull) L. H. Bailey	Aralia	Shrub	Exotic	Rare	Not listed	Ornamental		√
17	Araliaceae	*Schefflera*	*actinophylla*	(Endl.) Harms.	Umbrella plant	Tree	Exotic	Rare	Least concern	Ornamental		√

	FAMILY	GENUS	SPECIES	AUTHORITY	COMMON NAME	HABIT	STATUS	DAFOR STATUS	IUCN STATUS	USES/NOTES	GTFV	GTC
18	Arecaceae	*Adonidia*	*merrillii*	(Becc.) Becc.	Christmas Palm	Tree	Exotic	Rare	Vulnerable	Ornamental	√	√
19	Arecaceae	*Cocos*	*nucifera*	L.	Coconut	Tree	Exotic	Occasional	Not listed	Food	√	√
20	Asparagaceae	*Cordyline*	*fruticosa*	(L.) A. Chev.	Dragon's blood	Shrub	Exotic	Occasional	Least concern	Ornamental		√
21	Asteraceae	*Tridax*	*procumbens*	L.	Unknown	Herb	Native	Occasional	Not listed	Ecological		√
22	Boraginaceae	*Cordia*	*dentata*	Poir	Duppy cherry	Tree	Native	Rare	Least concern	Ecological	√	
23	Boraginaceae	*Cordia*	*sebestena*	L.	Scarlet cordia	Tree	Native	Rare	Least concern	Ornamental	√	
24	Boraginaceae	*Ehretia*	*tinifolia*	L.	Bastard cherry	Tree	Native	Occasional	Least concern	Ecological	√	√
25	Boraginaceae	*Heliotropium*	*angiospermum*	Murray	Dog's tail	Herb	Native	Rare	Not listed	Ecological		√
26	Cannaceae	*Canna*	*coccinea*	Mill.	Wild Canna	Herb	Exotic	Rare	Not listed	Ornamental		√
27	Caricaceae	*Carica*	*papaya*	L.	Papaw	Tree	Cultivated	Rare	Data deficient	Food		√
28	Casuarinaceae	*Casuarina*	*equisetifolia*	L.	Casuarina, Willow	Tree	Exotic	Rare	Least concern	Ecological		√
29	Cleomaceae	*Arivela*	*viscosa*	(L.) Raf.	Wild caia	Herb	Exotic	Occasional	Not listed	Ecological		√
30	Cleomaceae	*Cleoserrata*	*speciosa*	(Raf.) Itis	Cleome	Herb	Exotic	Rare	Not listed	Ecological		√
31	Combretaceae	*Laguncularia*	*racemosa*	(L.) Gaertn.	White mangrove	Tree	Native	Frequent	Least concern	Fuel	√	
32	Combretaceae	*Terminalia*	*catappa*	L.	West Indian almond	Tree	Naturalized	Frequent	Least concern	Food	√	√
33	Convolvulaceae	*Ipomoea*	*tiliacea*	(Willd.) Choisy	Wild slip, Wild potato	Vine	Native	Frequent	Least concern	Ecological		√
34	Convolvulaceae	*Merremia*	*dissecta*	(Jacq.) Hallier f.	Know you	Vine	Native	Rare	Not listed	Ecological		√
35	Cucurbitaceae	*Cucurbita*	*pepo*	L.	Pumpkin	Vine	Exotic	Rare	Least concern	Food		√
36	Cyperaceae	*Cyperus*	*odoratus*	L.	Cyperus	Herb	Native	Occasional	Least concern	Ecological		√
37	Cyperaceae	*Fimbristylis*	*dichotoma*	(L.) Vahl	Unknown	Herb	Native	Occasiona	Least	Ecological	√	

	FAMILY	GENUS	SPECIES	AUTHORITY	COMMON NAME	HABIT	STATUS	DAFOR STATUS	IUCN STATUS	USES/NOTES	GTFV	GTC
			subsp. dichotoma					l	concern			
38	Euphorbiaceae	*Codiaeum*	*variegatum*	(L.) Rumph. ex A. Juss.	Croton	Shrub	Exotic	Occasional	Least concern	Ornamental		√
39	Euphorbiaceae	*Euphorbia*	*hirta*	L.	Unknown	Herb	Native	Occasional	Not listed	Ecological	√	
40	Euphorbiaceae	*Euphorbia*	*lactea*	Haw.	Unknown	Shrub	Exotic	Rare	Not listed	Ornamental		√
41	Euphorbiaceae	*Euphorbia*	*lasiocarpa*	Klotzsch	Unknown	Herb	Native	Occasional	Not listed	Ecological	√	
42	Euphorbiaceae	*Euphorbia*	*prostrata*	Aiton	Milkweed	Herb	Native	Occasional	Not listed	Medicinal		√
43	Euphorbiaceae	*Ricinus*	*communis*	L.	Castor Oil tree, Oil nut	Shrub	Exotic	Frequent	Not listed	Medicinal	√	√
44	Fabaceae	*Albizia*	*lebbeck*	(L.) Benth.	Woman's tongue tree	Tree	Exotic	Rare	Least concern	Ecological	√	
45	Fabaceae	*Alysicarpus*	*vaginalis*	(L.) DC.	Medina	Herb	Exotic	Rare	Not listed	Medicinal		√
46	Fabaceae	*Caesalpinia*	*pulcherrima*	(L.) Sw.	Pride of Barbados	Tree	Exotic	Rare	Least concern	Ornamental	√	
47	Fabaceae	*Chamaecrista*	*nictitans subsp. Nictitans var. jaliscensis*	(L.) Moench.	Unknown	Herb	Native	Rare	Least concern	Ecological		√
48	Fabaceae	*Leucaena*	*leucocephala subsp. leucocephala*	(Lam.) de Wit	Lead tree	Tree	Exotic	Frequent	Not listed	Fuel		√
49	Fabaceae	*Macroptilium*	*lathyroides*	(L.) Urb.	Unknown	Herb	Native	Occasional	Not listed	Ecological	√	
50	Fabaceae	*Parkinsonia*	*aculeata*	L.	Jerusalem thorn	Tree	Native	Frequent	Least concern	Ecological		√
51	Fabaceae	*Pithecellobium*	*unguis-cati*	(L.) Benth.	Bread-and-cheese	Shrub	Native	Rare	Least concern	Ornamental		√
52	Fabaceae	*Prosopis*	*juliflora*	(Sw.) DC.	Cashaw	Tree	Exotic	Occasional	Not listed	Fuel	√	√
53	Fabaceae	*Samanea*	*saman*	(Jacq.) Merr.	Guango	Tree	Exotic	Rare	Least concern	Ecological		√

	FAMILY	GENUS	SPECIES	AUTHORITY	COMMON NAME	HABIT	STATUS	DAFOR STATUS	IUCN STATUS	USES/NOTES	GTFV	GTC
54	Fabaceae	*Senna*	*Alata*	(L.) Rocb.	King of the forest	Shrub	Native	Rare	Least concern	Medicinal	√	
55	Fabaceae	*Senna*	*occidentalis*	(L.) Link	Dandelion	Shrub	Native	Rare	Least concern	Medicinal	√	
56	Fabaceae	*Tamarindus*	*indica*	L.	Tamarind	Tree	Exotic	Rare	Least concern	Food		√
57	Lamiaceae	*Plectranthus*	*scutellarioides*	(L.) R. Br.	Joseph Coat	Herb	Exotic	Rare	Not listed	Ornamental	√	
58	Lauraceae	*Persea*	*americana*	Mill.	Pear, avocado	Tree	Exotic	Occasional	Least concern	Food		√
59	Malpighiaceae	*Malpighia*	*emarginata*	Sesse & Moc.	West Indian cherry	Tree	Exotic	Rare	Not listed	Food	√	√
60	Malvaceae	*Abutilon*	*permolle*	(Willd.) Sweet	Unknown	Herb	Native	Occasional	Not listed	Ecological	√	√
61	Malvaceae	*Guazuma*	*ulmifolia*	Lam.	Bastard cedar	Tree	Native	Occasional	Least concern	Ecological		√
62	Malvaceae	*Sida*	*acuta*	Burm.	Broomweed	Herb	Native	Occasional	Not listed	Ecological	√	√
63	Malvaceae	*Sida*	*rhombifolia*	L.	Unknown	Herb	Native	Occasional	Not listed	Ecological	√	√
64	Malvaceae	*Thespesia*	*populnea*	(L.) Sol. ex Correa	Seaside mahoe	Tree	Native	Frequent	Least concern	Ecological	√	
65	Moraceae	*Artocarpus*	*altilis*	(Parkinson) Fosberg	Breatfruit	Tree	Introduced	Abundant	Not listed	Food		√
66	Moringaceae	*Moringa*	*oleifera*	Lam.	Moringa, Horse Radish tree	Tree	Introduced	Frequent	Least concern	Medicinal	√	√
67	Musaceae	*Musa*	*acuminata*	Colla	Banana	Tree	Introduced	Occasional	Least concern	Food		√
68	Myrtaceae	*Psidium*	*guajava*	L.	Guava	Tree	Native	Rare	Least concern	Food		√
69	Myrtaceae	*Syzygium*	*cumini*	(L.) Skeels	Java plum, Ribena	Tree	Exotic	Occasional	Least concern	Food	√	
70	Myrtaceae	*Syzygium*	*malaccense*	(L.) Merr. & L.M. Perry	Otaheite apple	Tree	Exotic	Rare	Least concern	Food		√
71	Nyctaginaceae	*Boerhavia*	*coccinea*	Mill.	Hogweed	Herb	Native	Occasional	Not listed	Ecological	√	√

	FAMILY	GENUS	SPECIES	AUTHORITY	COMMON NAME	HABIT	STATUS	DAFOR STATUS	IUCN STATUS	USES/NOTES	GTFV	GTC
72	Nyctaginaceae	*Boerhavia*	*erecta*	L.	Unknown	Herb	Native	Occasional	Not listed	Ecological	√	
73	Nyctaginaceae	*Bougainvillea*	*glabra*	Choisy	Bougainvillea	Shrub	Exotic	Occasional	Least concern	Ornamental	√	√
74	Oxalidaceae	*Averrhoa*	*carambola*	L.	Star fruit	Tree	Introduced	Rare	Not listed	Food		√
75	Phyllanthaceae	*Phyllanthus*	*amarus*	Shumach. & Thonn.	Carry-me-seed	Herb	Native	Occasional	Not listed	Medicinal	√	√
76	Phytolaccaceae	*Petiveria*	*alliacea*	L.	Guinea hen weed	Herb	Native	Occasional	Not listed	Medicinal		√
77	Poaceae	*Cenchrus*	*echinatus*	L.	Unknown	Herb	Native	Occasional	Least concern	Ecological	√	√
78	Poaceae	*Chloris*	*barbata*	Sw.	Unknown	Herb	Native	Frequent	Not listed	Ecological		√
79	Poaceae	*Chloris*	*radiata*	(L.) Sw.	Unknown	Herb	Native	Occasional	Least concern	Ecological		√
80	Poaceae	*Cynodon*	*dactylon var. dactylon*	(L.) Pers.	Bahama grass	Herb	Exotic	Occasional	Not listed	Ecological		√
81	Poaceae	*Saccharum*	*officinarum*	L.	Cane	Shrub	Cultivated	Rare	Not listed	Food	√	√
82	Polygonaceae	*Antigonon*	*leptopus*	Hook. & Arn.	Coralita, Coralilla	Vine	Exotic	Abundant	Not listed	Medicinal	√	√
83	Polygonaceae	*Coccoloba*	*uvifera*	(L.) L.	Seaside grape	Tree	Native	Rare	Least concern	Food		√
84	Portulacaceae	*Portulaca*	*oleracea*	L.	Pussley	Herb	Native	Occasional	Least concern	Medicinal	√	√
85	Rhamnaceae	*Ziziphus*	*mauritiana*	Lam.	Coolie plum, Crab plum	Tree	Exotic	Frequent	Least concern	Food	√	√
86	Rubiaceae	*Ixora*	*coccinea*	L.	Ixora	Shrub	Exotic	Occasional	Not listed	Ornamental		√
87	Rubiaceae	*Morinda*	*citrifolia*	L.	Noni, Hog apple	Tree	Exotic	Frequent	Not listed	Medicinal	√	√
88	Rutaceae	*Citrus*	*aurantifolia*	(Christm.) Swingle	Lime	Tree	Exotic	Occasional	Not listed	Food		√
89	Rutaceae	*Murraya*	*paniculata*	(L.) Jack.	Murraya	Shrub	Exotic	Occasional	Not listed	Ornamental		√
90	Sapindaceae	*Blighia*	*sapida*	K.D. Koenig	Ackee	Tree	Introduced	Frequent	Least concern	Food	√	√
91	Sapindaceae	*Melicoccos*	*bijugatus*	Jacq.	Genip,	Tree	Introduce	Frequent	Least	Food	√	√

	FAMILY	GENUS	SPECIES	AUTHORITY	COMMON NAME	HABIT	STATUS	DAFOR STATUS	IUCN STATUS	USES/NOTES	GTFV	GTC
					Guinep		d		concern			
92	Sapotaceae	*Chrysophyllum*	*cainito*	L.	Star apple	Tree	Exotic	Rare	Least concern	Food		√
93	Typhaceae	*Typha*	*domingensis*	Pers.	Reedmace	Shrub	Native	Rare	Least concern	Ecological		√
94	Vitaceae	*Cissus*	*verticillata subsp. verticillata*	(L.) Nicolson & C. E. Jarvis	Pudding wiss	Vine	Native	Rare	Least concern	Ecological		√
95	Xanthorrhoeaceae	*Aloe*	*vera*	(L.) Burm.	Aloe vera, Sinkle bible	Herb	Exotic	Rare	Not listed	Medicinal	√	√
96	Zygophyllaceae	*Guaiacum*	*officinale*	L.	Lignum vitae	Tree	Native	Occasional	Endangered	Ornamental		√
97	Zygophyllaceae	*Kallstroemia*	*maxima*	(L.) Hook. & Arn,	Police macca	Herb	Native	Occasional	Not listed	Ecological	√	√

GTFV = Greenwich Town Fishing Village, GTC = Greenwich Town Community

14.4 **Appendix 4 -** Plant Checklist of the Gordon Town and associated communities in the middle elevation zone.

	FAMILY	GENUS	SPECIES	AUTHORITY	COMMON NAME	HABIT	STATUS	DAFOR STATUS	IUCN STATUS	USES/NOTES	GT 1	GT 2	GT 3
1	Acanthaceae	*Asystasia*	*gangetica*	(L.) T. Anderson	Chinese violet	Herb	Exotic	Occasional	Not listed	Ecological	√		
2	Acanthaceae	*Brillantaisia*	*owariensis*	P. Beauv.	Brillantaisia	Shrub	Exotic	Dominant	Least concern	Ornamental	√	√	
3	Acanthaceae	*Odontonema*	*cuspidatum*	(Nees) Kuntze	None	Shrub	Exotic	Occasional	Not listed	Ornamental		√	
4	Acanthaceae	*Sanchezia*	*nobilis*	Hook.	Zebra plant	Shrub	Exotic	Rare	Not listed	Ornamental		√	
5	Acanthaceae	*Thunbergia*	*alata*	Bojer ex Sims	Black-eye-susan	Vine	Exotic	Occasional	Not listed	Medicinal	√		
6	Anacardiaceae	*Comocladia*	*pinnatifolia*	L.	Maiden plum	Tree	Native	Frequent	Not listed	Ecological	√		√
7	Anacardiaceae	*Mangifera*	*indica*	L.	Mango	Tree	Introduced	Abundant	Data deficient	Food	√	√	
8	Apocynaceae	*Allamanda*	*blanchetii*	A. DC.	Purple allamanda	Vine	Exotic	Rare	Not listed	Ornamental			√
9	Apocynaceae	*Allamanda*	*cathartica*	L.	Yellow allamanda	Vine	Exotic	Occasional	Not listed	Ornamental			√
10	Apocynaceae	*Asclepias*	*curassavica*	L.	Redhead	Herb	Native	Occasional	Not listed	Medicinal	√		√
11	Apocynaceae	*Catharanthus*	*roseus*	(L.) G. Don	Periwinkle	Herb	Exotic	Occasional	Not listed	Medicinal		√	
12	Apocynaceae	*Pentalinon*	*luteum*	(L.) B.F. Hansen & Wunderlin	Nightshade	Vine	Native	Rare	Not listed	Ornamental	√		
13	Araliaceae	*Oreopanax*	*capitatus*	(Jacq.) Decn. & Planch	Woman wood	Tree	Native	Occasional	Least concern	Ecological		√	√
14	Araceae	*Alocasia*	*macrorrhizos*	(L.) G. Don	Scratch coco	Herb	Exotic	Frequent	Not listed	Ecological	√		
15	Araceae	*Anthurium*	*grandifolium*	(Jacq.) Kunth	Wild coco, Junction root	Herb	Native	Frequent	Not listed	Ecological		√	√
16	Araceae	*Epipremnum*	*pinnatum*	Nicolson	Devil's ivy	Vine	Exotic	Occasional	Not listed	Ornamental	√		√
17	Araceae	*Syngonium*	*auritum*	(L.) Schott.	Five-finger	Vine	Native	Rare	Not listed	Ecological			√
18	Araceae	*Syngonium*	*podophyllum*	Schott	Five-finger	Vine	Exotic	Rare	Not listed	Ecological			√
19	Arecaceae	*Acrocromia*	*aculeata*	(Jacq.) Lodd. ex Mart.	Maccafat	Tree	Native	Occasional	Least concern	Ecological	√		
20	Arecaceae	*Adonidia*	*merrillii*	(Becc.) Becc.	Christmas	Tree	Exotic	Rare	Vulnerable	Ornamental		√	

	FAMILY	GENUS	SPECIES	AUTHORITY	COMMON NAME	HABIT	STATUS	DAFOR STATUS	IUCN STATUS	USES/NOTES	GT 1	GT 2	GT 3
					Palm								
21	Arecaceae	*Cocos*	*nucifera*	L.	Coconut	Tree	Exotic	Occasional	Not listed	Food		√	
22	Arecaceae	*Roystonea*	*altissima*	(Mill.) H.E. Moore	Mountain cabbage	Tree	Endemic	Occasional	Not listed	Ecological		√	
23	Asparagaceae	*Agave*	*morrisii*	Baker	May pole	Shrub	Native	Occasional	Not listed	Ecological		√	
24	Asparagaceae	*Sansevieria*	*hyacinthoides*	(L.) Druce	Mother-in-law's tongue	Herb	Exotic	Occasional	Not listed	Ornamental		√	
25	Aspleniaceae	*Thelypteris*	*dentata*	(Forssk.) E.P.St. John	Downy maiden fern	Shrub	Exotic	Occasional	Least concern	Ecological		√	√
26	Asteraceae	*Bidens*	*cynapiifolia*	Kunth	Spanish needle	Herb	Native	Occasional	Not listed	Ecological		√	√
27	Asteraceae	*Bidens*	*pilosa var. pilosa*	L.	Spanish needle	Herb	Native	Occasional	Not listed	Medicinal	√	√	√
28	Asteraceae	*Bidens*	*reptans var. reptans*	(L.) G. Don	McKatty weed	Herb	Native	Occasional	Not listed	Medicinal		√	
29	Asteraceae	*Chromolaena*	*odorata*	(L.) R.M. King & H. Rob.	Jack-in-the-bush	Herb	Native	Frequent	Not listed	Medicinal	√		
30	Asteraceae	*Emilia*	*fosbergii*	Nicolson	Tassel flower	Herb	Exotic	Occasional	Not listed	Medicinal			√
31	Asteraceae	*Lepidaploa*	*acuminata*	(Less.) H. Rob.		Shrub	Endemic	Frequent	Not listed	Ecological			√
32	Asteraceae	*Mikania*	*micrantha*	Kunth	Guaco	Vine	Native	Frequent	Not listed	Medicinal	√	√	√
33	Asteraceae	*Tithonia*	*diversifolia*	(Hemsl.) A. Gray	Mexican Sunflower	Shrub	Exotic	Frequent	Not listed	Ornamental	√		
34	Asteraceae	*Tridax*	*procumbens*	L.	None	Herb	Native	Occasional	Not listed	Ecological	√		
35	Asteraceae	*Zemisia*	*discolor*	(Sw.) B. Nord.	Whiteback	Shrub	Endemic	Occasional	Not listed	Ecological		√	
36	Begoniaceae	*Begonia*	*glabra*	Aubl.	Begonia	Vine	Native	Occasional	Not listed	Ecological			√
37	Bignoniaceae	*Catalpa*	*longissima*	(Jacq.) Dum. Cours.	Yoke wood	Tree	Native	Occasional	Not listed	Ecological	√		
38	Boraginaceae	*Tournefortia*	*hirsutissima*	L.	Cold withe	Shrub	Native	Occasional	Not listed	Medicinal	√		
39	Bromeliaceae	*Tillandsia*	*recurvata*	(L.) L.	Ball moss	Herb	Native	Rare	Not listed	Medicinal		√	
40	Bromeliaceae	*Tillandsia*	*usneoides*	(L.) L.	Old man's beard	Herb	Native	Frequent	Least concern	Medicinal		√	
41	Bromeliaceae	*Tillandsia*	*utriculata*	L.	Wild pine	Herb	Native	Rare	Not listed	Ecological		√	
42	Campanulaceae	*Spathodea*	*campanulata*	P. Beauv.	African tulip tree	Tree	Exotic	Occasional	Least concern	Medicinal		√	

	FAMILY	GENUS	SPECIES	AUTHORITY	COMMON NAME	HABIT	STATUS	DAFOR STATUS	IUCN STATUS	USES/NOTES	GT 1	GT 2	GT 3
43	Cactaceae	*Hylocereus*	*triangularis*	(L.) Britton & Rose	God okra	Vine	Native	Occasional	Least concern	Ecological	√	√	
44	Cactaceae	*Rhipsalis*	*baccifera*	(J.S. Muell.) Stearn	Currant cactus	Herb	Native	Occasional	Least concern	Ecological		√	
45	Capparaceae	*Cynophalla*	*flexuosa*	(L.) J. Presl	Bottle-cod root	Shrub	Native	Occasional	Least concern	Ecological	√		
46	Caricaceae	*Carica*	*papaya*	L.	Papaya	Tree	Exotic	Rare	Data deficient	Food	√		
47	Clusiaceae	*Clusia*	*sp.*	Unknown		Tree	Native	Occasional	Unknown	Ecological		√	√
48	Combretaceae	*Conocarpus*	*erectus var. sericeus*	E. Forst. ex DC	Silver Button mangrove	Shrub	Native	Rare	Least concern	Ornamental	√		
49	Commeliniaceae	*Callisia*	*fragrans*	(Lindl.) Woodson	None	Herb	Exotic	Frequent	Not listed	Invasive	√	√	
50	Commeliniaceae	*Commelina*	*erecta var. erecta*	L.	Watergrass	Herb	Native	Occasional	Least concern	Medicinal		√	
51	Commeliniaceae	*Tradescantia*	*zebrina*	Heynh. ex Bosse	Water grass	Herb	Exotic	Occasional	Not listed	Ornamental			√
52	Convolvulaceae	*Cuscuta*	*americana*	L.	Dodder, Love bush	Vine	Native	Rare	Not listed	Ecological	√		
53	Cucurbitaceae	*Cucurbita*	*pepo*	L.	Pumpkin	Vine	Exotic	Rare	Least concern	Food	√		
54	Cyclanthaceae	*Carludovica*	*palmata*	Ruiz & Pav.	Jjippi Jappa	Shrub	Exotic	Occasional	Least concern	Craft		√	
55	Cyperaceae	*Cyperus*	*involuvcratus*	Rottb.	Cyperus	Herb	Exotic	Abundant	Least concern	Ecological	√	√	√
56	Euphorbiaceae	*Acalypha*	*wilkesiana*	Mull. Arg.	Jacob's coat	Shrub	Exotic	Rare	Not listed	Ornamental			√
57	Euphorbiaceae	*Alchornea*	*latifolia*	Sw.	Dove wood	Tree	Native	Occasional	Least concern	Ecological			√
58	Euphorbiaceae	*Codiaeum*	*variegatum*	(L.) Rumph. ex A. Juss.	Croton	Shrub	Exotic	Occasional	Least concern	Ornamental		√	
59	Euphorbiaceae	*Euphorbia*	*hypericifolia*	L.	Unknown	Herb	Native	Occasional	Not listed	Ecological			√
60	Euphorbiaceae	*Euphorbia*	*lactea*	Haw.	None	Shrub	Exotic	Rare	Not listed	Ornamental	√		
61	Euphorbiaceae	*Jatropha*	*curcas*	L.	Physic nut	Shrub	Native	Rare	Least concern	Ornamental		√	
62	Euphorbiaceae	*Jatropha*	*podagrica*	Hook.	None	Herb	Exotic	Rare	Not listed	Ornamental			√
63	Euphorbiaceae	*Ricinus*	*communis*	L.	Castor Oil	Shrub	Exotic	Frequent	Not listed	Medicinal		√	

	FAMILY	GENUS	SPECIES	AUTHORITY	COMMON NAME	HABIT	STATUS	DAFOR STATUS	IUCN STATUS	USES/NOTES	GT 1	GT 2	GT 3
					tree, Oil nut								
64	Fabaceae	*Abrus*	*precatorius*	L.	John crow bead	Vine	Exotic	Rare	Not listed	Ecological		√	
65	Fabaceae	*Adenanthera*	*pavonina*	L.	Red bead tree	Tree	Exotic	Occasional	Least concern	Ecological	√		
66	Fabaceae	*Bauhinia*	*purpurea*	L.	Poor man's orchid	Tree	Exotic	Rare	Least concern	Ornamental	√		
67	Fabaceae	*Calliandra*	*houstoniana var. calothyrsus*	(Meisn.) Barneby	Calliandra	Tree	Exotic	Abundant	Least concern	Ecological	√	√	
68	Fabaceae	*Cajanus*	*cajan*	(L.) Huth	Gungo peas	Shrub	Exotic	Occasional	Not listed	Food			√
69	Fabaceae	*Cojoba*	*arborea*	(L.) Britton & Rose	Wild tamarind	Tree	Native	Occasional	Least concern	Ecological		√	
70	Fabaceae	*Pachyrhizus*	*erosus*	(L.) Urb.	Unknown	Vine	Exotic	Frequent	Not listed	Ecological	√	√	
71	Fabaceae	*Piscidia*	*piscipula*	(L.) Sarg.	Jamaican dogwood	Tree	Native	Occasional	Least concern	Lumber	√	√	√
72	Gesneriaceae	*Achimenes*	*erecta*	(Lam.) H.P. Fuchs	Cupid's bower	Herb	Exotic	Frequent	Not listed	Ecological		√	√
73	Gesneriaceae	*Gesneria*	*exserta*	Sw.	None	Tree	Endemic	Occasional	Least concern	Ecological		√	√
74	Gesneriaceae	*Rhytidophyllum*	*tomentosum*	(L.) Mart.	Search-mi-heart	Shrub	Native	Occasional	Not listed	Medicinal		√	
75	Heliconiaceae	*Heliconia*	*caribaea*	Lam.	Wild plantain	Shrub	Native	Rare	Not listed	Ornamental		√	
76	Lamiaceae	*Holmskioldia*	*sanguinea*	Retz.	Mandarin hat	Shrub	Exotic	Occasional	Not listed	Ornamental	√		
77	Lamiaceae	*Leonotis*	*nepetifolia*	(L.) R. Br.	Christmas candlestick	Shrub	Exotic	Rare	Not listed	Ecological			√
78	Lauraceae	*Persea*	*americana*	Mill.	Pear, avocado	Tree	Exotic	Occasional	Least concern	Food		√	√
79	Malvaceae	*Guazuma*	*ulmifolia*	Lam.	Bastard cedar	Tree	Native	Occasional	Least concern	Ecological	√		
80	Malvaceae	*Hibiscus*	*elatus*	Sw.	Blue mahoe	Tree	Native	Occasional	Least concern	Lumber			√
81	Malvaceae	*Hibiscus*	*poeppigii*	(Spreng.) Garcke	Wild hibiscus	Shrub	Native	Occasional	Not listed	Ecological			√
82	Meliaceae	*Cedrela*	*odorata*	L.	West Indian Cedar	Tree	Native	Occasional	Vulnerable	Lumber		√	
83	Melastomataceae	*Blakea*	*trinervia*	L.	Jamaican	Vine	Endemic	Occasional	Not listed	Ecological			√

	FAMILY	GENUS	SPECIES	AUTHORITY	COMMON NAME	HABIT	STATUS	DAFOR STATUS	IUCN STATUS	USES/NOTES	GT 1	GT 2	GT 3
					Rose								
84	Moraceae	*Castilla*	*elastica var. elastica*	Cerv.	Rubber tree	Tree	Exotic	Frequent	Least concern	Ecological	√		
85	Moraceae	*Artocarpus*	*altilis*	(Parkinson) Fosberg	Breatfruit	Tree	Introduced	Abundant	Not listed	Food		√	
86	Moraceae	*Ficus*	*americana subsp. americana*	*Aubl.*	Jamaican cherry fig	Tree	Native	Occasional	Least concern	Ecological		√	
87	Moraceae	*Ficus*	trigonata	L.	Fig	Tree	Native	Occasional	Least concern	Ecological		√	
88	Musaceae	*Musa*	*acuminata*	Colla	Banana	Tree	Introduced	Occasional	Least concern	Food		√	
89	Myrtaceae	*Pimenta*	*dioica*	(L.) Merr. & L.M. Perry	Pimento	Tree	Native	Occasional	Least concern	Food			√
90	Myrtaceae	*Psidium*	*guajava*	L.	Guava	Tree	Native	Rare	Least concern	Food		√	√
91	Nyctaginaceae	*Bougainvillea*	*glabra*	Choisy	Bougainvillea	Shrub	Exotic	Occasional	Least concern	Ornamental		√	
92	Orchidaceae	*Trichocentrum*	*undulatum*	(Sw.) Ackerman & N.H. Chase	Brown gal	Herb	Native	Rare	Not listed	Ornamental	√		
93	Papaveraceae	*Bocconia*	*frutescens*	L.	John crow bush	Tree	Native	Frequent	Least concern	Ecological			√
94	Passifloraceae	*Passiflora*	*edulis*	Sims	Passion fruit	Vine	Exotic	Occasional	Not listed	Food	√		
95	Phytolaccaceae	*Trichostigma*	*octandrum*	(L.) H. Walter	Hoop withe, Basket withe	Shrub	Native	Occasional	Least concern	Ecological	√		
96	Pinaceae	*Pinus*	*sp.*	Unknown	Pine	Tree	Exotic	Abundant	Unknown	Lumber		√	√
97	Piperaceae	*Piper*	*aduncum var. aduncum*	L.	None	Shrub	Native	Frequent	Least concern	Medicinal			√
98	Piperaceae	*Piper*	*amalago var. amalago*	L.	Black jointa	Shrub	Native	Occasional	Least concern	Medicinal	√		
99	Piperaceae	*Piper*	*hispidum*	Sw.	None	Shrub	Native	Frequent	Least concern	Ecological		√	√
100	Piperaceae	*Piper*	*umbellatum*	L.	Cow foot	Shrub	Native	Occasional	Not listed	Medicinal			√
101	Plantaginaceae	*Russelia*	*equisetiformis*	Schltdl. & Cham.	Hummingbird bush	Shrub	Exotic	Rare	Not listed	Ornamental			√
102	Poaceae	*Arundo*	*donax*	L.	Giant reed	Shrub	Exotic	Abundant	Least concern	Invasive	√	√	√

	FAMILY	GENUS	SPECIES	AUTHORITY	COMMON NAME	HABIT	STATUS	DAFOR STATUS	IUCN STATUS	USES/NOTES	GT 1	GT 2	GT 3
103	Poaceae	*Bambusa*	*vulgaris*	Schrad. ex H.L. Wendl.	Bamboo	Shrub	Exotic	Frequent	Not listed	Invasive	√		
104	Poaceae	*Cenchrus*	*purpureus*	(Schumach.) Morrone	Elephant grass	Herb	Exotic	Dominant	Least concern	Invasive	√	√	√
105	Poaceae	*Cynodon*	*dactylon var. dactylon*	(L.) Pers.	Bahama grass	Herb	Exotic	Occasional	Not listed	Ecological	√		
106	Poaceae	*Megathyrsus*	*maximus*	(Jacq.) B.K. Simon & S.W.L. Jacobs	Guinea grass	Herb	Exotic	Frequent	Not listed	Invasive	√		
107	Polygonaceae	*Antigonon*	*leptopus*	Hook. & Arn.	Coralita, Coralilla	Vine	Exotic	Abundant	Not listed	Medicinal	√		
108	Polygonaceae	*Coccoloba*	*diversifolia*	Jacq.	Mountain grape	Tree	Native	Rare	Least concern	Ecological		√	
109	Polypodiaceae	*Pleopeltis*	*polypodioides*	(L.) E.G. Andrews & Windham	Resurrection fern	Herb	Native	Frequent	Not listed	Medicinal		√	
110	Pteridaceae	*Adiantum*	*tenerum*	Sw.	Maiden hair fern	Herb	Native	Occasional	Not listed	Ecological	√	√	
111	Rosaceae	*Rosa*	*indica*	L.	Rose	Shrub	Exotic	Rare	Not listed	Ornamental			√
112	Rosaceae	*Rubus*	*ellipticus*	Sm.	Cheeseberry	Shrub	Exotic	Occasional	Least concern	Food			√
113	Rubiaceae	*Coffea*	*arabica*	L.	Coffee	Shrub	Exotic	Frequent	Endangered	Food			√
114	Rubiaceae	*Spermacoce*	*laevis*	Lam.	Buttonweed	Herb	Native	Frequent	Least concern	Medicinal		√	√
115	Rutaceae	*Murraya*	*paniculata*	(L.) Jacq.	Murraya	Shrub	Exotic	Rare	Not listed	Ornamental	√	√	
116	Sapindaceae	*Allophylus*	*cominia var. cominia*	(L.) Sw.	None	Tree	Native	Occasional	Least concern	Ecological			√
117	Sapindaceae	*Blighia*	*sapida*	K.D. Koenig	Ackee	Tree	Introduced	Frequent	Least concern	Food	√	√	√
118	Sapindaceae	*Melicoccos*	*bijugatus*	Jacq.	Genip, Guinep	Tree	Introduced	Frequent	Least concern	Food	√		
119	Sapotaceae	*Chrysophyllum*	*cainito*	L.	Star apple	Tree	Exotic	Rare	Least concern	Food	√		
120	Simaroubaceae	*Bursera*	*simaruba*	(L.) Sarg.	Red birch	Tree	Native	Occasional	Least concern	Ecological			√
121	Simaroubaceae	*Simarouba*	*glauca*	DC.	Bitter Damsel	Tree	Native	Occasional	Least concern	Ecological		√	√

	FAMILY	GENUS	SPECIES	AUTHORITY	COMMON NAME	HABIT	STATUS	DAFOR STATUS	IUCN STATUS	USES/NOTES	GT 1	GT 2	GT 3
122	Solanaceae	*Brugmansia*	*suaveolens*	(Humb. & Bonpl. ex Willd.) Sweet	Angel's trumpet	Tree	Exotic	Abundant	Extinct in the wild	Ornamental	√	√	√
123	Solanaceae	*Solanum*	*torvum*	Sw.	Susumber, Gully bean	Shrub	Native	Occasional	Not listed	Food		√	√
124	Streliziaceae	*Ravenala*	*madagascariensis*	J.F Gmel.	Traveller's palm	Tree	Exotic	Rare	Least concern	Ornamental			√
125	Urticaceae	*Boehmeria*	*jamaicensis*	Urb.	Doctor johnson	Shrub	Endemic	Occasional	Least concern	Medicinal			√
126	Urticaceae	*Cecropia*	*peltata*	L.	Trumpet tree	Tree	Native	Occasional	Least concern	Ecological		√	√
127	Verbenaceae	*Lantana*	*camara*	L.	Sage	Shrub	Native	Occasional	Not listed	Medicinal			√
128	Verbenaceae	*Lantana*	*fucata*	Lindl.	None	Herb	Native	Rare	Not listed	Ecological		√	
129	Vitaceae	*Cissus*	*verticillata subsp. verticillata*	(L.) Nicolson & C. E. Jarvis	Pudding wiss	Vine	Native	Rare	Least concern	Ecological	√	√	
130	Zingiberaceae	*Alpinia*	*purpurata*	(Vieill.) K. Schum.	Red ginger lily	Herb	Exotic	Occasional	Not listed	Ornamental			√
131	Zingiberaceae	*Hedychium*	*coronarium*	J. Koenig	White giinger lily	Shrub	Exotic	Frequent	Data deficient	Ornamental		√	√

14.5 Appendix 5 - Plant Checklist of the Woodford and associated communities in the upper elevation zone.

	FAMILY	GENUS	SPECIES	AUTHORITY	COMMON NAME	HABIT	STATUS	DAFOR STATUS	IUCN STATUS	USES/NOTES	WF 1	WF 2	WF 3
1	Acanthaceae	*Asystasia*	*gangetica*	(L.) T. Anderson	Chinese violet	Herb	Exotic	Occasional	Not listed	Invasive	√		
2	Acanthaceae	*Brillantaisia*	*owariensis*	P. Beauv.	Brillantaisia	Shrub	Exotic	Dominant	Least concern	Ornamental	√	√	√
3	Acanthaceae	*Pachystachys*	*spicata*	(Ruiz & Pav.) Wassh.	Cardinal's guard	Shrub	Native	Occasional	Not listed	Ecological			√
4	Acanthaceae	*Sanchezia*	*nobilis*	Hook.	Zebra plant	Shrub	Exotic	Rare	Not listed	Ornamental	√		√
5	Acanthaceae	*Thunbergia*	*alata*	Bojer ex Sims	Black-eye-susan	Vine	Exotic	Occasional	Not listed	Medicinal	√		
6	Anacardiaceae	*Mangifera*	*indica*	L.	Mango	Tree	Introduced	Abundant	Data deficient	Food	√		√
7	Apocynaceae	*Allamanda*	*cathartica*	L.	Yellow allamada	Vine	Exotic	Occasional	Not listed	Ornamental			√
8	Apocynaceae	*Asclepias*	*curassavica*	L.	Redhead	Herb	Native	Occasional	Not listed	Medicinal	√	√	
9	Apocynaceae	*Catharanthus*	*roseus*	(L.) G. Don	Periwinkle	Herb	Exotic	Occasional	Not listed	Medicinal			√
10	Apocynaceae	*Pentalinon*	*luteum*	(L.) B.F. Hansen & Wunderlin	Nightshade	Vine	Native	Rare	Not listed	Ornamental	√		
11	Araceae	*Alocasia*	*macrorrhizos*	(L.) G. Don	Scratch coco	Herb	Exotic	Frequent	Not listed	Invasive	√	√	√
12	Araceae	*Colocasia*	*esculenta*	(L.) Schott.	Dasheen	Herb	Exotic	Frequent	Least concern	Food			√
13	Araceae	*Epipremnum*	*pinnatum*	Nicolson	Devil's ivy	Vine	Exotic	Occasional	Not listed	Ornamental	√	√	
14	Araceae	*Philodendron*	*lacerum*	(Jacq.) Schott	Wicker	Vine	Native	Rare	Not listed	Craft			√
15	Araceae	*Syngonium*	*auritum*	(L.) Schott.	Five finger	Vine	Native	Rare	Not listed	Ecological			√
16	Araceae	*Xanthosoma*	*sagittifolium*	(L.) Schott.	Coco	Herb	Exotic	Frequent	Not listed	Food		√	
17	Arecaceae	*Adonidia*	*merrillii*	(Becc.) Becc.	Christmas Palm	Tree	Exotic	Rare	Vulnerable	Ornamental	√		
18	Arecaceae	*Cocos*	*nucifera*	L.	Coconut	Tree	Exotic	Occasional	Not listed	Food	√		
19	Asparagaceae	*Cordyline*	*fruticosa*	(L.) A. Chev.	Dragon's blood	Shrub	Exotic	Occasional	Least concern	Ornamental			√
20	Asparagaceae	*Furcraea*	*sp.*	Unknown	Unknown	Shrub	Unknown	Occasional	Unknown	Ornamental			√

21	Asparagaceae	*Sansevieria*	*hyacinthoides*	(L.) Druce	Mother-in-law's tongue	Herb	Exotic	Occasional	Not listed	Ornamental			√
22	Asteraceae	*Acmella*	*uliginosa*	(Sw.) Cass.	Marsh para cress	Herb	Native	Occasional	Least concern	Ecological	√		
23	Asteraceae	*Bidens*	*pilosa var. pilosa*	L.	Spanish needle	Herb	Native	Occasional	Not listed	Medicinal	√		
24	Asteraceae	*Bidens*	*reptans var. reptans*	(L.) G. Don	McKatty weed	Herb	Native	Occasional	Not listed	Medicinal	√		
25	Asteraceae	*Chromolaena*	*odorata*	(L.) R.M. King & H. Rob.	Jack-in-the-bush	Herb	Native	Frequent	Not listed	Medicinal		√	
26	Asteraceae	*Emilia*	*fosbergii*	Nicolson	Tassel flower	Herb	Exotic	Occasional	Not listed	Medicinal	√		
27	Asteraceae	*Lepidaploa*	*acuminata*	(Less.) H. Rob.	Unknown	Shrub	Endemic	Frequent	Not listed	Ecological			√
28	Asteraceae	*Mikania*	*micrantha*	Kunth	Guaco	Vine	Native	Frequent	Not listed	Medicinal	√	√	√
29	Asteraceae	*Pseudelephantopus*	*spicatus*	(B. Juss. ex Aubl.) C.F. Baker	Packy weed	Herb	Native	Rare	Not listed	Medicinal		√	
30	Asteraceae	*Sphagneticola*	*trilobata*	(L.) Pruski	Marighoule	Herb	Exotic	Abundant	Not listed	Invasive	√	√	
31	Asteraceae	*Tridax*	*procumbens*	L.	unknown	Herb	Native	Occasional	Not listed	Ecological		√	
32	Asteraceae	*Zemisia*	*discolor*	(Sw.) B. Nord.	Whiteback	Shrub	Endemic	Occasional	Not listed	Ecological	√		
33	Begoniaceae	*Begonia*	*sp.*	Unknown	Begonia	Vine	Unknown	Occasional	Unknown	Ecological		√	
34	Bignoniaceae	*Catalpa*	*longissima*	(Jacq.) Dum. Cours.	Yoke wood	Tree	Native	Occasional	Not listed	Ecological			√
35	Boraginaceae	*Heliotropium*	*angiospermum*	Murray	Dog's tail	Herb	Native	Rare	Not listed	Medicinal			√
36	Boraginaceae	*Varronia*	*linnaei*	(Stearn) J.S. Miller	Unknown	Shrub	Native	Rare	Not listed	Ecological		√	
37	Bromeliaceae	*Hohenbergia*	*sp.*	Unknown	Wild pine	Shrub	Native	Occasional	Unknown	Ecological	√		
38	Bromeliaceae	*Tillandsia*	*sp.*	Unknown	Wild pine	Herb	Unknown	Rare	Unknown	Ecological			√
39	Campanulaceae	*Spathodea*	*campanulata*	P. Beauv.	African tulip tree	Tree	Exotic	Occasional	Least concern	Medicinal		√	√
40	Cactaceae	*Hylocereus*	*triangularis*	(L.) Britton & Rose	God okra	Vine	Native	Occasional	Least concern	Ecological			√
41	Cactaceae	*Rhipsalis*	*baccifera*	(J.S. Muell.) Stearn	Currant cactus	Herb	Native	Occasional	Least concern	Ecological			√
42	Cannaceae	*Canna*	*coccinea*	Mill.	Wild Canna	Herb	Exotic	Rare	Not listed	Ornamental		√	
43	Commeliniaceae	*Commelina*	*erecta var. erecta*	L.	Watergrass	Herb	Native	Occasional	Least concern	Medicinal	√		
44	Commeliniaceae	*Tradescantia*	*zebrina*	Heynh. ex Bosse	Water grass	Herb	Exotic	Occasional	Not listed	Ornamental		√	

45	Convolvulaceae	*Ipomoea*	*tiliacea*	(Willd.) Choisy	Wild slip, Wild potato	Vine	Native	Frequent	Least concern	Ecological		√	
46	Cucurbitaceae	*Cucurbita*	*pepo*	L.	Pumpkin	Vine	Exotic	Rare	Least concern	Food		√	
47	Cucurbitaceae	*Momordica*	*charantia*	L.	Cerasee	Vine	Exotic	Rare	Not listed	Medicinal		√	
48	Cyperaceae	*Cyperus*	*involuvcratus*	Rottb.	Cyperus	Herb	Exotic	Abundant	Least concern	Ecological	√	√	
49	Cyperaceae	*Kyllinga*	*brevifolia*	Rottb.	Unknown	Herb	Native	Occasional	Least concern	Ecological			
50	Euphorbiaceae	*Acalypha*	*wilkesiana*	Mull. Arg.	Jacob's coat	Shrub	Exotic	Rare	Not listed	Ornamental	√		√
51	Euphorbiaceae	*Codiaeum*	*variegatum*	(L.) Rumph. ex A. Juss.	Croton	Shrub	Exotic	Occasional	Least concern	Ornamental	√		
52	Euphorbiaceae	*Euphorbia*	*hirta*	L.	Unknown	Herb	Native	Occasional	Not listed	Ecological	√		
53	Euphorbiaceae	*Ricinus*	*communis*	L.	Castor Oil tree, Oil nut	Shrub	Exotic	Frequent	Not listed	Medicinal	√		√
54	Fabaceae	*Adenanthera*	*pavonina*	L.	Red bead tree	Tree	Exotic	Occasional	Least concern	Invasive			√
55	Fabaceae	*Bauhinia*	*purpurea*	L.	Poor man's orchid	Tree	Exotic	Rare	Least concern	Ornamental	√		√
56	Fabaceae	*Calliandra*	*houstoniana var. calothyrsus*	(Meisn.) Barneby	Calliandra	Tree	Exotic	Abundant	Least concern	Ecological	√		
57	Fabaceae	*Canavalia*	*ensiformis*	(L.) DC.	Overlook bean	Vine	Exotic	Rare	Not listed	Ecological			√
58	Fabaceae	*Cojoba*	*arborea*	(L.) Britton & Rose	Wild tamarind	Tree	Native	Occasional	Least concern	Ecological			√
59	Fabaceae	*Desmodium*	*incanun*	DC.		Herb	Native	Occasional	Not listed	Ecological		√	
60	Fabaceae	*Gliricidia*	*sepium*	(Jacq.) Kunth	Aaron's rod, Quick stick	Tree	Exotic	Frequent	Least concern	Ecological	√	√	
61	Fabaceae	*Mimosa*	*pudica var. pudica*	L.	Shame weed	Herb	Native	Occasional	Least concern	Medicinal	√		
62	Fabaceae	*Pachyrhizus*	*erosus*	(L.) Urb.	Unknown	Vine	Exotic	Frequent	Not listed	Ecological	√		
63	Gesneriaceae	*Rhytidophyllum*	*tomentosum*	(L.) Mart.	Search-mi-heart	Shrub	Native	Occasional	Not listed	Medicinal		√	
64	Heliconiaceae	*Heliconia*	*caribaea*	Lam.	Wild plantain	Shrub	Native	Rare	Not listed	Ornamental			√
65	Lamiaceae	*Holmskioldia*	*sanguinea*	Retz.	Mandarin hat	Shrub	Exotic	Occasional	Not listed	Ornamental	√		
66	Lamiaceae	*Hyptis*	*capitata*	Jacq.	Iron wort	Herb	Native	Occasional	Not listed	Ecological	√		
67	Lamiaceae	*Hyptis*	*verticillata*	Jacq.	John Charles	Shrub	Native	Occasional	Not listed	Medicinal		√	

68	Lamiaceae	*Leonotis*	*nepetifolia*	(L.) R. Br.	Christmas candlestick	Shrub	Exotic	Rare	Not listed	Ecological	√		
69	Lamiaceae	*Plectranthus*	*scutellarioides*	(L.) R. Br.	Joseph Coat	Herb	Exotic	Rare	Not listed	Ornamental	√		
70	Lauraceae	*Persea*	*americana*	Mill.	Pear, avocado	Tree	Exotic	Occasional	Least concern	Food	√		
71	Loganiaceae	*Spigelia*	*anthelmia*	L.	Worm grass	Herb	Native	Rare	Not listed	Medicinal		√	
72	Malvaceae	*Guazuma*	*ulmifolia*	Lam.	Bastard cedar	Tree	Native	Occasional	Least concern	Ecological	√		
73	Malvaceae	*Malvaviscus*	*penduliflorus*	Moc. & Sesse ex DC.	Sleeping hibiscus	Tree	Exotic	Rare	Not listed	Ornamental			√
74	Malvaceae	*Sida*	*acuta*	Burm.	Broomweed	Herb	Native	Occasional	Not listed	Ecological	√	√	
75	Malvaceae	*Sida*	*rhombifolia*	L.	None	Herb	Native	Occasional	Not listed	Ecological	√		
76	Malvaceae	*Theobroma*	*cacao*	L.	Cocoa	Tree	Exotic	Rare	Not listed	Food			√
77	Melastomataceae	*Miconia*	*laevigata*	(L.) D. Don	White wattle	Shrub	Native	Occasional	Not listed	Medicinal		√	√
78	Meliaceae	*Cedrela*	*odorata*	L.	West Indian Cedar	Tree	Native	Occasional	Vulnerable	Lumber	√	√	√
79	Moraceae	*Artocarpus*	*altilis*	(Parkinson) Fosberg	Breatfruit	Tree	Introduced	Abundant	Not listed	Food	√		
80	Moraceae	*Ficus*	*americana subsp. americana*	*Aubl.*	Jamaican cherry fig	Tree	Native	Occasional	Least concern	Ecological	√		
81	Moraceae	*Ficus*	*benjamina*	*L.*	Laurel fig	Tree	Exotic	Rare	Least concern	Ornamental	√		√
82	Moraceae	*Ficus*	*trigonata*	L.	Fig	Tree	Native	Occasional	Least concern	Ecological	√		
83	Moringaceae	*Moringa*	*oleifera*	Lam.	Moringa, Horse Radish tree	Tree	Introduced	Frequent	Least concern	Medicinal	√		
84	Musaceae	*Musa*	*acuminata*	Colla	Banana	Tree	Introduced	Occasional	Least concern	Food	√		√
85	Myrtaceae	*Pimenta*	*dioica*	(L.) Merr. & L.M. Perry	Pimento	Tree	Native	Occasional	Least concern	Food			√
86	Myrtaceae	*Psidium*	*guajava*	L.	Guava	Tree	Native	Rare	Least concern	Food		√	√
87	Myrtaceae	*Syzygium*	*jambos*	(L.) Alston	Rose apple	Tree	Exotic	Occasional	Least concern	Food		√	
88	Nyctaginaceae	*Bougainvillea*	*glabra*	Choisy	Bougainvillea	Shrub	Exotic	Occasional	Least concern	Ornamental		√	
89	Passifloraceae	*Passiflora*	*edulis*	Sims	Passion fruit	Vine	Exotic	Occasional	Not listed	Food	√		√

90	Phyllanthaceae	*Phyllanthus*	*amarus*	Shumach. & Thonn.	Carry-me-seed	Herb	Native	Occasional	Not listed	Medicinal	√	√	
91	Phytolaccaceae	*Rivina*	*humilis*	L.	Dogberry	Herb	Native	Rare	Not listed	Medicinal		√	
92	Phytolaccaceae	*Trichostigma*	*octandrum*	(L.) H. Walter	Hoop withe, Basket withe	Shrub	Native	Occasional	Least concern	Ecological	√	√	
93	Pinaceae	*Pinus*	*sp.*	Unknown	Pine	Tree	Exotic	Abundant	Unknown	Lumber	√		
94	Piperaceae	*Piper*	*aduncum var. aduncum*	L.	None	Shrub	Native	Frequent	Least concern	Ecological		√	√
95	Piperaceae	*Piper*	*amalago var. amalago*	L.	Black jointa	Shrub	Native	Occasional	Least concern	Medicinal	√	√	√
96	Piperaceae	*Piper*	*umbellatum*	L.	Cow foot	Shrub	Native	Occasional	Not listed	Medicinal	√		√
97	Plantaginaceae	*Russelia*	*equisetiformis*	Schltdl. & Cham.	Humming bird bush	Shrub	Exotic	Rare	Not listed	Ornamental		√	
98	Poaceae	*Bambusa*	*vulgaris*	Schrad. ex H.L. Wendl.	Bamboo	Shrub	Exotic	Frequent	Not listed	Invasive	√		
99	Poaceae	*Cenchrus*	*purpureus*	(Schumach.) Morrone	Elephant grass	Herb	Exotic	Dominant	Least concern	Invasive	√	√	√
100	Poaceae	*Chloris*	*barbata*	Sw.	None	Herb	Native	Frequent	Not listed	Ecological	√	√	
101	Poaceae	*Chloris*	*radiata*	(L.) Sw.	None	Herb	Native	Occasional	Least concern	Ecological	√		√
102	Poaceae	*Cynodon*	*dactylon var. dactylon*	(L.) Pers.	Bahama grass	Herb	Exotic	Occasional	Not listed	Ecological			√
103	Poaceae	*Megathyrsus*	*maximus*	(Jacq.) B.K. Simon & S.W.L. Jacobs	Guinea grass	Herb	Exotic	Frequent	Not listed	Invasive	√		
104	Poaceae	*Setaria*	*sp.*		Unknown	Herb	Unknown	Occasional	Unknown	Ecological		√	
105	Poaceae	*Saccharum*	*officinarum*	L.	Cane	Shrub	Introduced	Rare	Not listed	Food	√		
106	Polygonaceae	*Antigonon*	*leptopus*	Hook. & Arn.	Coralita, Coralilla	Vine	Exotic	Abundant	Not listed	Medicinal	√		
107	Polypodiaceae	*Pleopeltis*	*polypodioides*	(L.) E.G. Andrews & Windham	Resurrection fern	Herb	Native	Frequent	Not listed	Medicinal		√	
108	Portulacaceae	*Portulaca*	*oleracea*	L.	Pussley	Herb	Native	Occasional	Least concern	Medicinal		√	
109	Rubiaceae	*Coffea*	*arabica*	L.	Coffee	Shrub	Exotic	Frequent	Endangered	Food	√		
110	Rubiaceae	*Spermacoce*	*laevis*	Lam.	Buttonweed	Herb	Native	Frequent	Least concern	Medicinal	√	√	√

111	Rutaceae	*Citrus*	*aurantifolia*	(Christm.) Swingle	Lime	Tree	Exotic	Occasional	Not listed	Food			√
112	Rutaceae	*Citrus*	*aurantium*	L.	Orange	Tree	Exotic	Occasional	Not listed	Food	√		
113	Sapindaceae	*Allophylus*	*cominia var. cominia*	(L.) Sw.	None	Tree	Native	Occasional	Least concern	Ecological			√
114	Sapindaceae	*Blighia*	*sapida*	K.D. Koenig	Ackee	Tree	Introduced	Frequent	Least concern	Food	√	√	√
115	Sapindaceae	*Melicoccos*	*bijugatus*	Jacq.	Genip, Guinep	Tree	Introduced	Frequent	Least concern	Food	√		√
116	Solanaceae	*Brugmmansia*	*suaveolens*	(Humb. & Bonpl. ex Willd.) Sweet	Ange's trumpet	Tree	Exotic	Abundant	Extinct in the wild	Ornamental	√	√	√
117	Solanaceae	*Solanum*	*americanum*	Mill.	Gouma	Herb	Native	Occasional	Not listed	Medicinal	√		
118	Solanaceae	*Solanum*	*torvum*	Sw.	Susumber, Gully bean	Shrub	Native	Occasional	Not listed	Food	√		√
119	Urticaceae	*Cecropia*	*peltata*	L.	Trumpet tree	Tree	Native	Occasional	Least concern	Ecological	√	√	√
120	Urticaceae	*Pilea*	*microphylla var. microphylla*	(L.) Leibm.	Lace plant	Herb	Native	Occasional	Not listed	Medicinal		√	
121	Urticaceae	*Pilea*	*nummularifolia*	(Sw.) Wedd.	Creeping charlie	Herb	Native	Frequent	Not listed	Ecological	√	√	
122	Vebenaceae	*Lantana*	*camara*	L.	Sage	Shrub	Native	Occasional	Not listed	Medicinal	√	√	
123	Verbenaceae	*Stachytarpheta*	*mutabilis*	(Jacq.) Vahl	Pink rat tail	Herb	Native	Rare	Not listed	Ecological	√		
124	Xanthorrhoeaceae	*Aloe*	*vera*	(L.) Burm.	Aloe vera, Sinkle bible	Herb	Exotic	Rare	Not listed	Medicinal	√		

14.6 Appendix 6 - Plates

PLATE I

Achimenes erecta (1A)

Agave morrisii (1B)

Calliandra houstoniana var. calothyrsus (1C)

Lisianthius longifolius (1D)

Pilea microphylla var. microphylla (1E)

Spermacoce laevis (1F)

PLATE II

Asystasia gangetica (2A)

Hyptis verticillata (2B)

Momordica charantia (2C)

Pilea nummulariifolia (2D)

Piper umbellatum (2E)

Pseudelephantopus spicatus (2F)

PLATE III

Bidens reptans (3A)

Cyperus involuctratus (3B)

Vernonia divaricate (3C)

Thunbergia alata (3D)

Pachystachys spicata (3E)

Allophyllus cominia var. *cominia* (3F)

PLATE IV

Caesalpinia pulcherrima (4A)

Portulaca oleracea subsp. *oleracea* (4B)

Achyranthes aspera var. *aspera* (4C)

Pleopeltis polypodioides (4D)

14.7 Appendix 7 - Forestry Department Planting Sites Under UNEP CityAdapt Project

Name of School	Location	Seedlings				Total	Remarks/Comments
		Fruits	Ormntl	Timber	Palms		
Camperdown High	6B Camperdown Road	8	26	0	0	34	**Species planted**: • Pride of Barbados • Neem • Yellow Poui • Otaheite Apple • Queen Flower • Sour Sop • Jackfruit • Custard Apple
Vauxhall High	49 Windward Road	4	25	0	0	29	**Species planted**: • Star Apple • Cashew • Mulberry • Sour Sop • Pink Poui • White Poui
Rennock Lodge All Age	Rennock Lodge, Kingston 2	15	10	0	8	33	**Species planted**: • Christmas Palm • O. Apple • Custard Apple • Jackfruit • Soursop • Mullberry • Stinking Toe • White Poui • Shower of Gold • Yellow Poui
St. Andrew Technical High	64 Spanish Town Road, Kingston	45	28	0	0	73	**Species planted**: • Pink Poui • White Poui • Cassia • Mulberry • Sour Sop • Yellow Poui

Name of School	Location	Seedlings				Total	Remarks/Comments
		Fruits	Ormntl	Timber	Palms		
							• Star apple • Jackfruit • Mulberry • Cashew • Soursop • O. Apple • Custard Apple
Excelsior High	Mountain View Avenue	0	111	1	9	**121**	**Species planted:** • Christmas Palms • Blue Mahoe • Yellow Poui • White Poui • Pride of Barbados (orange)
Tarrant High School	31 Molynes Rd, Kingston	116	60	0	0	**176**	**Species planted:** • O. Apple • Soursop • Sweet tamarind • Guinep • Avocado • Star Apple • Acacia • Queen flower • Cassia J • Poor Man's orchid (Purple) • Shower of Gold
GRAND TOTAL		**188**	**260**	**1**	**17**	**466**	

Name of Institution	Location/Area	Seedlings				Total	Remarks/Comments
		Fruits	Ormntl	Timber	Palms		
KSAMC Councilor Office Olympic Way	• Seaward Primary football field • Marl Road Community Centre • Tower Hill	10	45	0	0	**55**	**Species planted:** • Queen Flower • Pride of Barbados (yellow) • O. Apple • Custard Apple • Poui (yellow)
Jamaica Defense Force (JDF)	• Jamaica National Service Corps (JNSC) • Caribbean Military Technical Institute (CMTTI) • Music School quarters (MSQ) • Engineer Regiment	0	99	10	0	**109**	**Species planted:** • Pink Poui • White Poui • Poorman's Orchid • Pride of Barbados (orange) • Cannon Ball • White Poui • Blue Mahoe • Santa Maria • Poorman's Orchid (purple)

Name of Institution	Location/Area	Seedlings				Total	Remarks/Comments
		Fruits	Ormntl	Timber	Palms		
Rockfort Community Centre	Rockfort, Kingston	50	122	0	0	**172**	**Species planted**: • Pride of Barbados (Orange) • Pride Of Barbados (Yellow) • Poui (White) • Shower of Gold • Sour Sop • Naseberry • Poui (yellow) • Tamarind • Jackfruit • Poorman's Orchid
Rose Town Foundation	26 Moore Street, Kingston	120	6	0	0	**126**	**Species planted**: • Jackfruit • Ackee • Java plum • O. Apple • Mulberry • Custard Apple • Indian Plum • Sweet Tamarind • Soursop • Jackfruit • Poui (Pink) • Shower of Gold
Rae Town CDC	Rae Town Kingston	34	0	0	12	**46**	**Species planted**: • Royal Palm • Poui (pink) • Poui (yellow) • Poinciana (yellow)
GRAND TOTAL		**214**	**272**	**10**	**12**	**508**	

Name of Institute	Location	Seedlings				Total	Remarks/Comments
		Fruits	Ormntl	Timber	Palms		
Three Miles Development Committee	Seaview Gardens, Kingston	598	545	85	135	1363	**Species planted:** • Acacia • Shower of Gold • Poui (White) • Poui (yellow) • Coolie plum • Java plum • Soursop • Jackfruit • Ackee • Indian Plum • Busy • Mulberry • Sweet Tamarind • Otaheite Apple • Star Apple • Shower of Gold • Seaside Mahoe • Acacia • Pimento • Pride of Barbados (yellow) • Moringa • Custard Apple • Stinking Toe • Sweet Sop • Christmas Palm • Washingtonia Palm • Naseberry • Christmas Palms
GRAND TOTAL		**598**	**545**	**85**	**135**	**1363**	The remaining 37 will be planted after the reporting this reporting period.

14.8 Appendix 8: Survey Instrument

Location/ Project: _______________________________________

Street/Section____

Dwelling No. ______________ Household No.: _______________

Instructions: Interviewer, please administer the questionnaire to the head of the household, if the head of household is not available, ensure that the respondent is able to answer on behalf of the Household Head. *Reassure all persons interviewed that their responses will be kept in strict confidence*

PERSONAL DATA

1. **Name and Alias of the Household Head** ____
2. **Name and alias of respondent (if different from household head)** ____________________________________

3. **How many housing units are on this lot?** _______

4. **How many households (family) occupy this dwelling unit?** _____ *[Interviewer: A separate questionnaire is to be completed for each household]*

5. **Including the household head, how many persons make-up this household?** ___________

H/H Members	Sex	Age	Union Status	Highest Level of School Attended
Head				
Partner				
03				
04				
05				
06				
07				
08				
09				
10				

Union Status: 1. Common-Law – living with partner; 2. Married;

3. Visiting; 4. Single; 5. Divorced; 6. Separated; 7. Widowed

Highest Level of Schooling: 1- Early Childhood; 2- Primary; 3 Secondary; 4 Tertiary; 5 Other

6. **Is the household head the landlord/landlady of this dwelling?** **1** ☐ Yes **2** ☐ No

STATUS OF LAND/DWELLING OCCUPIED

7. **How long have you been living in this community?**

   _________ Yrs. __________ Mths.

8. **What is your tenure status in regard to this plot of land?**

   1 ☐ Live **without** owner's permission

   2 ☐ Live **with** owner's permission / Rent-free

   3 ☐ Own **4** ☐ Inherit

   5 ☐ Lease **6** ☐ Rent ☐ Other/specify____________________

9. **What is your current status in regard to this dwelling?**

   1 ☐ Live **without** owner's permission **(Go to Ques. 13)**

   2 ☐ Live **with** owner's permission / Rent-free **(Go to Ques. 13)**

   3 ☐ Inherited **(Go to Ques. 13)**

   4 ☐ Own **(Go to Ques. 13)** **5** ☐ Lease **6** ☐ Rent

   ☐ Other/specify________________

10. **If dwelling is leased/ rented, what is the duration of the agreement (month/years)?**

    Rent: ______ Lease: ______

11. **If dwelling is leased/ rented, how much are you paying per month? $ __________________________**

12. **To whom is rent/lease paid?**

    ____

HOUSING CONDITION/INFRASTRUCTURE

13. **What is the material of the outer wall of the dwelling unit?**

    1 ☐ Concrete/Block & Steel **2**☐ **Timber/** Board

    ☐ Other, specify _____________________

14. **How many habitable rooms does your household occupy (exclude kitchen, bathroom and toilets)?** ________

15. ***[Interviewer, observe the condition of the dwelling using the descriptors below as a guide.***

1 □ Very Good **2** □ Good **3** □ Fair 4 □ Poor 5 □ Very Poor

Very good: *Sound physical structure, freshly painted. Doors and Windows intact and looks good.*

Good: *Structure good, may not be freshly painted, but in good physical condition.*

Fair: *May or may not need painting, may have need for minor repairs.*

Poor: *Structural damage, cracks, missing window panes or blades and doors.*

Very Poor: *Not fit for human habitation.*

ECONOMIC ACTIVITY/ HOUSEHOLD FINANCES

16. How many members of this household (including H/H head) are presently employed? __________; what is the employment status, occupation, gross weekly income of the household members including head & partner. (*Fill out using the same order used for each members in Ques.5)*

	Employment Status *	**Occupation**	**Gross Weekly Income**
Head			
Partner			
03			
04			
05			
06			
07			
		Total	

***Employment status –** 1. Full -time; 2. Part time 3. Self- employed (specify) 4. Seasonal; 5. Unemployed; 6. Seeking first job; 7. Seeking job; 8. Student; 9. Retired.*

17. Does the household receive regular additional income from any of the following sources? **[***Tick as many as applicable]*

1 □ Second job **2** □ State Assistance (e.g., PATH)

3 □ Remittances (Overseas) **4** □ Supported by local network of family members and friends

5 ☐ Child support **6** ☐ **N**one ***(Go To Ques. 18)***

7 ☐ Own Business **8** ☐Other, specify ______________

About how much additional income does the household receive on a weekly basis as additional income? $_______

18. What is your average weekly expenditure? $____________

19. Do you own or operate a business in this community?

1 ☐ Yes **2** ☐ No ***(If No, skip to Ques. 20)***

What is the type of business?

ACCESS TO SERVICES & PHYSICAL INFRASTRUCTURE

20. What toilet facility does the household mainly use? ***If any household is sharing their neighbours' facility, IDENTIFY the type of toilet the neighbour uses.***

1 ☐ Pit latrine – not shared **(Go to Ques. 21 and answer NONE)**
2 ☐ Pit latrine – shared **(Go to Ques. 21 and answer NONE)**
3 ☐ Flush – Outdoor, not shared
4 ☐ Flush – Outdoor shared
5 ☐ Flush – Indoor - not shared
6 ☐ Flush – Indoor – shared
7 ☐ Pour-flush Latrine – not shared **(Go to Ques. 21 and answer NONE)**
8 ☐ Pour-flush Latrine – shared **(Go to Ques. 21 and answer NONE)**
9 ☐ None ☐Other/specify __________________

21. What type of sewage system does the household have in place?

1 ☐ Septic Tank w Soak-a-way **2** ☐ Absorption pit

3 ☐ **Central** Sewer **4** ☐ None

5 ☐ **Other**/specify ______________________

22. What is your main method to dispose of your garbage?

1 □ Burn it **2** □ Bury it **3** □ Garbage Truck
4 □ Dump in gullies/ hillsides **5** □ Dump in River
□ Other/specify ___________________________

23. What is the main source of water used by the household?

1 □ Water piped into yard **2** □ Water piped into house

3 □ Standpipe **4** □ Private Tank/drum (Trucked Water)

5□ Private Tank/drum (Rainwater Catchment)

6 □ Public Tank **7** □ River □**Other/specify _____**

____

24. What are the alternate sources of water used by the household (e.g., during disruption of main source)?
____

25. What main type of fuel used by the household for cooking?

1 □ Gas **2** □ Charcoal **3** □ Kerosene 4 □ Wood

5 □ Electricity □ Other/specify ________________

26. ***Interviewer, observe the condition of the roads using the descriptors below as a guide.***
1 □ Very Good **2** □ Good **3** □ Fair 4 □ Poor 5 □ Very Poor
Very good: *Smooth asphalt surface with no potholes*
Good: *Drivable asphalt surface with few small potholes.*
Fair: *Surface has some small potholes and need for minor patching*
Poor: *Large potholes which make driving uncomfortable*
Very Poor: *Surface is removed, and gravel or marl are exposed with large potholes all over*

Understanding ecological concepts

27. Do you understand the concept of "watershed" and their importance?
1 □ Yes **2** □ No ***(If no, interviewer should explain)***

28. Do you think the Hope River watershed (HRWS) is being effectively managed?

1 ☐ Yes **2** ☐ No ☐ Other/specify __________

29. What ways do you think the management of the Hope River watershed (HRWS) can be improved (what tools can be used) e.g., river training, building retaining walls, check dam, etc.,

____

____

____

30. Do you understand the concept of "ecosystem" and how it operates?

1 ☐ Yes **2** ☐ No ***(If no, interviewer should explain)***

31. Do you depend on the ecosystem for goods and services?

1 ☐ Yes **2** ☐ No; If yes, Explain ___________________

____

32. How would you rank the following ecosystem services in your community? (very important, somewhat important, not important, I don't know)

(Interviewer: List ecosystem services and descriptions in table below to participant then enter rank)

Type of Ecosystem Service	***Examples of Services***
Regulating:	*Water purification (do you have clean water?)*
	Flood mitigation (water retention capability of surrounding areas)
	Erosion control/stabilization of land by vegetation
	Protection of coastal areas (lower reaches) from storm surges and floods
Supporting:	*Habitat for wild riverine and estuarine plant and animal species (e.g., fish, birds, migratory birds)*
	Plant conservation (riparian and mangrove species)
	Riverine/estuarine species conservation
	Terrestrial species conservation (water provided by river during dry season)
	Nursery habitats (i.e., places/locations that provide shelter and protection)
Cultural:	*Recreation*

	Tourism
	Intrinsic value (how special do you think the HRWS is)
	Spiritual (significant/spiritual-sacred sites)
	Science and education (how important do you think education is in protecting the environment?)
	History (how important is the history of your community within the HRWS?)
Provisioning:	*Water for domestic use (drinking, cooking, bathing)*
	Fisheries
	Fertile land for farming (subsistence and commercial [vegetables, fruit, coffee]
	Foraging for edible vegetation
	Wildlife for subsistence hunting [i.e., non-recreational]
	Raw material [wood] for building [forest exploitation]
	Inorganic raw material for building [extraction of gravel, sand]
	Fuelwood/charcoal
	Traditional medicinal plants

	Employment

Ecosystem Service Type	**Importance Rank**
Regulating	
Supporting	
Cultural	
Provisioning	

Importance Rank: 1. Not Important 2. Somewhat Important 3. Important

4. Very Important 5. I Don't Know

33. **How do you think that your activities and your household's impact the ecosystem?** ___________________
____
____

34. **What are some activities you observe in your community/ in broader Hope River watershed (HRWS) that are detrimental to the ecosystem [e.g., land clearing for farming, diversion of water, invasive species]**
____
____

35. **How have land-use changes affected ecosystem services in the past 5-10 years?**
____
____

36. **Have you ever experienced any climate-related, natural/ environmental hazard impact (in your community)?**

1 ☐ Yes 2 ☐ **No**

37. If Yes at Q36, Have you ever experienced any climate-related, natural/ environmental hazard impact (in your community)?, how were you and/or your household impacted?

____

____

38. What climate-related, natural/ environmental hazard impact have you and/your household experienced (in your community)? *[check all that apply]*

1 ☐ Flooding **2** ☐ Landslide **3** ☐ Earthquake
4 ☐ Tropical Storms/ Hurricanes **5** ☐ **Bush** Fire

6 ☐ Excess Dust **7** ☐ Water Contamination

8 ☐ **Other**/ specify ____________________

39. Since you and/or family members have been living here how many times have you and/or your household been impacted by such hazards? ___________________________

40. When was the most recent occurrence of any natural/ environmental hazard in your community? List the hazard:

1 ☐ <1 month ______________________________________
2 ☐ 1-6 months ______________________________________
3 ☐ 7-12 months _____________________________________
4 ☐ >1 year – **2 years** _________________________________
5 ☐ >2 years – 3 years _________________________________
6 ☐ > **3** years _______________________________________
5 ☐ **Other/specify**_______________________________________

41. In the past 5-10 years, have you and/your household experienced the following climate-related hazards? *(Check all that apply)*

1 ☐ More frequent flooding

2 ☐ Changes in 1-day maximum intensity of rainfall

3 ☐ More severe and longer lasting drought

4 ☐ Increases in the maximum sustained wind speeds and

rainfall rates associated with Hurricanes

5 ☐ Drying of the watershed *(drying in south of watershed far*

exceeds drying to the north)

6 ☐ Higher temperatures *(tends to be uniform across the Watershed)*

42. What climate-related or natural/ environmental hazards do you think affect the community most? ***Please rank by frequency with 1 being most frequent:***

1. ______________________________
2. ______________________________
3. ______________________________
4. ______________________________

43. In what ways do you think residents contribute to the climate-related, natural/ environmental hazards experienced in your community?

1 ☐ Diverting waterway **2** ☐ Deforestation **3** ☐ Construction
4 ☐ Dumping of garbage **5** ☐ Improper undercutting of slope
6 ☐ Sewage **7** ☐ Use of chemicals (Pesticides & fertilizers)
8 ☐ Other/specify, ____________________

44. In the case of deforestation, what is the main cause for this action by residents in your community?

1 ☐ Housing **2** ☐ Fence Posts **3** ☐ Charcoal

4 ☐ Broom sticks 5 ☐ Use of fire to clear land (slash and burn)

6 ☐ Farming **7** ☐ Other/specify ______________________

45. If you own a business in the community, has your business ever been affected by any climate-related or natural/ environmental hazard?

1 ☐ Yes **2** ☐ No 3 ☐ Not Applicable

46. Do you think residents contribute to the climate-related natural/ environmental hazards experienced in your community?

1 ☐ Yes **2** ☐ **No**

47. Why do you think residents' conduct actions that contribute to climate-related, natural/ environmental hazards in your community?

1 ☐ Ignorance **2** ☐ They don't care **3** ☐ Lack of alternative
4 ☐ I don't know **5** ☐ Other/specify ________________

48. What are some steps you think can be taken to change the residents' actions that contribute to climate-related, natural/ environmental hazards in your community? ***(Check all that apply)***

1 ☐ Educational Workshops **2** ☐ Increase alternatives
3 ☐ Financial support **4** ☐ Community denouncement of actions
5 ☐ Regulations and enforcement **6** ☐ Nothing
7 ☐ Other/specify ______________________________________

49. Do you think the ecosystem has protected the community from any of the disasters/hazards experienced?

1 ☐ Yes **2** ☐ **No**

If yes, how? ____

____

____

50. Do you think your household is vulnerable to any of the climate-related, natural/ environmental hazards experienced in your community?

1 ☐ Yes **2** ☐ **No**

51. How vulnerable do you think your household is to any of the climate-related, natural/ environmental hazards experienced in your community?

1 ☐ Very Vulnerable **2** ☐ Vulnerable **3** ☐ Moderately vulnerable
4 ☐ Low Vulnerability **5** ☐ Not Vulnerable

52. Are you aware of measures which have been taken by residents of the community or other representatives to protect and preserve the ecosystem?

1 ☐ Yes **2** ☐ No

If yes name them ___________________________________

____

53. Do you have any suggestions regarding the protection of the cosystem?____

____

54. Do you think the necessary works, regarding the protection of the ecosystem is the responsibility of residents or the Government?

☐ Residents **2** ☐ Government **3** ☐ Both

55. What types of community groups exist in your community? _______________________________________

____

56. Would you describe these groups that you have identified as *(select 1 from each category):*

1 ☐Active ☐ Very Active ☐ Inactive

2 ☐ Effective ☐ Very Effective ☐ Not Effective

Explain ____

____

57. Are you or any member of your household a member of any of the community groups?

1 ☐ Yes **2** ☐

If yes, which group/s? ________________________________

____

____

Would you be willing to submit your name and contact information (telephone/email) in case we need to contact you for verification/ follow-up purposes only? ______________________________

____

____

Interviewer Name: __________________Date: ___________

Editor & Coder's Name________________Date: ___________

Data entry - Name:___________________Date: ____________