INTERVENTIONS TO INCREASE CLIMATE RESILIENT INVESTMENTS IN BARBADOS, JAMAICA AND TRINIDAD AND TOBAGO

Identification of Hazards and Resilience Measures

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About IDB Invest

IDB Invest, a member of the IDB Group, is a multilateral development bank committed to promoting the economic development of its member countries in Latin America and the Caribbean through the private sector. IDB Invest finances sustainable companies and projects to achieve financial results and maximize economic, social, and environmental development in the region. With a portfolio of $13.1 billion in asset management and 385 clients in 23 countries, IDB Invest provides innovative financial solutions and advisory services that meet the needs of it's clients in a variety of industries.

About CEAC

CEAC Solutions Limited, based in Kingston, Jamaica, is a regional leader in consulting, design, and operations, with a strong reputation for excellence. With expertise in several disciplines, the firm has successfully undertaken civil, environmental, and coastal studies to protect and enhance the hotel, transportation and energy sectors. Its involvement in development initiatives has led to innovations and improvements in housing, subdivisions, and commercial buildings. CEAC has also played a vital role in regional and global climate change adaptation and mitigation strategies, conducting assessments for facilities, housing, energy, and transportation projects in the face of extreme weather impacts. Working closely with Clients, the firm's engineers and climate scientists determine appropriate climate models and downscaling methods to ensure effective solutions.

Executive Summary

The Inter-American Development Bank (IDB) is the primary source of financing for economic, social, and institutional development in Latin America and the Caribbean. The Caribbean is highly susceptible to intensifying climate change related events, sustained and extreme, which result in significant damage to the built environment in the region and have a wide-reaching impact on the economy and livelihoods. IDB Invest, a member of the IDB Group, is promoting economic development of its member countries in Latin America and the Caribbean through the private sector. IDB Invest finances sustainable companies and projects to achieve financial results and maximize economic, social and environmental development in the region. IDB Invest has identified a gap between the demand for and supply of resilient buildings, as well as a latent need to support the construction sector in the Caribbean by showing the business case for including climate resilience measures in the design and construction of residential and commercial buildings and building capacity among construction companies.

As such, IDB Invest is developing a publication for distribution to the public to reduce the market inefficiencies identified. The publication will highlight the main drivers and potential returns on investment associated with incorporating adaptive and resilient design and construction practices in buildings in three Caribbean countries. The project will focus on the residential and commercial sectors in Jamaica, Trinidad and Tobago and Barbados.

Small and Mid-size Enterprise (SME) and Residential Landscape

Caribbean residential and SME developments are susceptible to climate-related hazards' impacts due to the Caribbean's location and intensifying risks. The size of the SME landscape is estimated to be 11,275 for Barbados, 35,287 for Jamaica and 17,044 for Trinidad and Tobago. The SME sector accounts for the employment of 23% to 56% of the workforce, providing a range of services, including accommodation and food services, social and personal services, manufacturing, building, professional services and wholesale and retail trade. From the data collected on the SME sector, the Wholesale and Retail Trade sector was the most dominant SME industry.

The residential landscape consists of demands being met mainly through detached units, followed by townhouses across the three countries. Current demands outstrip market supply in all three countries with unmet annual demands of 500, 15,000 and 10,000 for Barbados, Jamaica and Trinidad and Tobago, respectively.

Climate Hazard Assessment

Regarding material climate hazards, present and future climate trends project a 9% reduction in annual rainfall totals with an increased likelihood of drought events. Drought is expected to be a standard feature, with at least one severe drought per decade. Floods are projected to become more severe across the three territories and mean annual temperatures have increased to 0.9°C since pre-industrial times. Further increases of 0.8°C are projected up to 2059. There are also projections of increased hurricane wind speeds, frequency of intense hurricanes and TC rain rates. Regional Sea Level Rise (SLR) suggests 2.5 mm/year trends, with regional variations being more significant for Trinidad and Tobago and lower for Barbados and Jamaica.

Damage history and risk assessments between 1955 and 2021 indicate that hurricane winds are the dominant catastrophic hazard observed in all three countries. Floods and drought were the second and third most frequent climate-related hazards. Annualised losses across the countries prioritise hurricane wind losses averaging US$215 million, with flooding 10 to 20 times less costly, followed by drought. Droughts are difficult to assess given the limited information available but are estimated to cost about US$500,000 annually. Energy consumption from increased cooling costs is estimated to cost US$1.4, US$8.7 and US$1.9 million annually for Barbados, Jamaica and Trinidad and Tobago, respectively.

Resiliency Measures

Architypes[1] were proposed for residential and commercial buildings to enable cost comparison of resilience measures. They consist of 70m2 affordable-income housing solutions, with concrete walls, hip or slab roofs for Trinidad and Tobago and Barbados, and concrete walls with concrete slab roofs for Jamaica. SME buildings are 465 m2 warehouses with mezzanine floors, steel sheeting cladding, or office-type masonry walls. In addition, international best practices for wind, heat, drought, and flooding mitigation were identified and included:

[1] Throughout this document, an architype is defined as **a typical example or prototype of buildings for either residential or commercial use.**

Table 0.1 Summary of Resiliency Measures for Respective Climate Related Hazards

Wind Mitigation measures	Heat Mitigation Measures	Drought Mitigation Measures	Flooding Mitigation Measures
Roof Clips and Ties	Solar shaders	Onsite water storage tanks	Elevating the Structure
Roof Anchorage to Wall	Climate Control system	Low flow faucets	Flood Doors
Impact Resistant Doors and Windows	Thermal radiant roof barriers	Rainwater harvesting	Permanent Flood Barriers
Impact Resistant Shutters	Reducing heat gain on building envelope		Storm water Retention and Infiltration Basins
Concrete roof structures	Cooling of internal spaces		Green roofs
Minimum eaves on buildings			Rainwater harvesting

Returns on Investments

Climate change resilience measures are generally economically viable. For example, resilience measures for flooding, hurricane winds, drought and extreme heat for residential units and SMEs in Jamaica, Trinidad and Tobago and Barbados have high ROIs on average.

ROI averages are generally greater for SME warehouses than residential units due to measures already covered by building codes. In addition, enforcement is stricter for commercial buildings, and the derived benefit of each measure is more for warehouses than residential units due to the value of the goods protected. Regarding ranking, the returns for implementing mitigation measures for all four hazards are greater for Barbados, followed by Jamaica and Trinidad and Tobago, when a 5-year timeline is used for comparison.

Market Demand

The 5-year potential for residential property development market in Barbados, Jamaica and Trinidad and Tobago is estimated at US$6.25, US$14.8 and US$10 billion, respectively; while for commercial property, the market is US$1.15, US$2.2 and US$2.5 billion respectively.

Access to financing, affordability and cost were among the top motivating factors when making a purchasing decision in all three countries, while exposure to extreme weather events was among the lowest decision-making factors. Unfortunately, financial institutions do not offer products targeted at climate-resilient infrastructure. However, mortgage financiers are willing to include resilience add-ons/products in mortgage financing to deal with drought and heat/cooling.

Insurance agents, risk assessors and sellers noted that the impact of climatic events is not solely factored in assessing risks for coverage. Insurance is mainly sought on a compulsory basis as a condition of mortgage, while coverage lags property values. Affordability, inflation and the cost of construction are impacting insurance takeup. Reinsurance capacity has also reduced in the region. Price increases for catastrophe insurance ranged from 5% to 25% during 2021/2022. With consistent severe hurricanes over the past five years, resulting in significant insurance losses, the pending revaluation could increase premiums.

Conclusions and Recommendations

Due to the location of the Caribbean and escalating risks, small and mid-size enterprises (SMEs) and residential landscapes are vulnerable to climate-related hazards. In addition, climate projections for the area indicate that climate hazards are becoming more intense or frequent.

The main catastrophic risk was hurricane winds. In Jamaica, Trinidad and Tobago and Barbados, resilience measures for flooding, hurricane winds, drought and extreme heat have high returns on investment. The ROI averages for archetypal SME warehouses are typically higher than those for residential properties across all countries.

There is a market for incorporating climate resilience into new or preexisting infrastructure with the greatest willingness to pay for heat resilience measures. The region's ability to re-insure losses has diminished. Most people get insurance because it's a mortgage requirement. Considering the increasing severity of climate-related events and the reluctance of developers to implement solutions that could drive up consumer costs, capacity building is essential.

The publication for the SME landscape should be targeted towards low and affordable-income stakeholders. Innovative lending arrangements should be designed to increase uptake, and initial lending products should be targeted at heat resilience measures. There should also be general awareness among consumers and the public on climate resilience infrastructure and mortgage financing options.

Contents

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Acronym List

AAL	Average Annual Loss
AR	Assessment Report
BTU	British Thermal Unit
CARIWIG	Caribbean Weather Impacts Generator
CDB	Caribbean Development Bank
CSO	Central Statistical Office
DEM	Department of Emergency Management
ECLAC	United Nations Economic Commission for Latin America and the Caribbean
EM-DAT	Emergency Events Database
GDP	Gross Domestic Product
GIS	Geographic Information System
GMSL	Global Mean Sea Level
GNSS	Global Navigation Satellite System
GPS	Global Positioning System
GSLR	Global Sea Level Rise
GWh	Gigawatt hours
HVAC	Heating, ventilation, and air conditioning
IDB	Inter-American Development Bank
IPCC	Intergovernmental Panel on Climate Change
IRD	Inland Revenue Department
kWh	kilowatt hour
LAC	Latin American and Caribbean
LED	Light Emitting Diode
MICAF	Ministry of Industry Commerce, Agriculture and Fisheries
MSL	Mean Sea Level
MSME	Micro, Small and Medium Sized Enterprises
NOAA	National Oceanic and Atmospheric Administration
ODPEM	Office of Disaster Preparedness and Emergency Management (Jamaica)
ODPM	Office of Disaster Preparedness and Management (Trinidad and Tobago)
PIOJ	Planning Institute of Jamaica
RCP	Representative Concentration Pathway
RTK	Real-time kinematic positioning
RX	Maximum consecutive precipitation
SLR	Sea Level Rise
SME	Small and Medium Enterprises
SPEI	Standardized Precipitation Evaporation Index
SPI	Standardized Precipitation Index
SSP	Shared Socioeconomic Pathways
STATIN	Statistical Institute of Jamaica
TC	Tropical Cyclone
USAID	United States Agency for International Development
US$	US Dollars

Introduction

Caribbean Islands are highly susceptible to impacts of climate-related hazards due to their size and location. These intensifying hazards include droughts, hurricanes, floods, higher temperatures, and sea-level rise, which can cause significant damage to the environment and, consequently, economic sectors. This predicament has led to the need for climate adaptation in the form of climate-resilient infrastructure to withstand the impacts of climate change.

The Inter-American Development Bank (IDB) is the primary source of development financing for economic, social, and institutional development in Latin America and the Caribbean. IDB Invest seeks to demonstrate the business case for incorporating climate resiliency measures in designing and constructing residential and commercial buildings and building capacity among construction companies. The goal is to highlight measures, costs, and benefits of climate adaptation in constructing residential, commercial, and industrial buildings across Barbados, Jamaica and Trinidad and Tobago.

IDB Invest intends to expand the range of climate adaptive services currently provided by regional SMEs to reduce market inefficiencies. The project aims to inform increased market efficiencies resulting from increased resilience, simulated economic activities and co-benefits of climate adaptive business services. The main objective is to develop a guide that identifies practicable measures for new and existing residential, commercial, and industrial building construction in Barbados, Jamaica, and Trinidad & Tobago. This publication will quantify added costs of their implementation to typical residential and commercial buildings and return on investment of such measures to justify their incorporation in building design. This will then aid in informing the public, investors, building professionals and the insurance industry of the main drivers and returns of climate adaptive and resilient measures.

Introduction

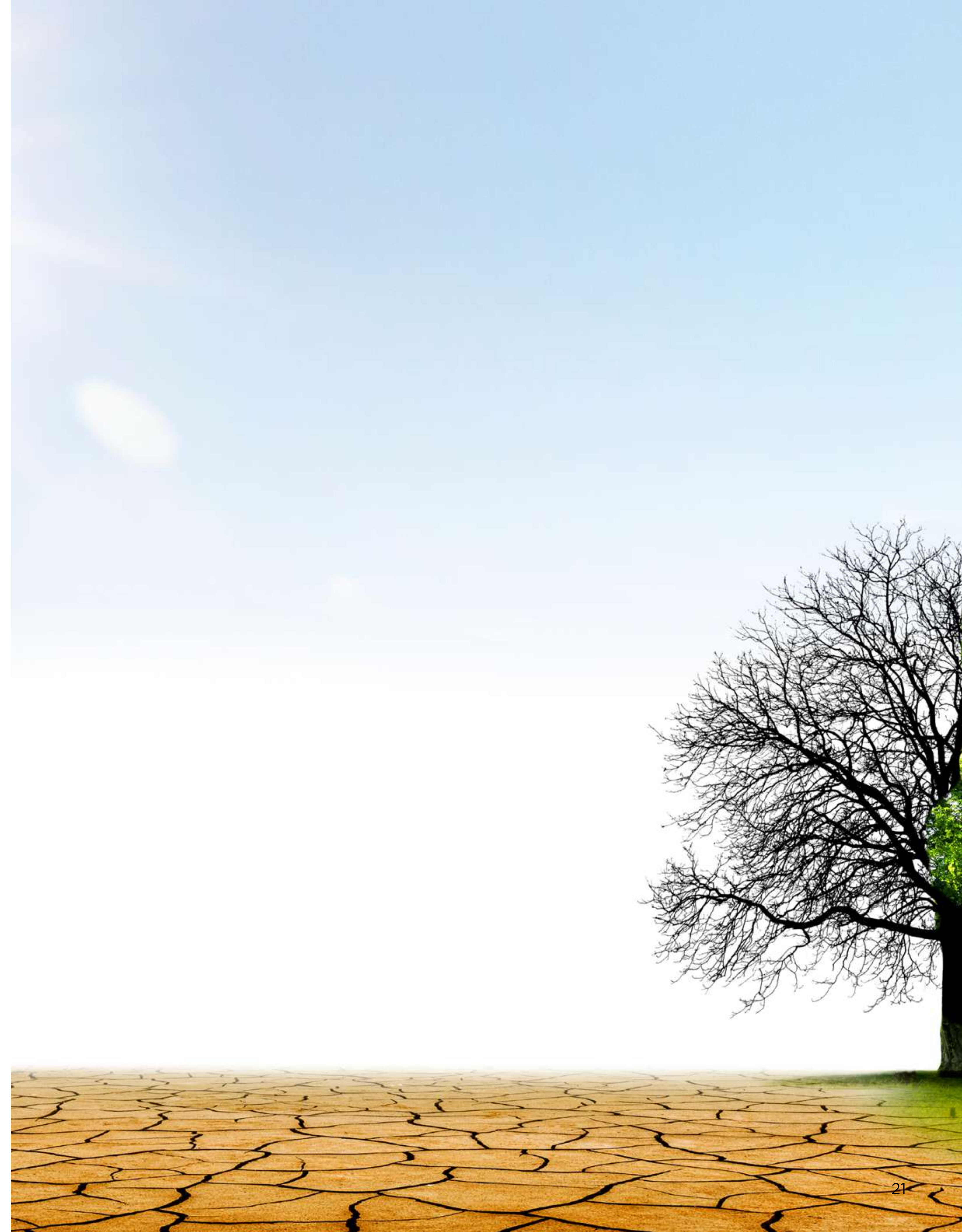
The following activities were undertaken to determine the main drivers and returns of climate resilience measures:

i. Identification of climate hazards for the built environment in the three countries. Four climate hazards which pose the most significant threats to the built environment, based on historical events, frequency/severity assessment and climate models, were then prioritised by country.

ii. Determination of the best resiliency measures and practices in construction based on international best practices and state-of-the-art measures for increasing the adaptability and resilience of commercial and residential buildings. The cost premiums of these measures over traditional design and construction practices were also included. Additionally, the building codes from the three countries were analysed to assess their compatibility with the proposed best resiliency practices.

iii. Calculation of estimated return on investment for each benchmarked measure for building resilience and impact of implementation on operational costs.

iv. Market demand analysis to estimate the market size for climate-resilient properties within each country's residential and commercial sectors and the willingness of individuals and businesses to pay the premium for resiliency measures. Surveys were also conducted to determine insurance products that account for climate-related events and the impact of resiliency measures on insurance premiums.



2 SME and Residential Landscapes

Key Findings:

1. Due to location and intensifying hazards, Caribbean residential and SME developments are susceptible to climate-related impacts.
2. The size of the SME landscape is estimated to be 11,275 for Barbados, 35,287 for Jamaica and 17,044 SMEs for Trinidad and Tobago. The SME sector employs 23% to 56% of the workforce, with the wholesale and retail trade sectors dominating all three countries.
3. Barbados, Jamaica and Trinidad and Tobago are estimated to have 78,936, 711,331 and 398,571 dwelling units, respectively. The residential landscape consists of demands mostly met by detached units across the three countries. As a result, current demands outstrip market supply in all three countries with deficits of unmet annual demands of 500, 15,000 and 10,000 for Barbados, Jamaica and Trinidad and Tobago, respectively.

2.1 Small and Medium Enterprises (SME) Landscape

2.1.1 Barbados

Barbados' Small Business Network Centre (2016)[2] estimated that there are approximately 11,275 registered small businesses in Barbados. The SME sector employs 34% of the entire labour force and 43% of the private sector workforce. This data was derived from the Inland Revenue Department (IRD) that highlighted the distribution of the registered small businesses in Barbados based on Sector.

[2] Subcommittee for the Development of a National Policy Framework for Micro, Small and Medium Sized Enterprises (MSMEs) in Barbados. (2019). A National Policy Framework for Micro, Small and Medium Sized Enterprises (MSMEs) in Barbados. Ministry of Industry, International Business, Commerce and Small Business Development.

2.1.2 Jamaica

"The Report on the Jamaica Survey of Establishments 2018"[3], authored by the Statistical Institute of Jamaica (STATIN) and published by the Planning Institute of Jamaica (PIOJ), provides baseline data on the quantities and distribution of SMEs in Jamaica. This report revealed that SMEs in Jamaica are dominantly involved in the Wholesale and Retail Trade Sector (55.7%) and Community, Social and Personal Services (23.3%) sectors. JIS (2022)[4] notes that medium, small, and micro enterprises (MSMEs) make up over 97% of the island's taxpaying businesses, and MIIC Policy (2013)[5] suggested a size of 93,110 enterprises.

The Ministry of Industry Commerce, Agriculture and Fisheries, MICAF (2017) revised policy provides a revision to the definition of MSME as follows in Table 2.1. MICAF also noted that 56% of the SMEs in Jamaica were in urban areas, and nationally, they provide 46% of the GDP income. However, an estimate of the size of the MSME was not evident save 35,287 in a PIOJ (2019)[6] report.

Table 2.1 Definition of micro, small and medium enterprises for Jamaica

	Turnover (2022)	Number of Employees
Micro	USD96,000	< 6
Small	USD96,000 to USD480,000	6 to 20
Medium	>USD480,000	21 to 50

2.1.3 Trinidad and Tobago

The Central Statistical Office of Trinidad and Tobago published data on Business Establishments in Trinidad and Tobago . The information gathered indicates that approximately 17,044 SMEs were operating in Trinidad and Tobago in 2018. Of this number, about 45% are involved in the Wholesale and retail trade, repair of motor vehicles and motorcycles sector.

[3]STATIN. (2019). The Report on the Jamaica Survey of Establishments 2018. Statistical Institute of Jamaica.

[4]Medium, Small and Micro Enterprises (MSMEs) – Government Support and Business Registration – Jamaica Information Service. (2021, November 21). Jis.gov.jm; Jamaica Information Service. https://jis.gov.jm/information/get-the-facts/medium-small-and-micro-enterprises-msmes-government-support-and-business-registration/#:~:text=Medium%2C%20small%20and%20micro%20enterprises%20(MSMEs)%20are%20essential%20to,million%20and%20%24425%20million%20annually

[5]Micro, Small and Medium Enterprises (MSME) and Entrepreneurship Policy. (2013). In JIS. Ministry of Industry, Investment and Commerce. https://jis.gov.jm/media/MSME-ENTREPRENEURSHIP-POLCY.pdf

[6]Exploring MSMEs through the Jamaica Survey of Establishments. (2019, October). FCGP. http://fcgp.pioj.gov.jm/2019/10/02/exploring-msmes-through-the-jamaica-survey-of-establishments/

The second most dominant sector was Accommodation and Food Service Activities, which accounted for 17% of all SMEs in Trinidad and Tobago[7]. The wholesale and retail trade, repair of motor vehicles and motorcycles sector is the dominant sector across all employment size groups of SMEs, i.e., 0-9 persons (48%), 10-49 persons (32.4%) and 50-250 persons (23.1%). The second most dominant sectors employing 0-9, 10-49 and 50-250 persons were the Accommodation and food service activities sector (19.3%), the Construction sector (14.3%) and the manufacturing sector (15.6%), respectively, as seen in Table 2.2.

Table 2.2 SME Employment Size Group by Sector for Trinidad and Tobago.

SECTOR	EMPLOYMENT SIZE GROUP 0-9	10-49	50-250	TOTAL
Agriculture, forestry and fishing	9	2	0	11
Mining and quarrying	107	82	42	231
Manufacturing	621	251	103	975
Electricity, gas, steam and air conditioning supply	0	1	0	1
Water supply; sewerage, waste management and remediation activities	14	12	8	34
Construction	653	372	87	1112
Wholesale and retail trade; repair of motor vehicles and motorcycles	6,604	845	153	7,602
Transportation and storage	297	118	33	448
Accommodation and food service activities	2655	209	42	2906
Information and communication	308	71	14	393
Financial and insurance activities	204	95	40	339
Real estate activities	264	30	16	310
Professional, scientific and technical activities	445	136	24	605
Administrative and support service activities	302	112	41	455
Education	200	84	14	298
Human health and social work activities	297	36	13	346
Arts, entertainment and recreation	278	44	7	329
Other service activities	501	110	24	635
Activities of households as employers of domestic personnel	13	0	1	14
TOTAL	**13,772**	**2,610**	**662**	**17,044**

2.2 Residential Landscape

2.2.1 Barbados

The Barbados Statistical Service (BSS)[8] captures and provides economic and social statistics data on the population of Barbados. The data captured by this service indicates that Barbados has a total of 78,936 occupied dwelling units (Table 2.3). Of this amount, 67,721 units are separate houses, 10,666 units fall in the Flat/Apartment/Townhouse category, 179 are part of a commercial building, and 370 are identified as "Other/Not stated".

[7]Central Statistical Office of Trinidad and Tobago (2018). Number of Business Establishments by Size and Industry. CSO. https://cso.gov.tt/subjects/business-and-industry-2/

[8]Barbados Statistical Service. (2010). Population and Demography Statistics. BSS. https://stats.gov.bb/subjects/social-demographic-statistics/population-demography-statistics/

Table 2.3 Total dwelling units based on type for Barbados.

Type of Dwelling Unit	Quantity	Percentage
Separate House	67,721	85.8%
Flat/Apt/Townhouse	10,666	13.5%
Part of a Commercial Blg	179	0.2%
Other/Not Stated	370	0.5%
Total	78,936	100%
Annual Demand	1,050	
Annual Supply (2014 to 2016)	300	
Deficit between demand and supply	500	

2.2.2 Jamaica

The Statistical Institute of Jamaica (STATIN)[9] is the local body invested with the power to analyse Jamaica census data and present the results. The data collected show an estimated 711,331 dwelling units in Jamaica. Of this amount, 642,650 (90.3%) are separate houses, 53,753 (7.6%) are attached units, 4,518 (0.6%) form part of a commercial building and the remaining 10,410 (1.5%) are "Other/Not stated". See Table 2.4.

Table 2.4 Total dwelling units based on type for Jamaica.

Type of Dwelling Unit	Quantity	Percentage
Separate House	642,650	90.3%
Flat/Apt/Townhouse	53,753	7.6%
Part of a Commercial Blg	4,518	0.6%
Other/Not Stated	10,410	1.5%
Total	711,331	100%
Annual Demand[10]	20,000	
Annual Supply (2014 to 2016)	5,000	
Deficit between demand and supply	15,000	

2.2.3 Trinidad and Tobago

Data collected from the Central Statistical Office (CSO) of Trinidad and Tobago[11] indicated 398,571 dwelling units nationwide. Of this number, 305,905 (78.8%) are separate units, 80,203 (20.1%) are attached units, and 4,218 (1.1%) are part of a commercial building. The remaining 8,245 (2.1%) are listed as "Other/Not stated".

[9]Statistical Institute of Jamaica. (2011). Number of Dwelling Units by Parish: 2001 and 2011. STATIN. https://statinja.gov.jm/Census/PopCensus/Completed/NumberofDwellingUnitsbyParish.aspx

[10]IDB (2016). The State of Social Housing in Six Caribbean Countries. https://publications.iadb.org/publications/english/document/The-State-of-Social-Housing-in-Six-Caribbean-Countries.pdft

[11]Central Statistical Office. (2011). Trinidad and Tobago Households. CSO. https://cso.gov.tt/subjects/population-and-vital-statistics/population/#-Household-Stock-and-Intercensal-Growth

Table 2.5 Total Dwelling units based on type for Trinidad and Tobago

Type of Dwelling Unit	Quantity	Percentage
Separate House	305,905	76.8%
Flat/Apt/Townhouse	80,203	20.1%
Part of a Commercial Blg	4,218	1.1%
Other/Not Stated	8,245	2.1%
Total	398,571	100%
Annual Demand[9]	10,000	
Annual Supply (2014 to 2016)	2,800	
Deficit between demand and supply	7,200	

2.3 Summary

The size of the SME landscape is estimated to be 11,275 for Barbados, 35,287 for Jamaica and 17,044 for Trinidad and Tobago. The SME sector accounts for the employment of 23% to 56% of the workforce, providing a range of services, including accommodation and food services, social and personal services, manufacturing, building, professional services and wholesale and retail trade. From the data collected on the SME sector Wholesale and Retail Trade sector was the most dominant SME industry. This industry accounted for 26%, 56% and 45% of the sector distribution for Barbados, Jamaica and Trinidad and Tobago, respectively.

Business continuity impact varies across the SME landscape based on tenure and vulnerability due to extreme climate-related events. For instance, 25% of SMEs in the USA do not reopen after extreme events. In addition, informal SMEs with less control over improvements and implementing resilience measures may be more vulnerable than those with tenure. Previous studies show that while the re-establishment of SMEs may occur after a disaster, complete recovery is a challenge[12].

Barbados, Jamaica and Trinidad and Tobago are estimated to have 78,936, 711,331 and 398,571 dwelling units, respectively. Separate (detached) houses were the most popular dwelling unit for all three nations. They account for 86%, 90% and 77% of all dwellings in Barbados, Jamaica and Trinidad and Tobago, respectively. Attached units were the second most dominant dwelling type noted in Barbados, Jamaica and Trinidad and Tobago. These include apartments, flats, townhouses, and condominiums. Dwelling units identified as part of a commercial building and "other" accounted for less than 4% of the dwelling units in all three countries. Demand for detached units is highest in the residential landscape, followed by townhouses. Current demands outstrip market supply in all

[12]Asgary, A., Anjum, M.I. and Azimi, N. (2012), "Disaster recovery and business continuity after the 2010 flood in Pakistan: Case of small businesses.", International Journal of Disaster Risk Reduction, Vol. 2, pp. 46-56.

three countries, with deficits of unmet annual demands of 500, 15,000 and 10,000 for Barbados, Jamaica and Trinidad and Tobago, respectively.

Figure 2.1 SME Sector Distribution for a) Barbados b) Jamaica and c) Trinidad and Tobago.

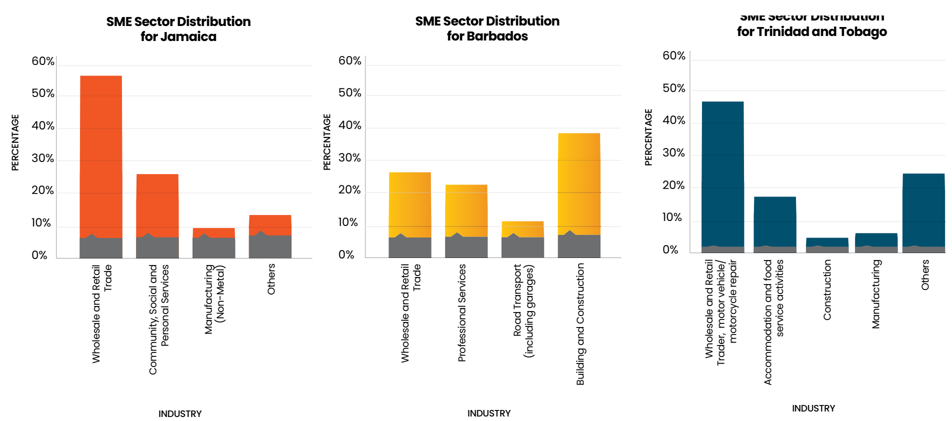
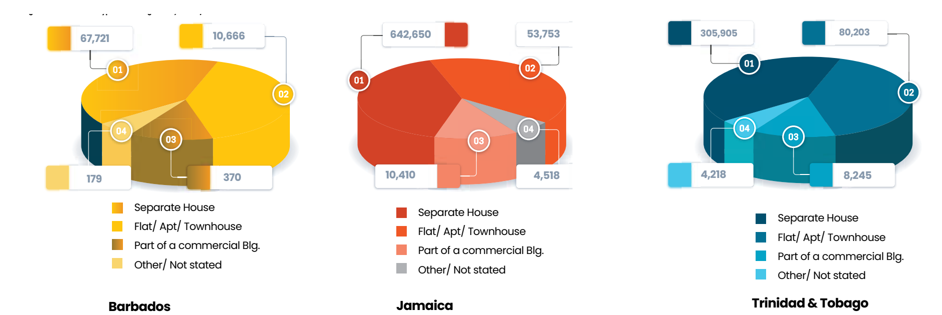


Figure 2.2 Distribution of Types of Dwelling Units by country.



3 Identification and Prioritization of Climate Hazards

Key Findings:

1. The results of the climate hazard assessment for present and future climate information are:
   a. Reduced rainfall annual totals of up to 12% with increased likelihood of more droughts.
   b. Floods will become more severe across the three countries.
   c. Barbados, Jamaica and Trinidad and Tobago's mean annual temperatures have increased to 0.9°C, with projections suggesting further increases of 0.8°C by 2059.
   d. Projections suggest increased hurricane wind speeds, frequency of intense hurricanes and TC rain rates.
   e. Droughts are expected to be a standard feature, with at least one severe drought per decade.
   f. Regional SLR suggestions align with GSLR, with a mid-century sea level rise of 0.24 to 0.49 m.
2. Damage History and Risk assessments:
   a. Hurricane winds are the predominant catastrophic hazard observed in all three countries. Floods and droughts are the 2nd and 3rd most frequently observed climate-related hazards.
   b. Annualised losses across the countries prioritise hurricane wind losses averaging US$215 million, with flooding 10 to 20 times less costly, followed by drought. Droughts were estimated to cost about US$500,000 per annum. In addition, energy consumption from increased cooling costs was estimated to cost US$1.4, 8.7 and 1.9 million per annum for Barbados, Jamaica and Trinidad, respectively.
3. Prioritisation of hazards was informed by climate and damage assessment. Prioritisation by persons affected and Average Annual Loss (AAL) suggest hurricane winds and floods ranked 1st and extreme heat or flooding 2nd. For all three countries, the order of priority ranking from 1st to 4th is hurricane winds, flooding, extreme temperature, and drought.

3.1 Present and Projected Climatic conditions

Climate information was gathered from "State of the Climate" reports and climate data portals, both historical data and projected. Climatology was defined from a 30-year average, and trends were explored from 1951 to 2020, where possible.

Table 3.1 Data sources for climatology and damage history.

Variables	Climatology, Trends and projectios
Mean and extreme rainfall	State of the Jamaican Climate (2015) and Caribbean Climate Report, CDB (2020) World Bank Climate knowledge portal *(https://climateknowledgeportal.worldbank.org)*
Mean and extreme temperatures	Caribbean Climate Report, CDB (2020) World Bank Climate knowledge portal *(https://climateknowledgeportal.worldbank.org)*
Hurricanes	IPCC Weather and Climate Extreme Events in a Changing Climate. In Climate Change 2021 AR6 Caribbean Weather Impacts Generator (CARIWIG) NOAA (2022) *https://coast.noaa.gov/hurricanes/#map=4/32/-80*
Drought and flows	SMHI, Climate Information (https://climateinformation.org)
Sea Levels	Caribbean Climate Report, CDB (2020) IPCC Climate Change (2022) AR6

3.1.1 Climatology and Trends[13]

3.1.1.1 Precipitation: Mean and Extreme

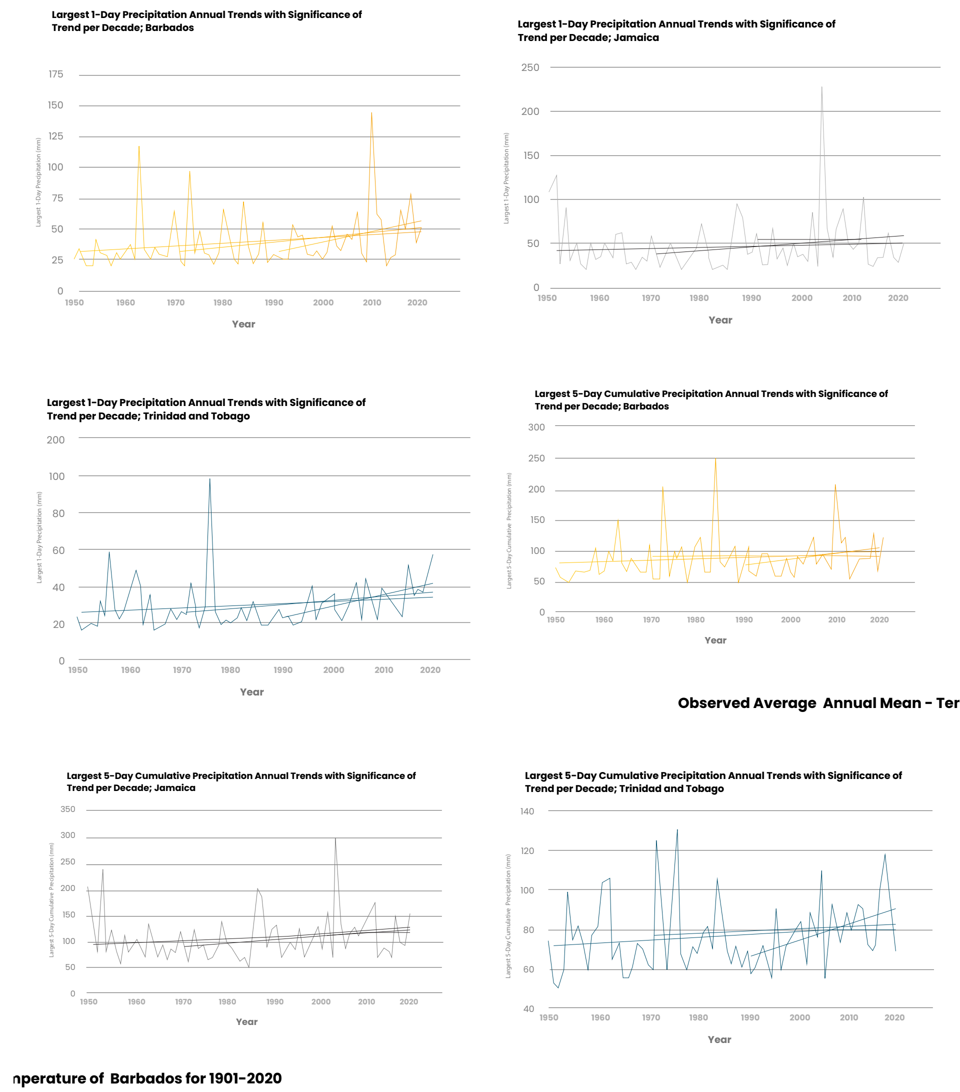
Across the Caribbean, rainfall climatology varies between unimodal and bimodal, with a rainfall season between May and November (monthly rainfall of 26 to 40 mm) and a dry season between December and April (monthly rainfall of 89 to 180 mm)[14]. For example, Barbados' monthly rainfall climatology is predominately unimodal, with a rainfall season of June to November (89 to 180 mm) and a dry season between December and May (89 to 180mm). In Trinidad and Tobago, rainfall peaks in July and August (220 to 240 mm), with a dry season between January to May (50 to 110 mm). In comparison, Jamaica's monthly rainfall climatology is bimodal, with rainfall seasons between May to June and September to November, with monthly averages of 270 to 330 mm of rain and an early dry season (mid-summer drought) between December and April and July and October with a low monthly average of 80 to 160 mm. Long-term (1950 to 2020) mean rainfall trends across the Caribbean vary between marginally decreasing to increasing trends in the recent past (1990 to 2020)[15].

[13] The World Bank Group. (2018). Download Data | World Bank Climate Change Knowledge Portal. Worldbank.org. https://climateknowledgeportal.worldbank.org/download-data
[14] Appendix Figure 8.1
[15] Appendix Figure 8.2.

The trends are insignificant and are believed to be influenced by decal and inter-annual variability. Notwithstanding, there are changes in the annual mean rainfall of 0.54 to -0.7 mm per decade across the Caribbean. Inter-annual variability suggests pronounced drying in June and July across the region, with 13.0 to -21.0 mm per decade.

The Caribbean has an increasing trend in the extreme rainfall indices (RX1 and RX5), as shown in Figure 3.1. The trends at significant levels include Trinidad's RX1 and RX5 increase of 0.67 and 0.84 mm/decade and suggest the likelihood of more flood events.

Figure 3.1 RX1 and RX5 rainfall for Barbados, Jamaica and Trinidad and Tobago for the period 1951 to 2020



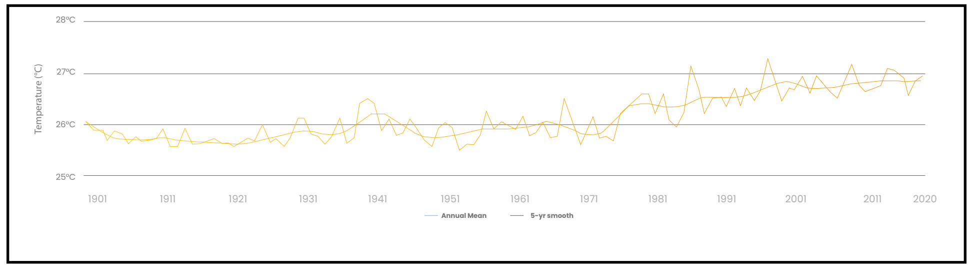
3.1.1.2 Air temperature: Mean and Extreme

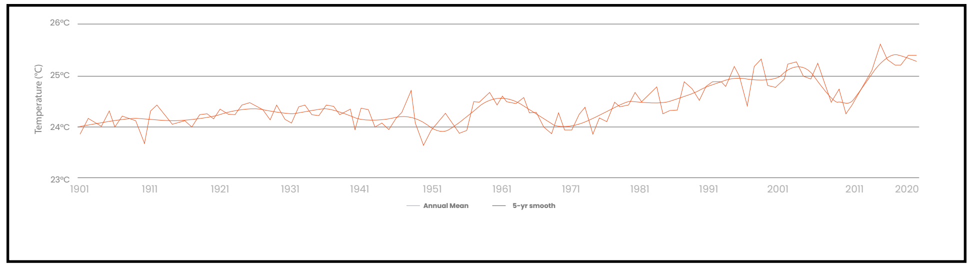
Air temperature climatology for the Caribbean suggests that the mean monthly air temperature ranges between 22°C and 28°C, with the warmest (coolest) months of May to September (October to April). See Figure 3.2. Generally, Jamaica is cooler than Barbados and Trinidad and Tobago. There is an increasing trend of about 0.1 °C per decade between 1920 and 2020, with an accelerating trend of 0.2 °C per decade between 1980 and 2020. This is also consistent with the global surface temperature trends.

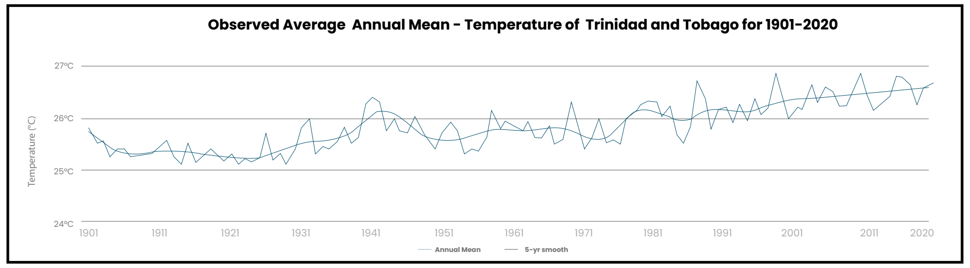
Barbados, Jamaica and Trinidad and Tobago's mean annual temperatures have increased by 0.9°C, 0.8°C and 0.8°C respectively, at an average rate of 0.14°C per decade since 1960. Generally, minimum temperatures rise faster (~0.27 °C/decade) than maximum temperatures (~0.06 °C/decade) with decreasing diurnal temperature range.

Day and night temperature trends also suggest an increasing day and marked increased night-time temperatures since 1980 and underscores hotter days and nights, with reduced diurnal range. This may have implications for the residential landscape where people who usually seek respite from high day heat might not find relief at night

Figure 3.2 Trends in air temperature for Barbados, Jamaica and Trinidad and Tobago for the period 1901 to 2020







There is an increasing trend in daily maximum and minimum temperatures for all three countries, with more pronounced changes in Jamaica. Barbados and Trinidad and Tobago have had warmer nights with increased temperatures of 0.3 to 0.5°C in the last two decades, compared to Jamaica with temperatures of 0.7 to 1.5°C. Maximum daytime temperatures have also increased in all three countries between 0.3 to 0.7°C, suggesting more extreme night-time temperatures that may drive the need for cooling.

3.1.1.3 Hurricanes[16]

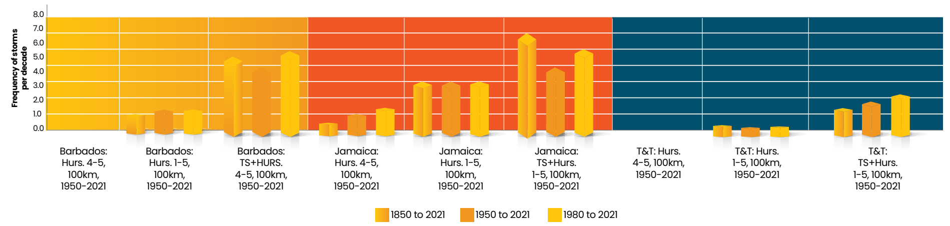
The climatology of the hurricane season in the Gulf of Mexico, Caribbean Sea and North Atlantic, which occurs between June and November, coincides with weakening trade winds (that result in decreased vertical wind shear) and increased sea surface temperatures of over 26°C. See Figure 3.3. The hurricane season peaks between August to October, with Jamaica being exposed for extended periods, both at the start (July) and end (November), as opposed to Barbados and Trinidad and Tobago.

Jamaica has the greatest hurricane exposure, averaging three hurricanes per decade within 100 kilometres, while Barbados experiences one hurricane on average per decade. Tropical storm exposure for both countries is comparable to experiencing between 5 and 7 storms per decade. Barbados experienced seven storm events between 1955-2015 but did not suffer a direct hurricane hit. Notwithstanding, Barbados does experience damage from passing storms in the form of extreme rainfall. This is in comparison to Trinidad and Tobago, which experiences 1 or 2 storms per decade.

Trends in hurricane winds activities are difficult to rationalise when factors such as climate connections to other indices (e.g., the Atlantic Multi-decal Oscillation) and changes in observation techniques and accuracy are considered. There is increasing understanding and growing consensus of a decreasing trend in the number of events and an increasing trend in the number of severe (categories 4 and 5) events. There are few observable trends in frequency for Barbados, Jamaica or Trinidad and Tobago, save and except i) increased categories 4 and 5 storms for Jamaica from about 1.0 to ~1.5 storms per decade between the periods 1950-2021 and 1980-2021, and ii) increased tropical storms for Trinidad and Tobago between 1980 to 2021, where tropical storms increased from 1 to 2 storms per decade.

[16]National Hurricane Center. (n.d.). Historical Hurricane Tracks. Coast.noaa.gov; NOAA Office for Coastal Management. Retrieved May 2022, from https://coast.noaa.gov/hurricanes/#map=4/32/-80

Figure 3.3 Tropical storm and decal frequency of cyclone activities for the periods 1850-2021, 1950-2021 and 1980-2021 for Barbados, Jamaica and Trinidad and Tobago



3.1.1.4 Drought

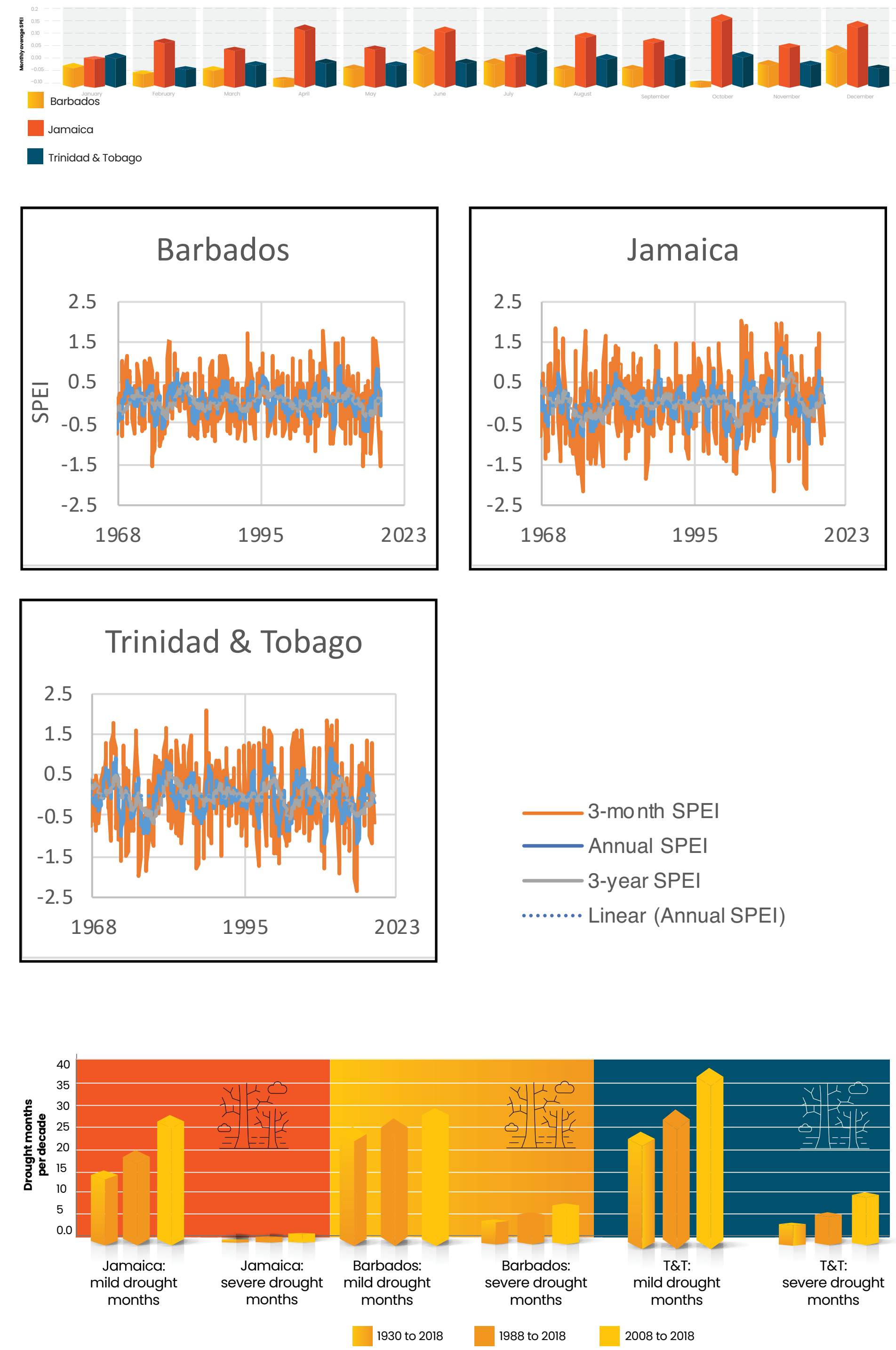
Generally, the north Caribbean (i.e., Jamaica and Cuba) seems the least prone to extreme drought compared to Barbados and Trinidad and Tobago, which have experienced extreme water stress. See Figure 3.4. Several indices measure drought based on precipitation and evaporation or flow. The indices include the Standardized Precipitation Index (SPI) and Standardized Precipitation Evaporation Index (SPEI[17]). Since the 1970's, Barbados and Jamaica experienced three severe droughts in 1975, 2010 and 2015 and 1975, 2015 and 2018, respectively, while Trinidad experienced 2 in 1976 and 2015.

Barbados' drought climatology suggests an increased likelihood of drought between January to March and again in October (with SPEI as low as -2.2 to -2.8). For Trinidad, the most likely period is February to June (with SPEI as low as -2.5 to -2.6). Jamaica's traditional dry season appears to be from January to March, when the SPEI may reach as low as -1.6 to -2.3.

Trends in SPEI and frequency of severe drought events suggest a tendency to drier conditions and increased droughts. Mild droughts (SPEI<-1.0) increased in frequency by 4 to 28% in the last decade in all three countries, with Jamaica and Trinidad being the worst affected. Severe droughts have increased more markedly for Barbados and Trinidad and Tobago by 87 to 217% in the last decade.

[17]Beguería, S., Latorre, B., Reig, F., & Vicente-Serrano, S. M. (n.d.). The Standardised Precipitation-Evapotranspiration Index. SPEI. Retrieved May 2022, from https://spei.csic.es/spei_database/#map_name=spei01#map_position=1415

Figure 3.4 Drought indices (SPEI) climatology, time series (middle) and frequency per decade (bottom) for Barbados, Jamaica and Trinidad and Tobago for the period 1930 to 2018.

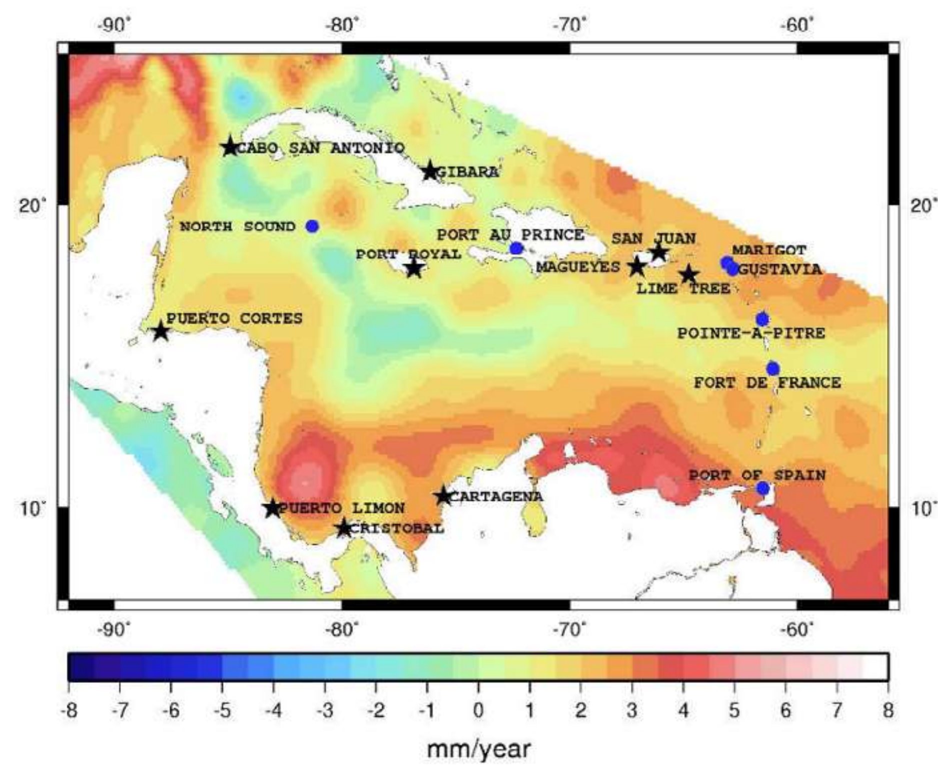


3.1.1.5 Sea Level Rise

Global sea level rise (GSLR)[18] rate is estimated at 1.5 mm/year from 1920 to 2010 or an SLR of 0.16 m from gauges. Satellite altimeter data since 1992 suggests an accelerating rate of 0.084 mm/year due to increased Greenland mass loss, resulting in a current rate (2006 to 2015) of 3.6mm/year or twice the long-term rate. This global sea level rise acceleration is expected to continue because of increased global warming.

Regionally, studies are limited due to short record lengths; however, they show Caribbean SLR trends are like global trends of 2.5 mm/year. Additionally, there are regional variations and climate connections with El Nino events. See Figure 3.5. For example, 0.26 mm/year off the coast of Venezuela to 10.76 mm/year for the Port-au-Prince, Haiti station and increased SL during strong El Nino events of up to 11.3 cm. The trends appear greatest for Trinidad and lowest for Barbados and Jamaica.

Figure 3.5 Map of altimetry-based sea level trends from 1993 to 2009 with the tide gauge locations superimposed (H. Palanisamy, et al. 2012).



18 Oppenheimer, M., Glavovic, B., Hinkel, J., Van De Wal, R., Magnan, A., Biesbroek, R., Buchanan, M., Abe-Ouchi, A., Gupta, K., Pereira, J., Oppenheimer, M., Glavovic, B., Hinkel, J., Van De Wal, R., Magnan, A., Abd-Elgawad, A., Cai, R., Cifuentes-Jara, M., Pörtner, H.-O., & Roberts, D. (2019). Chapter 4 - Sea Level Rise and Implications for Low-Lying Islands, Coasts and Communities. In Intergovernmental Panel on Climate Change (IPCC). Cambridge University Press. https://doi.org/10.1017/9781009157964.006

Identification and Prioritization of Climate Hazards

3.1.2 Projections

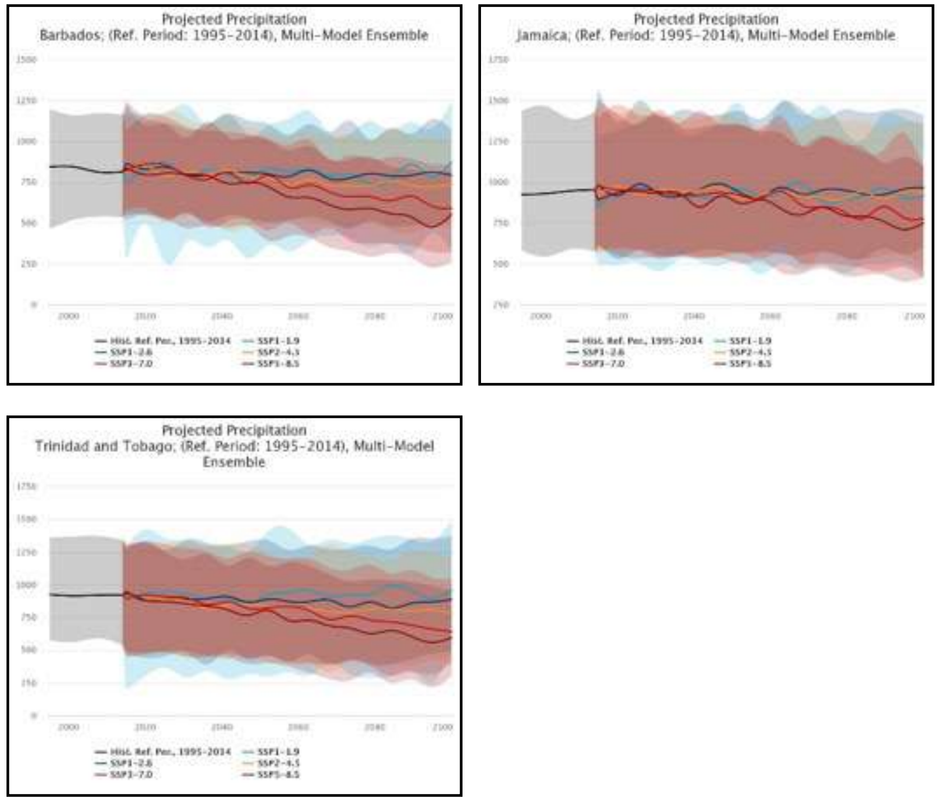
Future climate projections were limited to the mid-term (2050 to 2070) for Shared Socioeconomic Pathway 2, which approximates Representative Concentration Pathway 4.5 or near the middle of the road outlook. This is believed to represent the current and projected conditions in the future and avoids extreme scenarios.

3.1.2.1 Precipitation: Mean and Extreme

Precipitation is projected to be reduced by 6 to 12%, with the most significant changes occurring across the three countries in the early dry season. The most significant changes are projected in Barbados and Trinidad and Tobago, with Jamaica expected to experience 2 to 7% reductions. The projections suggest the likelihood of more drought events. See Figure 3.6 and Appendix 8.2.1.

RX1 and RX5 display increasing trends in the projects, with 12 to 20% increases in RX1 and 16 to 33% increases in RX5. The projections strongly suggest the likelihood of more flood events.

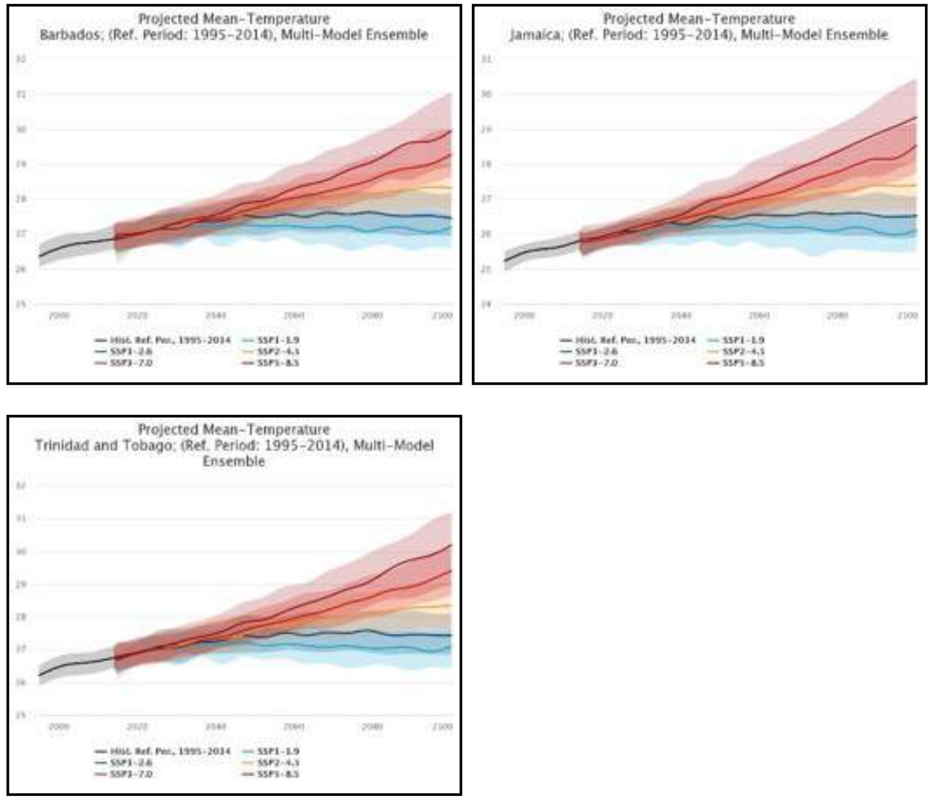
Figure 3.6 Projected annual precipitation and climatology mean for Barbados, Jamaica and Trinidad and Tobago for the period 2040 to 2059, from SSP 2 (RCP 4.5) ensemble means.



3.1.2.2 Air temperature: Mean and Extreme

Air temperature increasing trends continue to 2059 when increases of 0.8°C are expected across the three countries. See Figure 3.7 and Appendix 8.2.2. This is consistent with global and regional accelerating trends of 0.2°C per decade from 1980 to 2020. In addition, more significant temperature increases are expected in peak summer months (August and September) where nighttime temperatures are expected to rise by 1.3.°C. This is likely to have implications for increased cooling requirements for both the residential and SME sectors.

Figure 3.7 Projected mean, max of maximum and min of minimum climatology in air temperature for Barbados, Jamaica and Trinidad and Tobago for the period 2040 to 2059, from SSP 2 (RCP 4.5) ensemble means.



3.1.2.3 Hurricanes

IPCC AR6 Special Report on Weather and Climate Extreme Events in a Changing Climate (2021)[19] offer several insights on how hurricanes may change in the mid-century. In summary,

1. Hurricane wind speeds will increase average peak TC wind speeds. The increase in global TC maximum surface wind speeds is about 5% for a 2°C global warming is projected.

[19]Seneviratne, S.I., X. Zhang, M. Adnan, W. Badi, C. Dereczynski, A. Di Luca, S. Ghosh, I. Iskandar, J. Kossin, S. Lewis, F. Otto, I. Pinto, M. Satoh, S.M. Vicente-Serrano, M. Wehner, and B. Zhou, 2021: Weather and Climate Extreme Events in a Changing Climate. 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-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, Cambridge, United Kingdom and New York, NY, USA, pp. 1513–1766, doi:10.1017/9781009157896.013

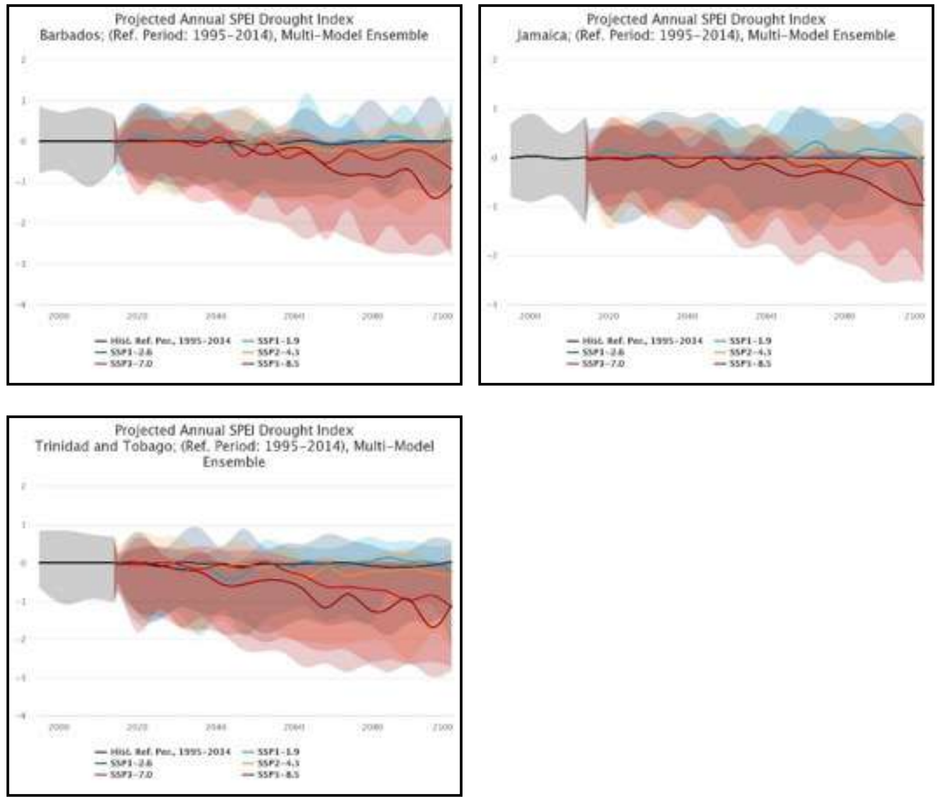
2. Intense hurricane frequencies will increase, according to Emanuel (2013)[20]: the proportion of Category 4–5 TCs will likely increase globally with warming.

3. Average TC rain rates will likely increase with warming. A projected increase in global average TC rain rates of about 12% for a 2°C global warming is projected.

3.1.2.4 Drought

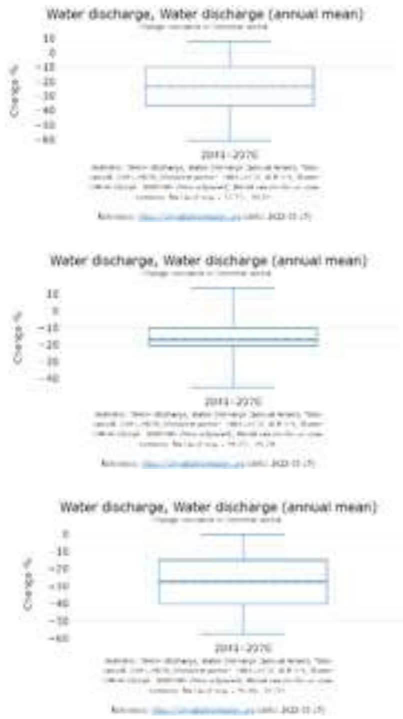
Drought is expected to be a standard feature each decade, with at least one severe drought per decade on average. See Table 8.3 and Figure 3.8. By 2059, discharges for major streams and rivers are expected to decline by 15 to 50%, with the most significant decreases in Barbados and Trinidad and Tobago. This has implications for surface water sources that will likely become less reliable. Overall, the drying impact will affect all three islands but is expected to be more severe in Barbados and Trinidad.

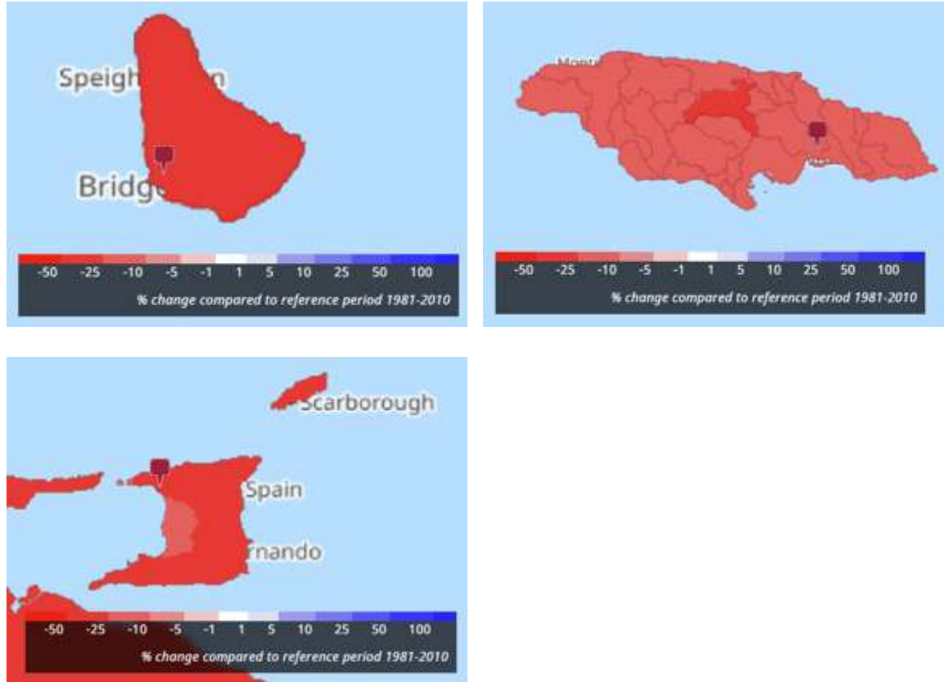
Figure 3.8 Projected drought indices (SPEI) annual mean for Barbados, Jamaica and Trinidad and Tobago for the period 2040 to 2059, from SSP 2 (RCP 4.5) ensemble means (top) and water discharge[21] annual mean for the period 2041 to 2070 for RCP 4.5 CMIP5 Global bias adjusted model (middle and bottom).



[20]Emanuel, K. A. (2013). Downscaling CMIP5 climate models shows increased tropical cyclone activity over the 21st century. Proceedings of the National Academy of Sciences, 110(30), 12219–12224. https://doi.org/10.1073/pnas.1301293110

[21]Green Climate Fund. (n.d.). Data Access Platform. Climateinformation.org. Retrieved May 2022, from https://dap.climateinformation.org/



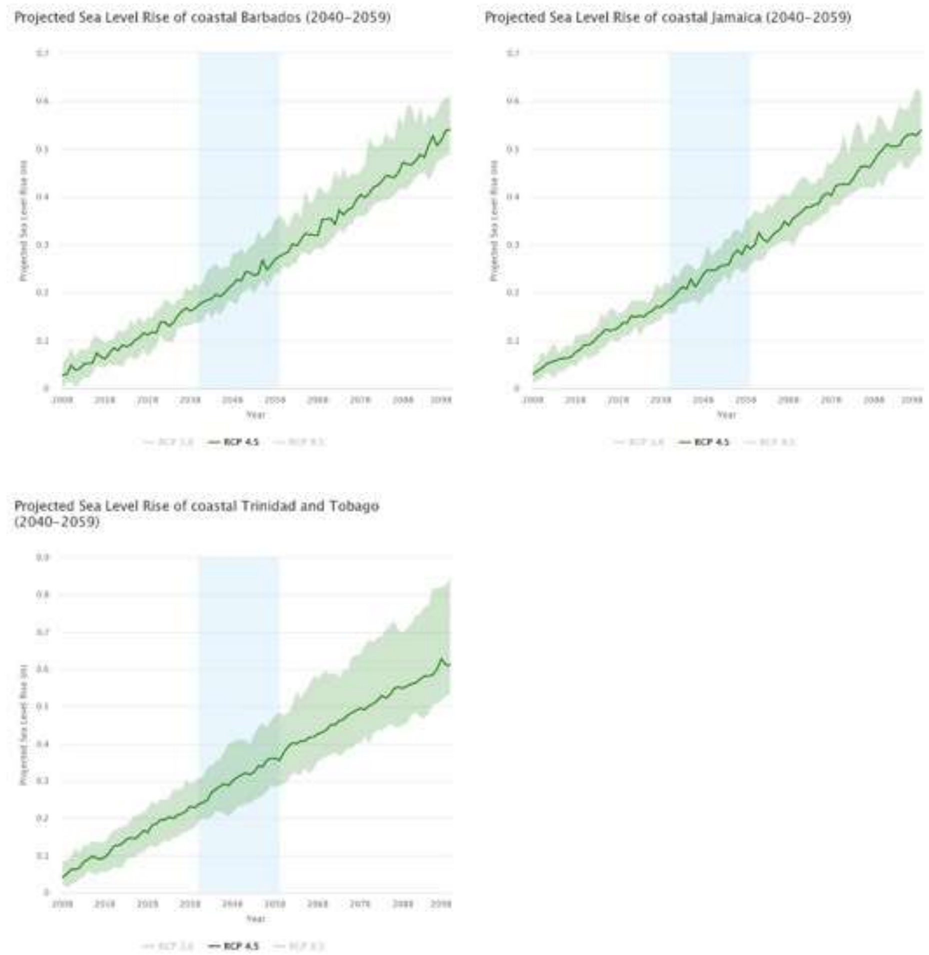


3.1.2.5 Sea Level Rise

Sea-levels are projected to rise across the Caribbean, in line with GSLR, with mid-century of 0.24 and 0.49 m, with Trinidad and Tobago having the highest projected mean increase of 0.36 m by 2059. See Figure 3.9. The end of century SLR is projected to be as high as 0.84 m for Trinidad, with Barbados and Jamaica projected to be lower at 0.61 and 0.62 m respectively, and congruent with the historical trends.

Identification and Prioritization of Climate Hazards

Figure 3.9 SLR projections for Barbados, Jamaica and Trinidad and Tobago under SSP 2



3.2 Hazards: Damage History and Risks

Data on the damage history of the hazards was retrieved from multiple sources and is included in the findings. The data was mainly sourced from:

i. EM-DAT[22] International Disaster Database – a compilation of essential core data on the occurrence and effects of over 22,000 mass disasters in the world from 1900 to the present day. The database is compiled from various sources, including UN agencies, non-governmental organisations, insurance companies, research institutes, and press agencies.

ii. Economic Commission for Latin America and the Caribbean (ECLAC) Study[23] highlights energy efficiency trends in selected Caribbean countries.

[22] Centre for Research on the Epidemiology of Disasters (CRED). (n.d.). EM-DAT International Disaster Database. Retrieved June 15, 2022, from https://public.emdat.be/

[23] Lapillone. (2019). Study on trends in energy efficiency in selected Caribbean countries. Economic Commission for Latin America and the Caribbean (ECLAC). Retrieved from https://repositorio.cepal.org/bitstream/handle/11362/45046/1/S1900929_en.pdf

iii. Energy Transitions Initiative (ETI) Energy Snapshots (2022) highlight the energy landscape of islands in the Caribbean, including Barbados[24], Jamaica[25] and Trinidad and Tobago[26] and the Pacific and the surrounding areas. .

3.2.1 Catastrophic

Records of catastrophic events between 1955 and 2021 (66 years) and the impact of climate-related hazards offered insights that assisted in prioritising the hazards and the relevant resilience measures. Two primary and reliable data sources were available in EM-DAT and ECLAC reports. Records are, however, biased as they represent catastrophic events. Nonetheless, they are the best sources of data. First, Latin American and Caribbean (LAC) countries were explored, followed by Barbados, Jamaica and Trinidad and Tobago. This allowed for an exploration of the relative magnitude of the disaster history for LAC countries with a population of 44 million compared to the subject countries with a combined population of approximately 4 million.

The impact of climate-related events is far-reaching because of the frequency and magnitude of the events. In addition, dense populations and socio-economic conditions drive vulnerability. Therefore, we explored the five major hazards (hurricanes, floods, drought, coastal flooding, and heat waves) across the residential and SME sectors. However, there were limitations in how the residential and SME sector's damage history was investigated related to data being limited to persons affected and normalised damage. As a result, the residential sector is explored in terms of persons affected. In addition, normalised US$ is a proxy for the damage to the SME sector representing most of the three countries' economies.

3.2.1.1 Regional and sub-regional scale

Hurricane winds are the predominant catastrophic hazard observed in the three subject countries (45 country events), speaking to the homogeneity of exposure to the north Atlantic hurricane belt across the region, as seen in Figure 3.11. Floods and droughts were the 2nd and 3rd most frequent climate-related hazards.

The frequency of the hazards in Barbados, Jamaica, and Trinidad and Tobago is mirrored by the number of people affected and the total damage. Cyclones affected more than 1.77 million people in all three countries. The fact that the cost of damage from cyclones is 15 times greater than that of floods (US$6 billion vs US$0.4 billion) highlights the need for increased hurricane resilience. Despite this, the number of people affected by floods (1 million) is not significantly different from that of hurricanes (1.7 million), highlighting the need to consider both costs and affected individuals when implementing mitigation measures.

Annualised losses point to the disproportionally heavy losses inflicted by hurricane winds averaging US$215 million in the three subject countries. On the other hand, flooding has historically been 10 to 20 times less costly, followed by drought. Therefore, consideration of the impact of both hurricane winds and flood should be prioritised. Coastal floods and heat waves have occurred across the three countries, but the costs are considerably less and events relatively infrequent in comparison to cyclones, floods, and droughts.

Figure 3.10 Number of recorded catastrophic climate-related events since 1955, across the three countries (Source: EMDAT)

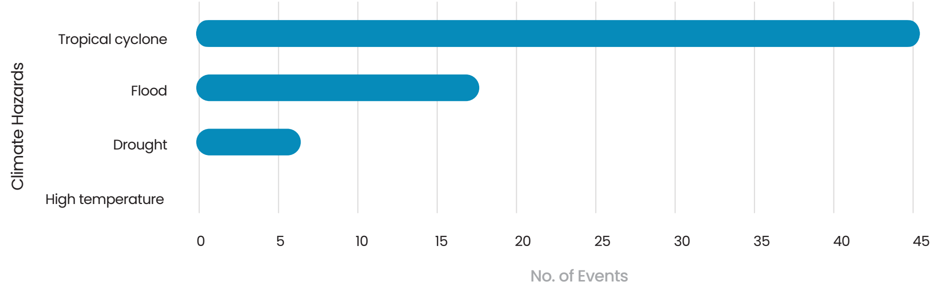
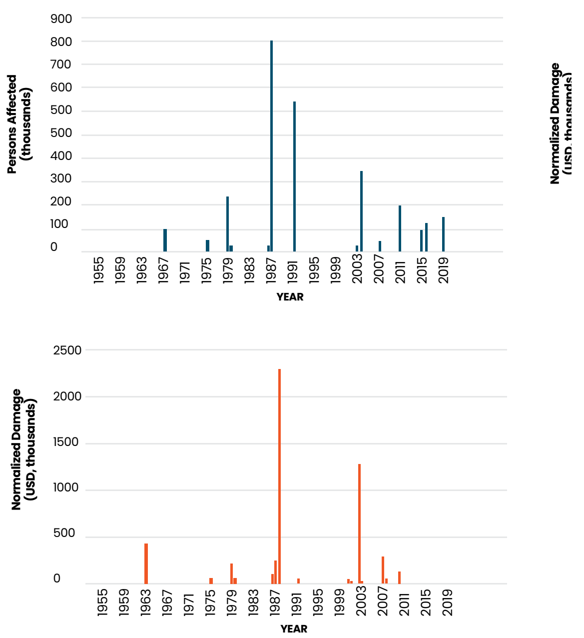


Figure 3.11 Catastrophic climate-related events time series of persons affected and normalized damage for Barbados, Jamaica and Trinidad and Tobago for the period 1955 to 2021 from EMDAT.



[24]National Renewable Energy Laboratory (NREL). (2020, June). ETI Energy Snapshot - Barbados. Office of Energy Efficiency &; Renewable Energy. Retrieved June 2022, from https://www.energy.gov/sites/prod/files/2020/09/f79/ETI-Energy-Snapshot-Barbados_FY20.pdf
[25]National Renewable Energy Laboratory (NREL). (2020, June). ETI Energy Snapshot - Jamaica. Office of Energy Efficiency &; Renewable Energy. Retrieved June 2022, from https://www.energy.gov/sites/prod/files/2020/09/f79/ETI-Energy-Snapshot-Jamaica_FY20.pdf
[26]National Renewable Energy Laboratory (NREL). (2020, November). ETI Energy Snapshot - Trinidad and Tobago. Office of Energy Efficiency &; Renewable Energy. Retrieved June 2022, from https://www.energy.gov/sites/prod/files/2020/11/f80/ETI-Energy-Snapshot-Trinidad-Tobago-FY21.pdf

3.2.1.2 Country scale: Barbados, Jamaica and Trinidad and Tobago

The country-level assessment focuses primarily on the impact of hurricane winds (in terms of both affected individuals and total damages) and occurrences. See Table 3.2 and Figure 3.12. Hurricane winds are 2 to 4 times more frequent than floods and droughts across the three countries. Additionally, the damage is 10 to 50 times greater than the other hazards. However, Trinidad and Tobago's flood experiences are the exception, impacting three times more people than cyclones.

Average annualised losses (AAL) across the three countries suggest that tropical cyclones, followed by floods, are the two most important climate-related hazards, with cyclones being 10 to 100 times costlier than floods. Although 1, 4 and 1 drought events were recorded for Barbados, Jamaica and Trinidad and Tobago, respectively, from 1900 to 2021, no cost estimate was found in the literature of the countries to enable an estimate of the AAL. However, the following could be summarised:

1. Jamaica's hurricane winds AAL (US$162 million) is 40 times that of both Barbados (US$4.1 million) and Trinidad and Tobago (US$4.9 million)
2. Barbados (US$0.1 million) and Trinidad and Tobago (US$0.06 million) flood AAL are comparable. Table 3.3. show catastrophic damage history (total normalised damage, persons affected, number of events and average annualised damage and losses) of Barbados, Jamaica and Trinidad and Tobago from 1955 to 2021.

Identification and Prioritization of Climate Hazards

Table 3.2 AAL Estimates across the three countries for the different hazards.

	Total Damages, Adjusted ('000 US$)	Total Damages as a % of GDP	Total Affected (Percentage of Population)	Number of Events	AAL (USD, Million)
BARBADOS (2020) POPULATION = 287,000 AND GDP = USD4.4 BILLION)					
Hurricane Winds	$251	0.006%	13917 (57%)	9	$4.1
Flood	$3	0%	310 (57%)	2	$0.1
Drought	$0	0%	0	1	$0.0
Coastal Flood	$0	0%	0	0	$0.0
Heat Wave	$0	0%	0	0	$0.0
JAMAICA (2020) POPULATION = 3 MILLION AND GDP = USD13.8 BILLION)					
Hurricane Winds	$5,355	0.039%	1704705 (57%)	29	$162
Flood	$373	0.003%	903712 (30%)	13	$11
Drought	$13	0%	191545 (6.6%)	4	$0
Coastal Flood	$0	0%	0	0	$0
Heat Wave	$0	0%	0	0	$0
TRINIDAD AND TOBAGO (2020) POPULATION = 1.4 MILLION AND GDP = USD21.5 BILLION)					
Hurricane Winds	$357	0.002%	51560 (3.6%)	7	$4.93
Flood	$4	0%	150210 (10.9%)	3	$0.06
Drought	$0	0%	0	1	$0.00
Coastal Flood	$0	0%	0	0	$0.00
Heat Wave	$0	0%	0	0	$0.00

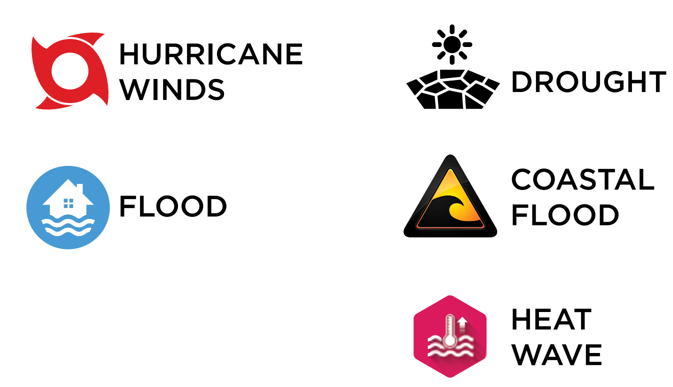
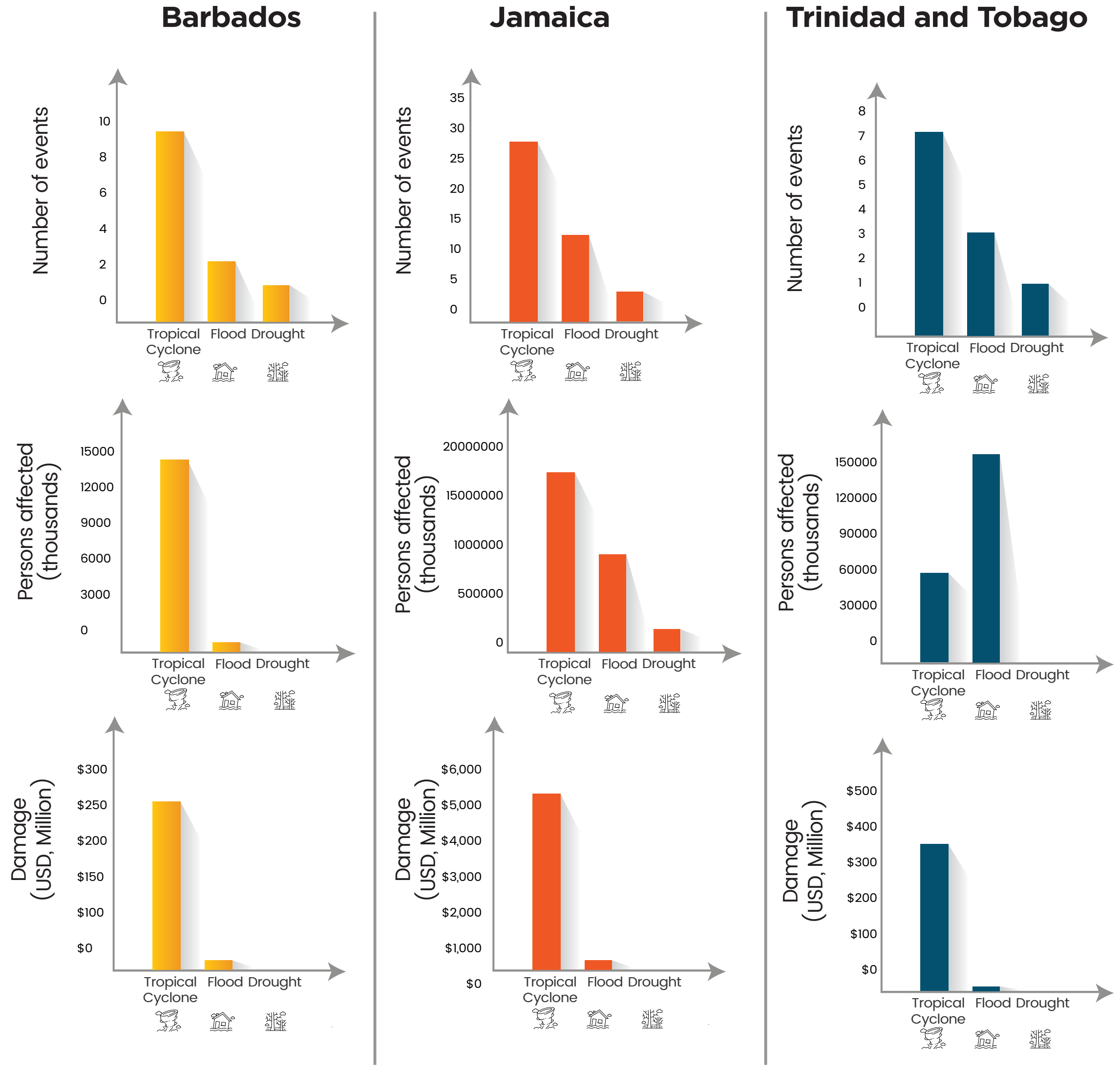


Figure 3.12 Catastrophic climate-related events occurrence, persons affected and total damage (US$) for Barbados, Jamaica and Trinidad and Tobago for the period 1955 to 2021 from EMDAT.



3.2.2 Droughts

There is limited information on the material losses from droughts across the region, save for qualitative descriptions of impacts. Notwithstanding, several regional publications have derived present and future annual estimates as follows:

1. Barbados: there were 22 drought events between 1946 and 2009, with 1994 to 1995 events affecting 3000 households and IDB (2019)[27] noting the 2008/2009 and 2016 episodes.
2. Jamaica: Severe droughts between 2013 and 2014 cost Jamaica US$6.5 million (USAID, 2022[28]). Drought costs in 2019/2020 cost the Ministry of Agriculture US$200,000 in response. Since 1987, there have been three severe droughts, with estimated annualised losses of US$210,000.
3. Trinidad and Tobago: The severe impact of the 2009/2010 drought episode was discussed in IDB (2017)[29], and present and future climate estimates of losses of US$220,000 and 270,000, respectively, were derived

3.2.3 Heat

Electricity consumption for cooling loads is expected to increase due to increased daytime and night-time temperatures and are comparable to AAL of historical damages identified in Table 3.3. For example, the annual change in heat-related costs for Barbados is estimated at US$1.4 million, whereas the average yearly loss from hurricane winds is US$4.1 million. The energy consumption of residential and commercial sectors in the three countries allowed for cost estimates of cooling loads in the present and future climate. The estimate accounts for increased temperatures and energy consumption on the grid. Still, it does not consider the increased use of mitigation measures or renewable energy sources across the Caribbean. Therefore, it is likely that the estimate is conservative and that cooling load impacts will be lower in all three countries. Annual changes in cooling costs are believed to be comparable to AAL for natural hazard impacts, as they represent an increase in cost due to the temperature rise. The estimated costs of the effects of climate change to 2059 are US$1.4, 8.7 and 1.9 million per annum for Barbados, Jamaica and Trinidad and Tobago, respectively.

[27]Shik, O., Boyce, R., & Paolo De Salvo, C. (2019). Analysis of Agricultural Policies in Barbados 2016. In IADB. Inter-American Development Bank. https://publications.iadb.org/publications/english/document/Analysis_of_Agricultural_Policies_in_Barbados_en_en.pdf

[28]Weller, K. (2021, June 11). Still Standing, Still Serving in the Midst of Extreme Weather. Usaid.gov. https://www.usaid.gov/jamaica/news/still-standing-still-serving-midst-extreme-weather

[29]IDB, Factor CO2, IH Cantabria, & University of the West Indies. (2014). Understanding the Economics of Climate Adaptation in Trinidad and Tobago. In IADB. Inter-American Development Bank. https://publications.iadb.org/publications/english/document/Understanding-the-Economics-of-Climate-Adaptation-in-Trinidad-and-Tobago-Full-Report.pdf

Table 3.3 Estimate annual cooling costs in the present and future climate for Barbados, Jamaica and Trinidad and Tobago

	BARBADOS	JAMAICA	TRINIDAD & TOBAGO
Total Annual Electricity consumption (GWh)[30]	970	4020	8590
Cost per KWH (USD/KWH)[31]	$0.25	$0.28	$0.05
% Residential	33%[32]	37%[33]	33%[34]
Present climate cooling costs - residential (USD, Millions)	$8.2	$45.1	$15.4
Future climate cooling costs - residential (USD)	$10	$54	$18
Climate change impact	$2	$9	$3
Present climate cooling costs - commercial (USD)	$7.8	$78.7	$7.7
Future climate cooling costs - commercial (USD)	$8.9	$87.4	$8.5
Climate change impact	$1.0	$8.7	$0.9
Total cooling costs- present climate[35]	$16.1	$123.8	$23.1
Total cooling costs- future climate	$18.9	$141.3	$26.9
Δ Cooling cost (USD Millions) due to climate change	$1.4	$8.7	$1.9

3.3 Prioritization

The approach taken to identify and prioritize the climate-related risks to the residential and SME sector included climate information reviews and assessments and analysis and assessment of the damage history of the sectors. Hazards were prioritized based on a combination of individuals affected and AAL across the three countries. The prioritizations are:

Table 3.4 Hazard prioritization of each country based on the results of climate and damage assessments.

Priorities	Barbados (both residential and SME)	Jamaica (both residential and SME)	Trinidad and Tobago (residential)	Trinidad and Tobago (SME)
1st	Hurricane Winds	Hurricane Winds	Flood	Hurricane Winds
2nd	Heat wave	Flood	Hurricane Winds	Heat wave
3rd	Flood	Heat wave	Heat wave	Drought
4th	Drought	Drought	Drought	Flood

[30]Ritchie, H., Roser, M., & Rosado, P. (2020). Energy. Our World in Data. https://ourworldindata.org/energy/country

[31]Electricity prices around the world, December 2021 | GlobalPetrolPrices.com. (2021). GlobalPetrolPrices.com. https://www.globalpetrolprices.com/electricity_prices/

[32]U.S. Department of Energy. (2020). Barbados Island Energy Snapshot 2020. Energy.gov. https://www.energy.gov/eere/downloads/barbados-island-energy-snapshot-2020

[33]U.S. Department of Energy. (2020). Jamaica Island Energy Snapshot 2020. Energy.gov. https://www.energy.gov/eere/downloads/jamaica-island-energy-snapshot-2020

[34]U.S. Department of Energy. (2020). Trinidad & Tobago Island Energy Snapshot 2020. Energy.gov. https://www.energy.gov/eere/downloads/trinidad-tobago-island-energy-snapshot-2020

[35]Total cooling costs for the present climate were calculated by multiplying the total annual energy consumption x the cost (US$/KWH) x %cooling to total consumption. For the future climate, the projected percentage increase in temperatures (IPCC 2020) was also factored into the consumption value.

The recommended prioritisation approximates existing national-level prioritisations as follows:

1. Barbados: Department of Emergency Management (DEM) (2014) notes that 1st and 3rd place-ranked hazards were hurricane winds and floods[36], respectively.
2. Jamaica: IDB (2019) determined wind and flood AAL of US$124 and US$9 million, respectively, compared to the US$161 and US$ 11 million determined here and supports the prioritisation.
3. Trinidad and Tobago: ODPM (2014) Preliminary Vulnerability Assessment of Trinidad and Tobago ranked flooding and Hurricane winds as 1st and 2nd ranked climate-related priorities.

3.4 Summary

1. The results of the climate hazard assessment for present and future climate information showed:

   a. Drying trends in June and July across the three countries and increasing trends in extreme rainfall indices. Projections are for reduced annual totals of 6 to 12% with an increased likelihood of more drought events and 12 to 33% increases in maximum consecutive 1-day (RX1) and maximum consecutive 5-day (RX5) rainfall. Floods will become more severe across the three countries.

   b. Barbados, Jamaica and Trinidad and Tobago's mean annual temperatures have increased to 0.9°C with marked increases in night-time temperatures of 0.7 to 1.5°C. Projections suggest further increases of 0.8°C to 2059 and 1.3°C for night-time temperatures.

   c. While Jamaica has a higher hurricane exposure, the tropical storm exposure is comparable to Barbados, which experiences between 5 and 7 storms per decade. Therefore, projections suggest increased hurricane wind speeds, frequency of intense hurricanes and TC rain rates.

   d. Barbados, Jamaica, and Trinidad and Tobago have typically experienced three severe droughts since the 1970s, with an increased likelihood of drought between January to March and again in October with trends of increasing droughts in recent times. Droughts are expected to be a standard feature, with at least one severe drought per decade.

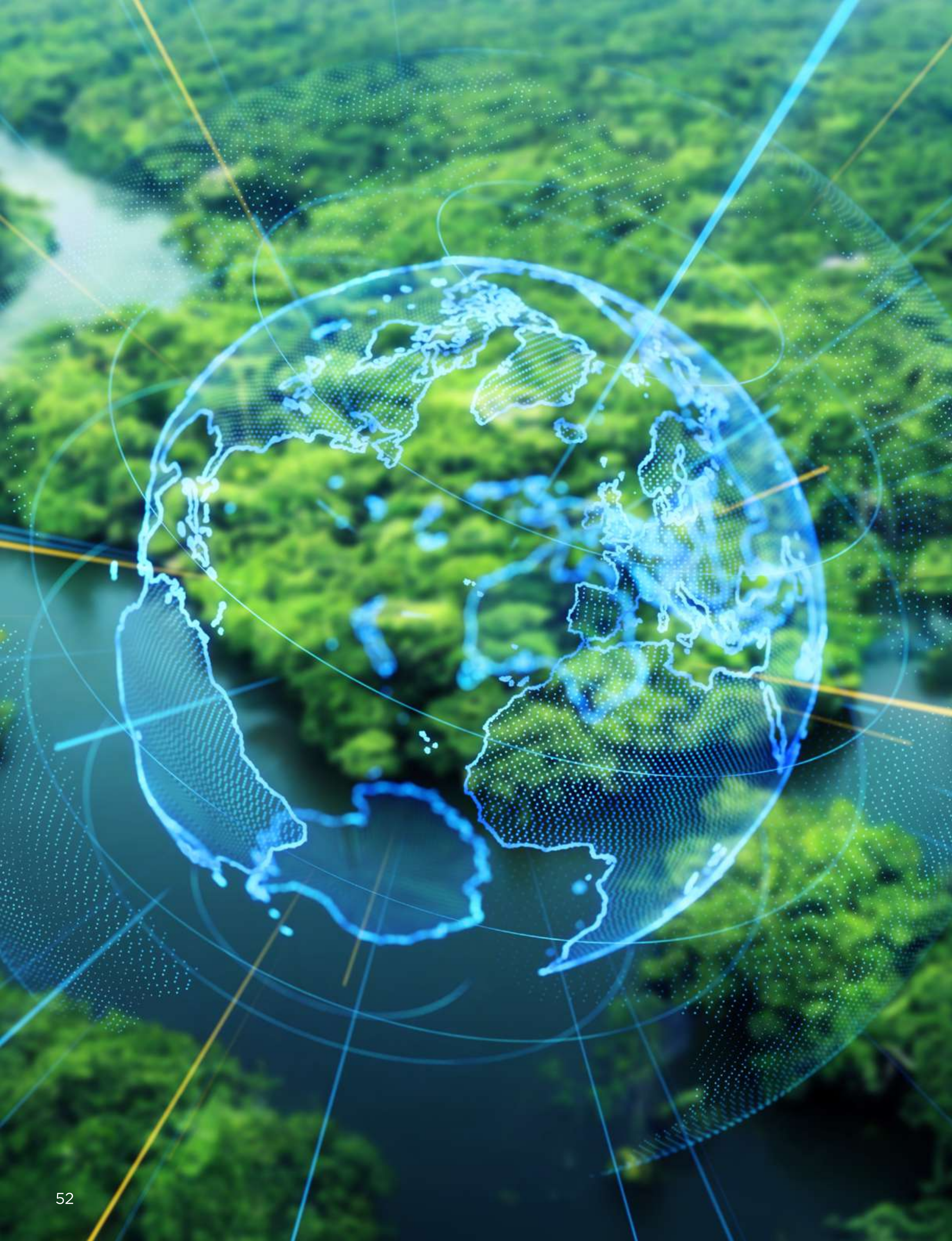
   e. Regional SLR suggests 2.5 mm/year trends, with regional variations being most significant for Trinidad and lowest for Barbados and Jamaica. Projections align with GSLR, with a mid-century sea level rise of 0.24 and 0.49 m.

[36]Evanson, D. (2014). Country Document for Disaster Risk Reduction: Barbados, 2014. In DIPECHO LAC. Department of Emergency Management (DEM). https://dipecholac.net/docs/files/784-documento-pais-barbados-web.pdf

Identification and Prioritization of Climate Hazards

2. Damage history and risk assessments from 1955 to 2021 indicate that hurricane winds are the predominant catastrophic hazard observed in both LAC and the three subject countries. Floods and droughts were the 2nd and 3rd most frequent climate-related hazards. Annualised losses across the countries prioritise hurricane winds losses that average US$215 million, with flooding 10 to 20 times less costly, followed by drought. Droughts are difficult to assess, given limited information but are estimated to cost about US$500,000 annually. Energy consumption from increased cooling costs is estimated to cost US$1.4, 8.7 and 1.9 million per annum for Barbados, Jamaica, and Trinidad and Tobago, respectively.

3. Prioritisation, by the number of persons affected and AAL, resulted in hurricane winds and floods typically being ranked 1st and 2nd, while extreme heat and droughts are ranked 3rd and 4th. Again, these generally align with national rankings



4 Resilience Measures

Key Findings:

1. Architypes, representing market share for residential and SME buildings, were chosen from consultation across the three countries. The characteristics are as follows:
   a. Residential: 70 m2 affordable-income housing solutions with concrete walls and hip roofs
   b. SME: 465 m2 warehouses for 50 to 100 employees with mezzanine floors, sandwich thermal insulation steel sheeting cladding.
2. Building codes must be more comprehensive, and gaps in incorporating climate resilience measures in construction are identified.
3. Cost premiums across residential and SME units for the three countries are relatively small and add an average of 1.5 and 1.3% to the base cost of the units, respectively.
4. Resilience measures are marginally more expensive for Jamaica than Barbados and Trinidad and Tobago and generally more expensive for application to SME units than residential units. The difference in costs is attributed to the economic conditions of each country, including GDP, taxes and tariffs and market conditions.
5. Overall, climate resilience measures are expected to present few economic hurdles to development costs, and consideration can be given to incorporating drought and heat mitigation measures as they are cost-effective.

4.1 Architypes for residential and SME

Architypes that are representative of the market share for both residential and SME buildings were chosen from consultation across the three countries. The characteristics are as follows:

Table 4.1 Examples of Architypes for residential and SME

75 m2 affordable-income housing solutions with concrete walls and hip roofs

465 m2 warehouses for 50 to 100 employees with mezzanine floors, sandwich thermal insulation steel sheeting cladding

Resilience Measures

4.2 International Best Practices

4.2.1 Flooding Mitigation Measures

The methodology to determine international best practices for residential and SME structures included desktop research for the hazards to gather information on recommended international best practices for mitigation measures. A review of past studies on flooding and hurricanes also assisted in identifying mitigation measures that could apply to Trinidad, Jamaica, and Barbados. Drought and High temperatures were analysed using energy models.

4.2.2.1 Elevating the Structure

Elevating a structure to avoid floods can prevent property damage and loss of life. However, the elevated structure must also withstand all the relevant loads, including static flood loads.

Figure 4.1 A completed single story unit of a 90-unit project in Trinidad and Tobago.

A structure can be elevated using columns, piles, foundation perimeter or stem walls. The structure should be designed to resist floatation, collapse, permanent lateral displacement, erosion and scour because of flood loads. Using fill as a structural support to elevate structures in flood-prone areas is not advised. The structure's elevation would be determined based on the elevation of the design flood as specified by local authorities. This mitigation measure applies to both residential and SME buildings.

4.2.2.2 Flood Doors

Flood doors prevent water ingress from entering homes/buildings during flood events. While preserving the aesthetics of the building, these doors act as a permanent barrier when closed, as there is no need for activation during a flood event. This flood mitigation measure provides no disruption to day-to-day activities. This flood mitigation measure applies to both residential and SME buildings.

Figure 4.2 Flood door after installation in New York, USA.

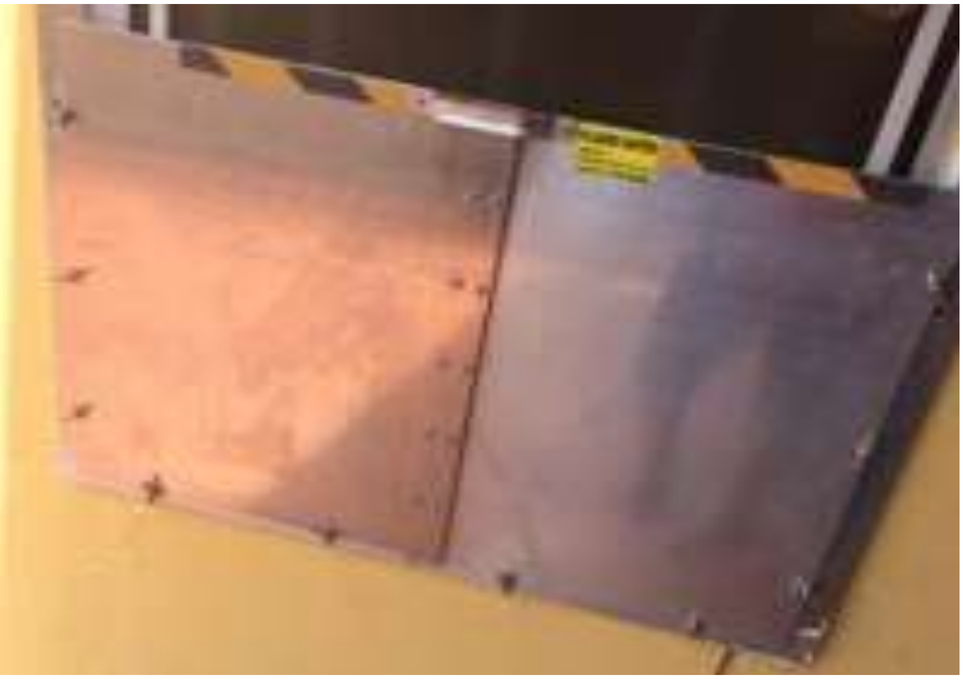
4.2.2.3 Permanent Flood Barriers

Flood barriers prevent floods from infiltrating weak spots such as doors and windows and bear impact loads caused by flood waters. As shown below, they can be used with flood doors or placed in other areas. These permanent barriers can also be:

1. Fixed: concrete, masonry
2. Demountable: galvanized, steel

Figure 4.3 Permanent Flood Barrier installed at a SME in Trinidad and Tobago.

Figure 4.4 Permanent Floor Barrier installed in Trinidad and Tobago

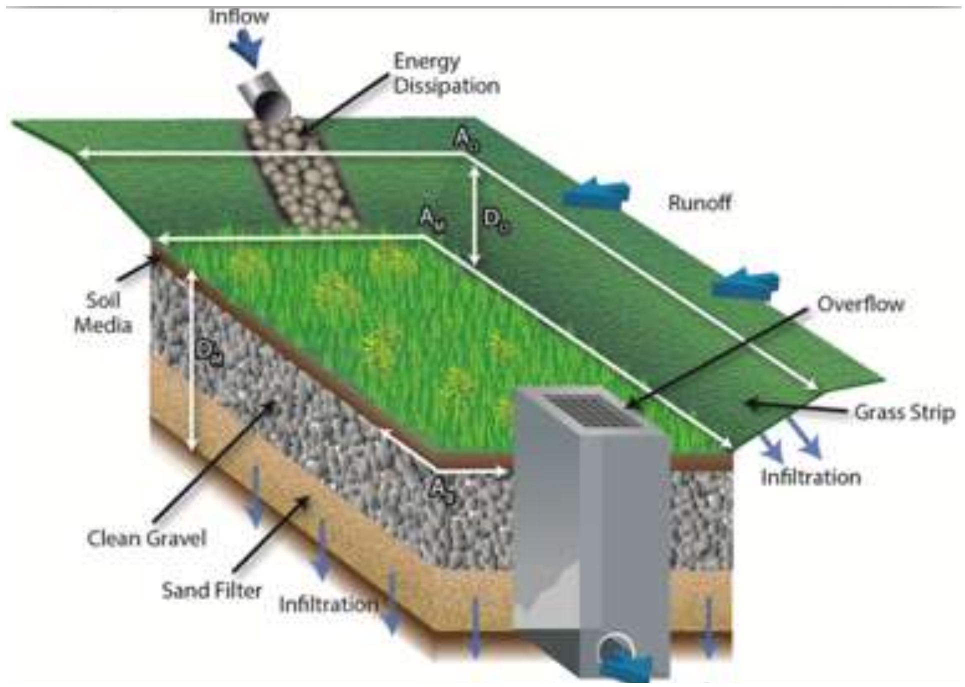


These permanent barriers are fixed in place and should be designed to resist floatation, collapse, permanent lateral displacement, erosion and scour because of flood loads. They are available in different sizes and materials, making them suitable for residential and SME buildings.

4.2.2.4 Storm Water Retention & Infiltration Basins

Adding impermeable surfaces via urban development removes opportunities for stormwater to reabsorb into the ground. Stormwater retention and infiltration basins can compensate for this by collecting excess water during rainfall and recharging groundwater aquifers.

Figure 4.5 a) Diagram of infiltration basin and b) Stormwater Retention Pond, Church Village Green, Bridgetown.



Resilience Measures

A green roof/living roof refers to the roof of a building where a layer of vegetation is planted over a waterproofing system with a growing medium installed on top of a flat or slightly sloped roof. A green roof may include drainage and irrigation systems. Green roofs contain a medium for planting and vegetation and are considered a flood mitigation measure. The green roof aids in reducing the amount of water in the runoff due to its ability to store water in the soil substrate. This mitigation measure is mainly applicable to SME buildings.

Figure 4.6 Examples of Green Roof atop: a) residential - Singapore and b) commercial building – Chicago, USA.

Rainwater harvesting is the collection of roof runoff in moderate to heavy rainfall events and storage in water tanks for later use in landscape and water closet flushing. This reduces the surface runoff into drains and water demand.

Figure 4.7 Rainwater collection from roof top, Jamaica.

4.2.3 Hurricane Wind Mitigation Measures

4.2.3.1 Hurricane/Wind Roof Clips and Ties

Roof clips and ties secure the roof to the rest of the house to ensure it does not blow off. These can be used for wood or steel framing and are made of steel. The roof ties should be placed at all connections supporting the roof, providing a path for wind forces from the top to the foundations. Locations requiring these roof clips/ties are rafter to purlin, rafter to rafter, gable, and other roof components to the primary framing of the house. Each type of connection uses a different kind of tie. This measure is common to both residential and SME buildings

Figure 4.8 Examples of roof clips and ties.

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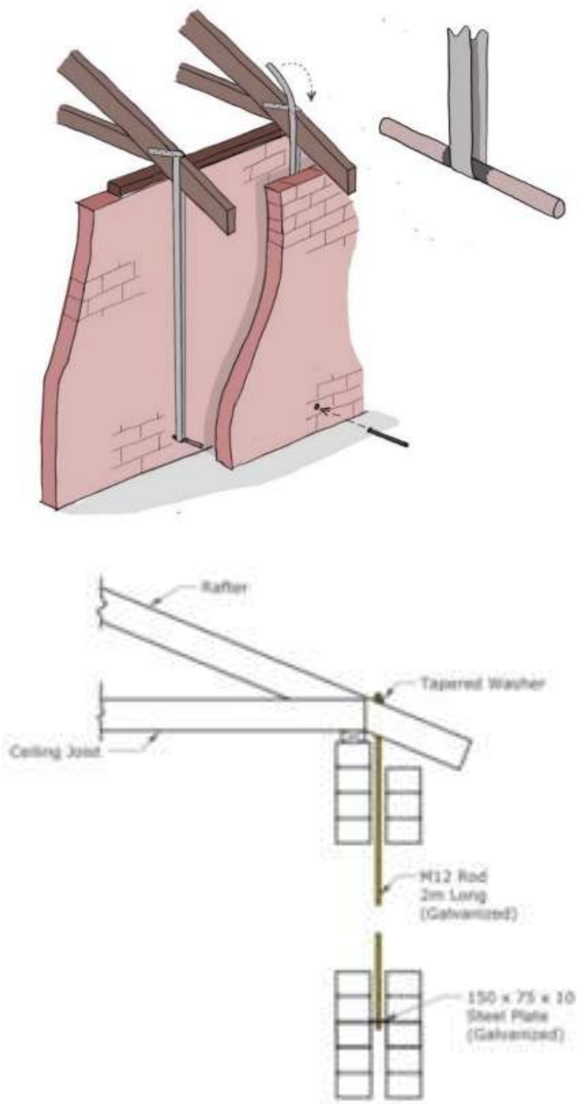
4.2.3.2 Hurricane/Wind Roof Anchorage to Wall

Roof members can be anchored to the wall of a building by galvanised steel straps or threaded rods and plates, as shown below. Two application methods are shown in figures 8 and 9 below. The first involves wrapping a galvanised strap around a metal bar dowelled into a cavity wall and onto the roof members. The second method uses a steel plate sandwiched between bricks of the cavity wall where a threaded rod is attached to the plate at one end and the rafter at the other, using washers and nuts. This measure applies to both residential and SME buildings.

Figure 4.9 Roof Member anchored to wall using galvanized straps.



4.2.3.3 Impact Resistant Doors and Windows

Impact-resistant windows and doors are designed to withstand extreme weather conditions like hurricane winds. These windows and doors help prevent wind-borne debris and water intrusion from natural disasters such as hurricanes from entering homes/buildings. It also helps avoid any uplift of roofs by preventing wind pressures from entering the homes/building. This mitigation measure is common to both residential and SME buildings.

Figure 4.10 a) Glazing installed at Ministry of Works and Transport Office, Caroni, Trinidad and Tobago and b) Section of Impact Resistant Glazing.

4.2.3.4 Hurricane Shutters

Hurricane Shutters are a barrier to prevent hurricane winds and wind-borne debris from penetrating the doors and windows. Hurricane shutters can be temporary timber plywood boards, galvanised sheets fastened over the doors and windows, or permanent shutters made using aluminium or steel attached above window and door openings. The temporary shutter is more common in residential applications, while permanent shutters, such as aluminium/steel rolling shutters, are most common in SME buildings. Temporary shutters are preferred for residential applications as they are usually more economical and generally made from scrap wood or galvanised steel.

Figure 4.11 Timber shutter and Rolling shutters.

Resilience Measures

4.2.3.5 Concrete Roof Structures

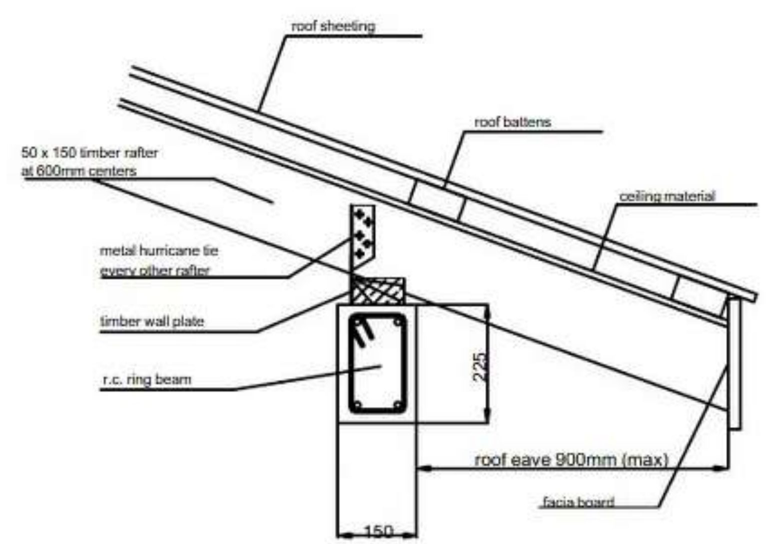
The roofs of structures are exposed to higher wind loads than other structural elements. Concrete roofs help prevent the roof from being uplifted during a hurricane as they can resist higher wind loads and prevent water infiltration.

Figure 4.12 Concrete roof on SME, Eastern Washington, USA.

4.2.3.6 Minimum Eaves on Buildings

The eaves on the building are subjected to high wind pressures on a structure. As such, keeping the eaves to a minimum would help reduce the uplift forces on the roof by higher wind loads.

Figure 4.13 Diagram showing roof eave



4.2.4 Heat Mitigation Measures

High temperatures increase the internal temperature of building space, affecting occupants' thermal comfort. This results in an increased need for cooling, which increases power consumption. Resilient buildings must ensure that high external temperatures don't adversely affect the internal space.

The building envelope is a divide which transfers heat from the external to the internal space. Therefore, analysis of the material used on the building's envelope will guide the effect on the cooling requirements of the building. The following studies the use of various materials on the building's envelope and observe the impact on energy consumption and, by extension, the electrical cost in Barbados and Trinidad. Standard residential and SME warehouse buildings were evaluated.

4.2.4.1 Reducing Heat gain on Building Envelope

4.2.4.1.1 Roof

Figure 4.14 Example of radiant barriers to roof

Most of the heat gain in a building is via the roof. To reduce the heat gain, roofs can have an insulative layer under the metal roofing, or a reflective barrier can be installed under the metal roof sheeting. In addition, photovoltaic cells can be installed above the metal roof to generate electricity; this also absorbs and reflects the heat generated by direct sunlight. Ventilation grilles or fans can also be placed in the attic space to facilitate the exhaust of hot air trapped in the attic space.

Resilience Measures

Below are more examples of roof barriers that will increase the insulative value of the roof to decrease the solar gain transferred to the internal space. In addition, the following are options for improving the insulative values:

Table 4.2 Heat Resilience Measure for roofs and examples of usage

Installing 1" fiber glass insulation or polyurethane insulation to the underside of concrete roof

Installing a 10mm layer of Prodex (a radiant barrier with 10mm insulation) to the underside of concrete or other roof

Using: a) sheet metal roof in lieu of a concrete roof and
b) install a 1/2" insulative ceiling

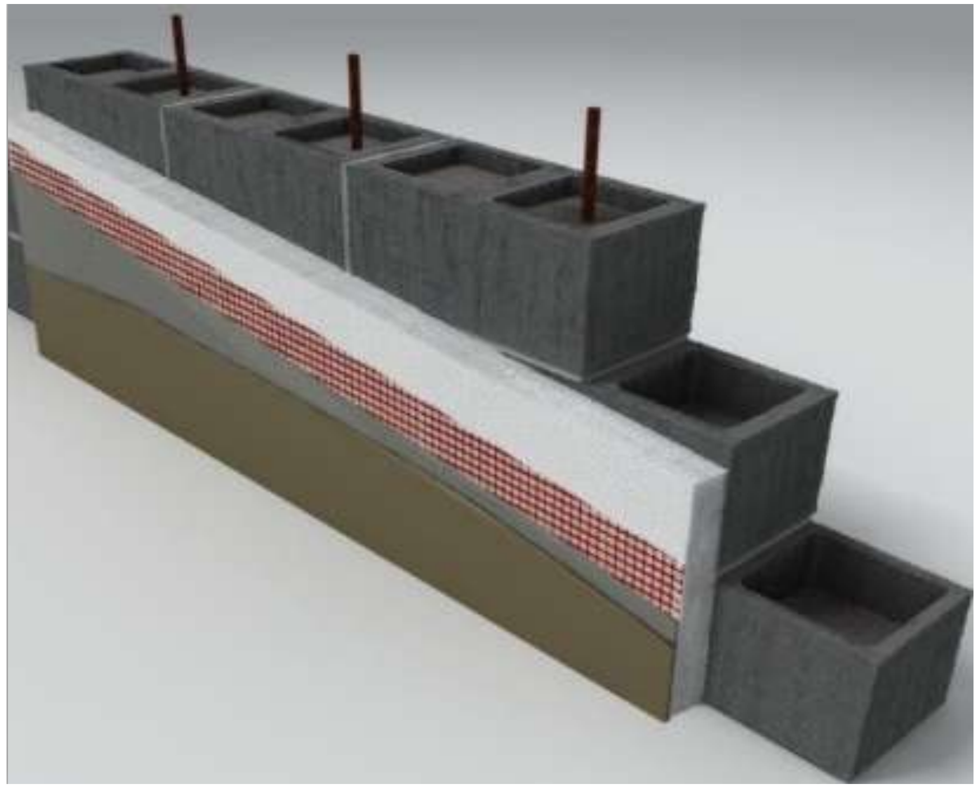
Using wooden roof tiles on 1/2" ply board in lieu of concrete roof. This would be coated with a waterproof sealant.

Installing a 60 KW photovoltaic system on the sheet metal roof to generate renewable electricity; absorb and emit solar heat.

4.2.4.1.2 Walls

Walls and windows exposed to sunlight gain significant heat, which is transferred to the internal space. Therefore, walls should possess an excellent insulative value. Composite walls with insulation such as perlite/styrofoam can be used as they have good insulative values. Sealed Wooden walls also can be an alternative. Below are more examples of reducing heat gain on walls:

Table 4.3 Heat Resilience Measure for walls and photographic examples of usage



Add 1" insulation and 3/4 gypsum board to internal side of hollow block wall

Install 4" filled concrete block wall in lieu of hollow clay blocks

Resilience Measures

Reducing sunlight exposure to walls using natural shading such as plants or a high fence

Install a 10mm layer of Prodex (radiant barrier and 10mm insulation) to exterior walls (SMEs)

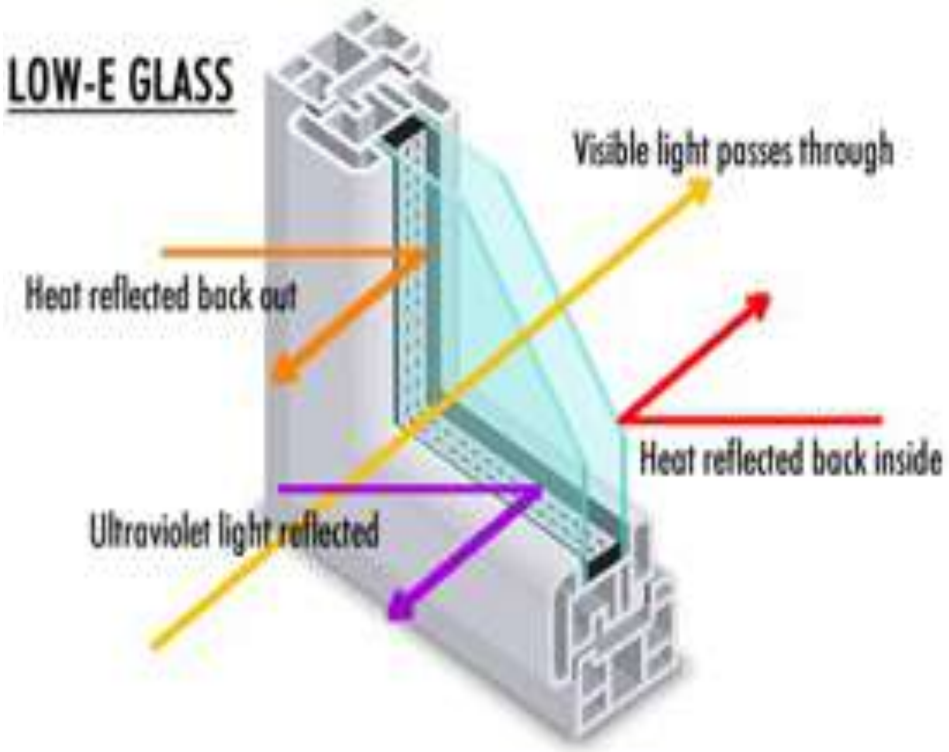
4.2.4.1.3 Windows

Windows should also possess a good insulation value. Windows can be double glazed or the arrangement of the windows in the building to reduce the radiative and conductive heat transfer to the internal space. In addition, window overhangs/shadings such as solar shaders can be introduced to reduce the window's direct exposure to the sun. The following measures help increase insulation values:

Table 4.4 Heat Resilience Measure for windows and photographic examples of usage

Using internal blinds for windows

Using external shading overhangs and blinds



Install Low-E double glazing in lieu of single glazing (SMEs)

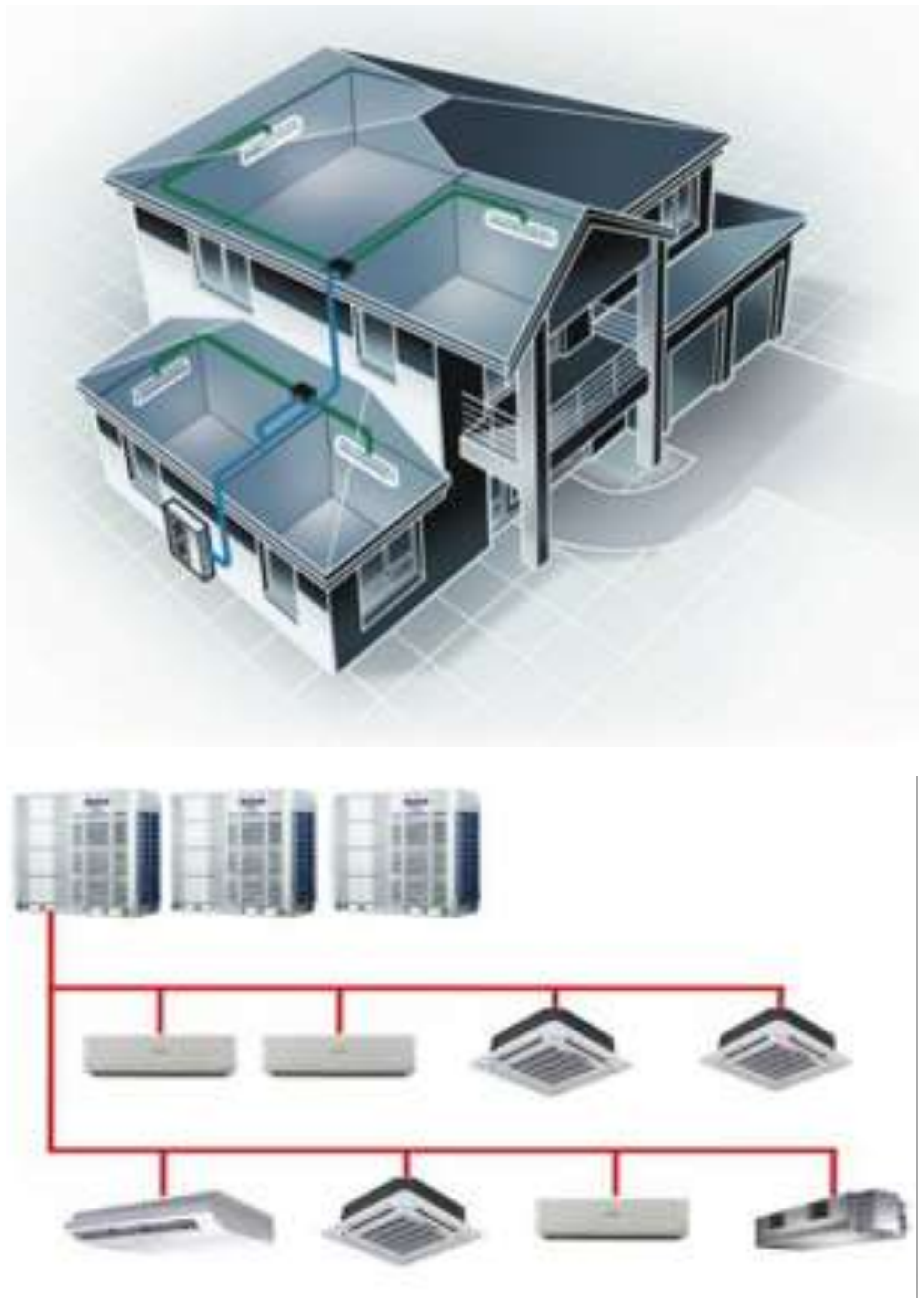
4.2.4.2 Energy Efficient Air Conditioning Units

Mechanical ventilation can also be installed for cooling internal spaces. Air conditioning often creates ideal thermal conditions within the area; however, the equipment is energy-intensive, increasing electricity costs and associated emissions. Therefore, the recommended cooling equipment should be labelled as energy efficient. Utilising energy-efficient units such as VRF Inverter units reduces the energy consumed for the increased cooling. Developers can use the following guidelines to assist them in selecting the most energy-efficient HVAC units:

1. Seek out appliances with the ENERGY STAR certification: This government-backed label recognises energy-efficient devices. To ensure they are among the most energy-efficient solutions available, developers should look for HVAC units that have earned the ENERGY STAR rating.
2. Consider the appliance's seasonal and overall energy efficiency ratios (SEER and EER): These indicate an HVAC system's effectiveness. Higher SEER and EER-rated units are more energy-efficient, saving builders and occupants money and energy over time.
3. Determine the optimal HVAC unit size by determining the cooling load. This can be achieved by:
   i. Manual J calculation for the building. This calculation considers several factors such as square footage, climate zone, ductwork, number, style of windows, etc.
   ii. The rule of thumb sizing method. This method uses the square footage of the residential or commercial building and determines the required British Thermal Unit (BTU).
4. Integrating HVAC with programmable thermostats allows designers to programme heating and cooling cycles, which can cut energy use while spaces are vacant. Over time, this may result in significant energy savings.
5. Look for appliances with variable-speed fans and compressors: Compressors and fans with variable speeds can change their output to meet the space's needs for heating and cooling, which can lower energy use and boost efficiency. Compressors and fans with variable speeds can change their output to meet the space's needs for heating and cooling, which can lower energy use and boost efficiency.

6. Consider the architecture of the building: HVAC systems' energy efficiency can be impacted by the architecture of the building. When choosing HVAC units, developers should consider elements like insulation, windows, and building orientation to ensure they are sized and suited for the space.

Figure 4.15 Examples showing the layout of Energy Efficient Air Conditioning Units



4.2.4.3 Orientation of Building

The Atlantic trade winds provide natural cooling of Caribbean islands; thus, relying on nature-based solutions that leverage this phenomenon would be economically advantageous. Windows and doors should be facing the direction of the flowing winds to allow for natural ventilation. The solar heat gained from walls can be reduced by reviewing the orientation of the building. Solar heat gain mainly occurs on the eastern walls (morning sun) and western walls (setting sun). Windows and doors should, where possible, face away from these directions.

4.2.5 Drought Mitigation Measures

4.2.5.1 Utilise water-efficient fixtures

The architype residential building usually contains the following fixtures: one water closet, one shower, one lavatory faucet, one kitchen faucet and external hose bibs. SME warehouse buildings typically include the following fixtures: eight water closets, four showers, eight lavatory faucets, one kitchen faucet and exterior hose bibs for an estimated 60 occupants. Water efficient fixtures reduce water consumption by including aerators and flow restrictors and operating with less volume of water.

4.2.5.2 Rainwater harvesting

Rainwater can be captured and stored via tanks and cisterns in residential buildings. Water can then be used for flushing toilets & irrigating the landscape.

SME warehouses typically have a large roof area (580m2) which can serve as a catchment for rainwater, which can then be stored in cisterns or above-ground tanks. Water can then be used for flushing toilets and landscape irrigation. The quantity of water that can be harvested is based on actual yearly rainfall.

Resilience Measures

Figure 4.16 Examples of utilising rainwater harvesting for drought mitigation

4.2.5.3 Utilising alternative water

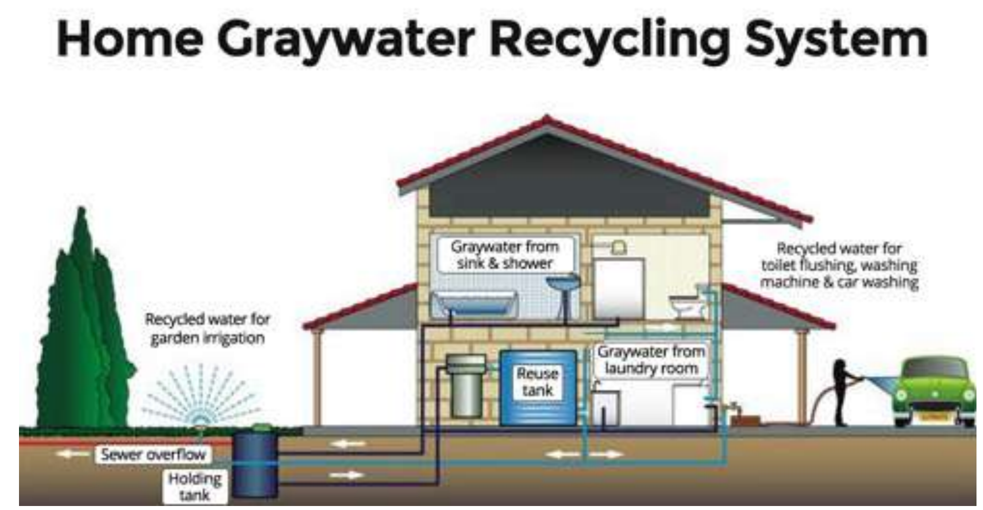
Method

Air conditioning (AC) condensate water can be captured and stored via tanks and cisterns. Water can then be used for flushing toilets & irrigating the landscape. The expected daily capture of condensate from AC units operating for 8 hours in traditional homes is 16 gallons, enough to irrigate the landscape.

Figure 4.17 Examples of installation of Recycling water from AC units

Use of grey water for landscaping irrigation. Water from lavatory sinks and washing machines is considered grey water and can be collected to irrigate surrounding landscapes.

Figure 4.18 Examples of grey water storage and reuse



4.2.5.4 Onsite water storage tanks

Onsite water storage tanks can also help mitigate drought conditions' impact. Storage paired with water conservation and using alternative water sources will enable residential and SME occupants to endure drought conditions better as they will still have access to potable water.

Figure 4.19 Example of water storage tank

4.2.5.5 Public Education on Water Conservation

Educating the public on water conservation will help to develop awareness and promote a culture of saving water. Education can be via schools, media and water bills.

Figure 4.20 a) Public Education Signage to encourage water conservation (Source: Southwest Florida Water Management District) b) Public Education Signage to encourage saving water.

4.3 Building Codes Review

The codes relevant to each country were reviewed to determine whether the mitigation measures were considered. The list of codes reviewed is included in the appendices.

4.3.1 Barbados

The relevant building codes partially cover wind and flood. Wind maps are provided by CUBIC code: the Barbados National Code and the IBC guide hurricane ties, roof anchorage and impact-resistant doors. The national building code does not cover specific flood mitigation measures. However, the IBC gives flood-resistant materials, barriers, and equipment elevation guidelines. In addition, the physical Development Plan (Draft) Section requires the approval of developments in flood susceptible areas.

Both drought and heat mitigation measures are covered by the IBC and CREEBC, respectively. However, the International plumbing code of the IBC needs to reflect the present efficient fixtures selection accurately. The CARICOM Regional Energy Efficient Building Code (CREEBC) provides guidelines for reducing heat gain in SME (Commercial) and residential buildings. It provides guidelines on the building's envelope types and insulative values. The code also gives guidance on ventilation and the selection of AC equipment. This is a recent code published by the International Code Council in 2018. CARICOM states are in the process of adopting the code. However, it is available to any developer who wishes to utilise the code to reduce the heat gain on buildings and to find ways to reduce energy consumption to cool the internal spaces.

4.3.2 Jamaica

The Jamaica Building Code and the International Building Code have guidelines relating to flood mitigation measures, such as elevating the structure, installing flood barriers, and elevating equipment. However, they have yet to mention specifications for flood doors. Hurricane wind mitigation measures such as hurricane straps, window glazing, and hurricane shutters are also covered in the Jamaica Building Code, the International Building Code and the ASCE 7 code. However, guidelines regarding minimum eaves on buildings were not identified.

The CARICOM Regional Energy Efficient Building Code (CREEBC) provides guidelines for reducing heat gain in SME (Commercial) and residential buildings. However, none of the codes reviewed highlighted policies on international green roofs and rainwater harvesting.

4.3.3 Trinidad and Tobago

Overall, the relevant building codes partially cover both wind and flood. The Trinidad & Tobago Small Building Code (2004) addresses basic building systems. Organisation of Eastern Caribbean States Build Code (1992) and the Caribbean Uniform Building Code (CUBIC)[37], revised in 2016, are still commonly used by regulatory bodies. ASCE 7, IRC and the Small Building code of Trinidad and Tobago cover floor levels based on flood and equipment elevation. These codes did not mention flood doors, permanent flood barriers, or stormwater basins. Requirements for Drainage Design Approval (Land Developments) provided by the Ministry of Works and Transport: Drainage Division outlines the requirements for the drainage design approval for land development. The Small Building Code and the International Building Code (IBC) guide the use of hurricane clips for fastening rafters to the plates, purlins and roof anchorages and recommend minimum eaves based on calculations from ASCE 7. They also include recommendations for glazing and the use of hurricane shutters. The Small Building Code of Trinidad and Tobago does not mention impact resistance doors and windows.

The National Plumbing Code and the Guidelines for Design and Construction of Water and Wastewater Systems governing fixtures and fittings do not provide clear guidance on high-efficiency fixtures and fittings. In addition, no guidelines on green roofs or rainwater harvesting were noted in the Small Building Code or the IBC.

4.3.4 Gaps

Gaps were identified in all three building codes for Barbados, Jamaica and Trinidad and Tobago concerning some of the recommended flood mitigation measures, such as flood doors and permanent flood barriers. There also needed to be more information on drought mitigation measures such as onsite water storage tanks, low-flow faucets and rainwater harvesting. The National Plumbing Code for Trinidad and Tobago needs to guide the performance of plumbing fixtures and fittings. As such, many installed fixtures are considered inefficient compared to other countries. Designers in Trinidad usually refer to the IBC codes for guidance on fixture performance. Additionally, both international and local building codes reviewed only covered energy-efficient internal cooling. There needed to be more information on reducing the heat gain on the building envelope.

[37]Caribbean Community Secretariat. (1996). The Caribbean Uniform Building Code. https://www.caribank.org/publications-and-resources/resource-library/guides-and-toolkits/caribbean-uniform-building-code

Resilience Measures

4.3.5 Barriers and Challenges of codes

Below are some general barriers and challenges arising from Codes to project developers and building designers:

1. Clarity and simplicity of the recommendations
2. The complexity of Code Structure
3. Lack of options for alternatives
4. Frequent revisions to codes
5. Increase in cost of construction/design as no flexibility is available.

4.4 Cost Premiums

Resilience measures aligned with the prioritised hazards and requiring implementation by the developer at the time of construction were costed. The incremental cost premium due to the physical damage caused by climate hazards[38] versus pure developmental or building code compliance was determined and compared to the base cost of the unit. Material and market prices for each measure were analysed to determine the capital cost of incorporation on residential buildings and SME warehouses in Barbados, Jamaica and Trinidad and Tobago.

The cost of resiliency measures in the Caribbean is relatively constant since the materials required are imported into the respective countries. The base cost of affordable-income (75 m2) residential units was estimated at US$60,000, and the 500 m2 SME warehouses base cost was US$525,000.

Quantity surveyors maintain a database of building construction costs using actual tender prices for different work items. These prices are adjusted based on the construction location and inflation. When necessary, missing prices are calculated by considering the costs of labour, materials, equipment, overheads, and profit. Prices are initially calculated in Trinidad and Tobago currency and then converted to United States currency

[38]Prevailing market costs for each resilience measure were used as an initial basis, to which a climate change factor (CF) was applied to determine the incremental climate change cost of the resilience measure. This method is consistent with Green Climate Fund policy and avoids double counting measures that should already be included for compliance with building codes and response to natural hazards. As some of these measures were already included in local and international building codes, this method would determine additional cost for each measure as a result of the intensification of climate hazards.

The standard residential building is a 750 sq. ft. building with a 4" thick concrete roof in Barbados, Jamaica and Trinidad and Tobago. The external walls usually consist of 4" blocks with glass windows. The standard SME warehouse building is a 5,000 sq. ft. warehousing area and 2,500 sq. ft. office space; it has a 4" metal roof, 4" concrete blocks as the external walls, free ventilation in the warehouse area and central split air conditioning in the office area with fluorescent lighting, with 60 occupants.

4.4.1 Barbados

Resilience measures for the prioritised hazards for Barbados would add an estimated $840 to each affordable income architype or approximately 1.4% of the construction cost ($60,000). In addition, the proposed mitigation measures for SMEs for the hazards of hurricane winds and floods are expected to add an estimated $6,970 (1.3%) to the construction cost ($525,000) of the warehouse architype. The capital cost values for the measures and the percentage increase to the base cost of the architypes are presented in Table 4.1.

Table 4.5 Incremental climate-change related cost estimates for proposed hurricane wind and flood mitigation measures on affordable income residential units and SME warehouses for Barbados.

HAZARDS	ARCHITYPE	MITIGATION MEASURE	COST OF RESILIENCE MEASURE	COST OF RESILIENCE MEASURE CONSIDERED BY EXISTING BUILDING CODES	COST OF EACH RESILIENCE MEASURE WITH RESPECT TO CLIMATE CHANGE	% INCREASE ON BASE COST
Flood	Residential - Affordable income	Using fill to make up levels contained with block basewalls	$4,000	$3,360	$640	1.1%
		Installing flood doors	$1,800	$0	$1,800	3.0%
		Water retention and infiltration	$650	$546	$104	0.2%
	SME - Warehouse	Elevating structures	$2,300	$1,932	$368	0.1%
		Elevation of equipment	$11,400	$9,576	$1,824	0.3%
Hurricane Winds	Residential - Affordable income	Installation of hurricane/ wind roof clips and ties	$180	$171	$9	0.0%
		Installation of hurricane shutters	$1,900	$0	$1,900	3.2%
	SME - Warehouse	Installation of hurricane/ wind roof clips and ties	$1,200	$1,140	$60	0.0%
		Installation of impact resistant windows and doors	$1,800	$1,710	$90	0.0%
Drought	Residential - Affordable income	Install high efficiency toilets	$1,200	$400	$800	1.3%
		Install water efficient faucets and shower heads	$90	$30	$60	0.1%
		Install tanks for rainwater collection	$240	$80	$160	0.3%
	SME - Warehouse	Install high efficiency toilets	$1,200	$400	$800	0.2%
		Install water efficient faucets and shower heads	$1,900	$633	$1,267	0.2%
		Install tanks for rainwater collection	$8,600	$2,867	$5,733	1.1%
Heat	Residential - Affordable income	Prodex 10mm insulation and radiant barrier	$450	$0	$450	0.8%
		Use concrete filling to block walls	$1,100	$1,070	$30	0.1%
		Install double glazed windows	$3,800	$3,696	$104	0.2%
	SME - Warehouse	Prodex 10mm insulation and radiant barrier	$4,500	$4,377	$123	0.0%
		3/4" gypsum board lining	$17,700	$0	$17,700	3.4%
		Install double glazed windows	$3,800	$3,696	$104	0.0%

[39]Material, equipment, and labour prices were retrieved from a locally maintained database for building construction costs. These costs are periodically updated using actual tender prices for the various items of works. In cases where our database does not provide the needed prices, such are built up from first principles by taking into consideration the cost of the various resource requirements needed for the operation.

[40]The cost attributed to climate change was derived from projected increases in frequencies and/or intensities of the climate hazards as follows: Flood - 16%, Extreme Wind - 5%, Drought - 67%, High heat - 2.7%.

4.4.2 Jamaica

Resilience measures for the prioritised hazards for Jamaica would add an estimated $1,270 to each affordable-income architype or approximately 2.1% of the construction cost ($60,000). The proposed mitigation measures for SMEs for the hazards of hurricane winds and floods are expected to add an estimated $6,970 (1.3%) to the construction cost ($525,000) of the warehouse architype. The capital cost values for the measures and the percentage increase to the base cost of the architypes are presented in Table 4.2.

Table 4.6 Incremental climate-change related cost estimates for proposed hurricane wind and flood mitigation measures on affordable income residential units and SME warehouses for Jamaica.

HAZARDS	ARCHITYPE	MITIGATION MEASURE	COST OF RESILIENCE MEASURE	COST OF RESILIENCE MEASURE CONSIDERED BY EXISTING BUILDING CODES	COST OF EACH RESILIENCE MEASURE WITH RESPECT TO CLIMATE CHANGE	% INCREASE ON BASE COST
Flood	Residential - Affordable income	Using fill to make up levels contained with block basewalls	$2,000	$1,680	$320	0.5%
		Installing flood doors	$1,800	$0	$1,800	3.0%
		Water retention and infiltration	$650	$546	$104	0.2%
	SME - Warehouse	Elevating structures	$2,300	$1,932	$368	0.1%
		Elevation of equipment	$$11,400	$9,576	$1,824	0.3%
Hurricane Winds	Residential - Affordable income	Installation of hurricane/ wind roof clips and ties	$180	$171	$9	0.0%
		Installation of hurricane shutters	$1,900	$0	$1,900	3.2%
	SME - Warehouse	Installation of hurricane/ wind roof clips and ties	$1,200	$1,140	$60	0.0%
		Installation of impact resistant windows and doors	$1,800	$1,710	$90	0.0%
Drought	Residential - Affordable income	Install high efficiency toilets	$1,200	$400	$800	1.3%
		Install water efficient faucets and shower heads	$90	$30	$60	0.1%
		Install tanks for rainwater collection	$240	$80	$160	0.3%
	SME - Warehouse	Install high efficiency toilets	$1,200	$400	$800	0.2%
		Install water efficient faucets and shower heads	$1,900	$633	$1,267	0.2%
		Install tanks for rainwater collection	$8,600	$2,867	$5,733	1.1%
Heat	Residential - Affordable income	Prodex 10mm insulation and radiant barrier	$450	$0	$450	0.8%
		Use concrete filling to block walls	$1,100	$1,070	$30	0.1%
		Install double glazed windows	$3,800	$3,696	$104	0.2%
	SME - Warehouse	Prodex 10mm insulation and radiant barrier	$4,500	$4,377	$123	0.0%
		Use of light weight concrete walls instead of blocks	$7,100	$6,906	$194	0.0%
		Install double glazed windows	$7,100	$6,906	$194	0.0%

4.4.3 Trinidad and Tobago

Resilience measures for the prioritised hazards for Trinidad and Tobago would add an estimated $838.00 to each of the affordable income architype or approximately 1.4% of the construction cost ($60,000). The proposed mitigation measures for SMEs for the hazards of hurricane winds and floods are expected to add an estimated $6,962.25 (1.3%) to the construction cost ($525,000) of the warehouse architype. The capital cost values for the measures and the percentage increase to the base cost of the architypes are presented in Table 4.3.

Table 4.7 Incremental climate-change related cost estimates for proposed hurricane wind and flood mitigation measures on affordable income residential units and SME warehouses for Trinidad and Tobago.

HAZARDS	ARCHITYPE	MITIGATION MEASURE	COST OF RESILIENCE MEASURE	COST OF RESILIENCE MEASURE CONSIDERED BY EXISTING BUILDING CODES	COST OF EACH RESILIENCE MEASURE WITH RESPECT TO CLIMATE CHANGE	% INCREASE ON BASE COST
Flood	Residential - Affordable income	Using fill to make up levels contained with block basewalls	$4,000	$3,360	$640	1.1%
		Installing flood doors	$1,800	$0	$1,800	3.0%
		Water retention and infiltration	$650	$546	$104	0.2%
	SME - Warehouse	Elevating structures	$2,300	$1,932	$368	0.1%
		Elevation of equipment	$$11,400	$9,576	$1,824	0.3%
Hurricane Winds	Residential - Affordable income	Installation of hurricane/ wind roof clips and ties	$180	$171	$9	0.0%
		Installation of hurricane shutters	$1,900	$0	$1,900	3.2%
	SME - Warehouse	Installation of hurricane/ wind roof clips and ties	$1,200	$1,140	$60	0.0%
		Installation of impact resistant windows and doors	$1,800	$1,710	$90	0.0%
Drought	Residential - Affordable income	Install high efficiency toilets	$1,200	$400	$800	1.3%
		Install water efficient faucets and shower heads	$90	$30	$60	0.1%
		Install tanks for rainwater collection	$240	$80	$160	0.3%
	SME - Warehouse	Install high efficiency toilets	$1,200	$400	$800	0.2%
		Install water efficient faucets and shower heads	$1,900	$633	$1,267	0.2%
		Install tanks for rainwater collection	$8,600	$2,867	$5,733	1.1%
Heat	Residential - Affordable income	Prodex 10mm insulation and radiant barrier	$450	$0	$450	0.8%
		Use concrete filling to block walls	$1,100	$1,070	$30	0.1%
		Install double glazed windows	$3,800	$3,696	$104	0.2%
	SME - Warehouse	Prodex 10mm insulation and radiant barrier	$4,500	$4,377	$123	0.0%
		3/4" gypsum board lining	$17,700	$0	$17,700	3.4%
		Install double glazed windows	$7,100	$6,906	$194	0.0%

4.4.4 Summary

Cost premiums across residential and SME units for the three countries are relatively small and add an average of 1.5% and 1.3% to the base cost of the units, respectively. Resilience measures are marginally more expensive for Jamaica than Barbados and Trinidad and Tobago and generally more expensive for application to SME units than residential units. Resilience measures addressing floods and hurricane winds (1.4%) are more costly than drought and extreme heat (1.1%). Overall, climate resilience measures are expected to present few economic hurdles to development costs, and consideration can be given to incorporating drought and heat mitigation measures as they are cost-effective.

4.5 Summary

1. Architypes were proposed for residential and commercial buildings to enable cost comparison of resilience measures. They comprise 350 to 1,100 ft2 of low- and affordable-income housing solutions, with concrete walls and hip or slab roofs. SME buildings are 5,000 to 10,000 ft2 warehouses with mezzanine floors, steel sheeting cladding, or office-type masonry walls.

Resilience Measures

2. International best practices for wind, heat, drought, and flooding mitigation were identified and included:
    a. Flooding Mitigation Measures
        i. Elevating the Structure
        ii. Flood Doors
        iii. Permanent Flood Barriers
        iv. Stormwater Retention and Infiltration Basins
        v. Rainwater harvesting
    b. Wind Mitigation Measures
        i. Roof Clips and Ties
        ii. Roof Anchorage to Wall
        iii. Impact Resistant Doors and Windows
        iv. Impact Resistant Shutters
        v. Concrete roof structures
        vi. Minimum eaves on buildings
    c. Drought Mitigation Measures
        i. Onsite water storage tanks
        ii. Low flow faucets
        iii. Rainwater harvesting
    d. Heat Mitigation Measures
        i. Solar shaders
        ii. Thermal radiant roof barriers
        iii. Reducing heat gain on building envelope
        iv. Cooling of internal spaces
        v. Green roofs

5 Investments and Opportunities

Key Findings:

1. Resilience measures that address all four prioritised hazards of flood, hurricanes, heat, and drought are economically viable to implement in residential and SME developments.
2. The cost savings for implementing mitigation measures for all four hazards are generally more significant for Barbados (35x), followed by Jamaica (26x) and then Trinidad and Tobago (17x) over five years.
3. Flood resilience measures included filling and raising floors and raising equipment, and hurricane wind resilience measures included roofs, shutters, and impact windows.
4. Marginally more maintenance is required, given the nature of the resilience measures proposed.
5. Current opportunities for introducing financial products targeting climate-resilient infrastructure are more likely to be in agricultural warehousing, distribution goods warehousing and the provision of low-income and affordable housing.
6. Several opportunities exist based on the gap between possible resilience solutions and those currently employed. Opportunities exist for:
    a. Retailing certain materials such as hurricane shutters, radiant barriers, and low-flow water fixtures.
    b. Providing installation services for less popular resilience measures such as rainwater harvesting systems, flood barriers and photovoltaic systems.

5.1 Return on Investment (ROI) Estimates

Return on Investment (ROI) determines the profitability of an investment and is calculated by dividing an investment's cost benefit by its' initial cost then multiplying by 100.

$$ROI = \frac{\text{(Derived benefits- Initial cost)}}{\text{(Initial Cost)}} \times 100$$

Return on Investment estimates for each resilience measure were determined and used to rationalise prioritising opportunities resilience measures. Prevailing market costs for each resilience measure were used as an initial basis, to which a climate change factor (CF) was applied to determine the incremental climate change cost of the resilience measure. This method is consistent with Green Climate Fund policy[41] and avoids double counting measures that should already be included to comply with building codes and respond to natural hazards. As some of these measures were already included in local and international building codes, this method would determine the additional cost for each measure because of the intensification of climate hazards.

Benefits throughout the economic life of the several measures were identified on a year-by-year basis present values determined using discounted cash flow techniques. The different benefits across countries were largely influenced by the cost of energy in the respective countries. Return on Investment was then computed from the aggregated current value of the benefits and the cost of the resiliency measure. Based on the literature reviewed, the list of measures identified was reduced to the most pragmatic for each prioritised hazard for each country and those options that developers rather than owners would most likely implement. Owner-implemented measures were not prioritised in this assessment.

[41]Green Climate Fund. (2021). Policy on Incremental Cost and Full Cost Methodologies. In GCF. https://www.greenclimate.fund/sites/default/files/document/gcf-b29-inf10.pdf

5.1.1 Barbados

The ROI on the most likely combination of resilience measures averaged 21x for affordable residential units, while the ROI for SMEs averaged 51x over five years. The lowest estimated returns are expected for drought resilience measures at 3.5x and 2.5x on residential and SME units, respectively. The highest predicted returns were identified for mitigation against hurricane winds for residential architypes at 60.7x and extreme heat for SMEs at 14x.

Table 5.1 Barbados ROI estimates of proposed resilience measures for floods, hurricane winds, drought and heat.

HAZARDS	ARCHITYPE	MITIGATION MEASURE	COST OF EACH RESILIENCE MEASURE WITH RESPECT TO CLIMATE CHANGE	DERIVED BENEFITS OVER 5 YEARS	ROI IN 5 YEARS
Flood	Residential - Affordable income	Using fill to make up levels contained with block base walls	$640	$2,000	2.1x
		Installation of flood doors	$1,800	$2,000	0.1x
	SME - Warehouse	Water retention and infiltration	$104	$2,000	18.2x
		Elevation of structures	$368	$12,875	34.0x
		Elevation of equipment	$1,824	$12,875	6.1x
Hurricane Winds	Residential - Affordable income	Installation of hurricane /wind roof clips and ties	$9	$1,103	121.6x
		Installation of hurricane shutters	$1,900	$1,424	-0.3x
	SME - Warehouse	Installation of hurricane/ wind roof clips and ties	$60	$1,060	16.7x
		Installation of impact resistant windows and doors	$90	$2,120	22.6x
Drought	Residential - Affordable income	Install high efficiency toilets	$800	$600	-0.3x
		Install water efficient faucets and shower heads	$60	$600	9.0x
		Install tanks for rainwater collection	$160	$420	1.6x
	SME - Warehouse	Install high efficiency toilets	$800	$5,400	5.8x
		Install water efficient faucets and shower heads	$1,267	$2,250	0.8x
		Install tanks for rainwater collection	$5,733	$12,000	1.1x
Heat	Residential - Affordable income	Prodex 10mm insulation and radiant barrier	$450	$3,650	7.1x
		Use concrete filling to block walls	$30	$1,245	40.5x
		Install double glazed windows	$104	$2,875	26.7x
	SME - Warehouse	Prodex 10mm insulation and radiant barrier	$123	$48,390	393.3x
		3/4" gypsum board lining	$17,700	$13,900	-0.2x
		Install double glazed windows	$104	$2,875	26.7x

5.1.2 Jamaica

ROI is primarily positive and attractive for most resilience measures. For example, the ROI on Jamaica's most likely combination of resilience measures averaged 18x for affordable income residential units, while the ROI for SMEs averaged 32x over five years. The lowest estimated returns are expected for drought resilience measures at 2x and -41% on residential and SME units, respectively. The highest predicted returns were identified for mitigation against hurricane winds for residential architypes at 60.7x and extreme heat for SMEs at 140x.

Table 5.2 Jamaica ROI estimates of proposed resilience measures for floods, hurricane winds, drought and heat.

HAZARDS	ARCHITYPE	MITIGATION MEASURE	COST OF EACH RESILIENCE MEASURE WITH RESPECT TO CLIMATE CHANGE	DERIVED BENEFITS OVER 5 YEARS	ROI IN 5 YEARS
Flood	Residential - Affordable income	Using fill to make up levels contained with block base walls	$320	$3,375	9.6x
		Installation of flood doors	$1,800	$2,000	0.1x
	SME - Warehouse	Water retention and infiltration	$104	$3,375	31.5x
		Elevation of structures	$368	$12,875	34.0x
		Elevation of equipment	$1,824	$12,875	6.1x
Hurricane Winds	Residential - Affordable income	Installation of hurricane /wind roof clips and ties	$9	$1,103	121.6x
		Installation of hurricane shutters	$1,900	$1,424	-0.3x
	SME - Warehouse	Installation of hurricane/ wind roof clips and ties	$60	$1,060	16.7x
		Installation of impact resistant windows and doors	$90	$2,120	22.6x
Drought	Residential - Affordable income	Install high efficiency toilets	$800	$350	-0.6x
		Install water efficient faucets and shower heads	$60	$350	4.8x
		Install tanks for rainwater collection	$160	$563	2.5x
	SME - Warehouse	Install high efficiency toilets	$800	$900	0.1x
		Install water efficient faucets and shower heads	$1,267	$375	-0.7x
		Install tanks for rainwater collection	$5,733	$2,000	-0.7x
Heat	Residential - Affordable income	Prodex 10mm insulation and radiant barrier	$450	$2,180	3.7x
		Use concrete filling to block walls	$30	$445	13.8x
		Install double glazed windows	$104	$1,710	15.5x
	SME - Warehouse	Prodex 10mm insulation and radiant barrier	$123	$28,785	233.5x
		3/4" gypsum board lining	$194	$488	1.5x
		Install double glazed windows	$194	$1,723	7.9x

5.1.3 Trinidad and Tobago

The ROI on the most likely combination of resilience measures for Trinidad and Tobago averaged 14x for affordable income residential units, while ROI for SMEs averaged 15x over five years. The lowest estimated returns are expected for drought resilience measures at 1x and -41% on residential and SME units, respectively. The highest predicted returns were identified for mitigation against hurricane winds for residential architypes at 61x and extreme heat for SMEs at 25x.

Table 5.3 Trinidad and Tobago ROI estimates of proposed resilience measures for floods, hurricane winds, drought and heat.

HAZARDS	ARCHITYPE	MITIGATION MEASURE	COST OF EACH RESILIENCE MEASURE WITH RESPECT TO CLIMATE CHANGE	DERIVED BENEFITS OVER 5 YEARS	ROI IN 5 YEARS
Flood	Residential - Affordable income	Using fill to make up levels contained with block base walls	$640	$2,000	2.1x
		Installation of flood doors	$1,800	$2,000	0.1x
	SME - Warehouse	Water retention and infiltration	$104	$2,000	18.2x
		Elevation of structures	$368	$12,875	34.0x
		Elevation of equipment	$1,824	$12,875	6.1x
Hurricane Winds	Residential - Affordable income	Installation of hurricane /wind roof clips and ties	$9	$1,103	121.6x
		Installation of hurricane shutters	$1,900	$1,424	-0.3x
	SME - Warehouse	Installation of hurricane wind roof clips and ties	$60	$1,060	16.7x
		Installation of impact resistant windows and doors	$90	$2,120	22.6x
Drought	Residential - Affordable income	Install high efficiency toilets	$800	$100	-0.9x
		Install water efficient faucets and shower heads	$60	$100	0.7x
		Install tanks for rainwater collection	$160	$705	3.4x
	SME - Warehouse	Install high efficiency toilets	$800	$900	0.1x
		Install water efficient faucets and shower heads	$1,267	$375	-0.7x
		Install tanks for rainwater collection	$5,733	$2,000	-0.7x
Heat	Residential - Affordable income	Prodex 10mm insulation and radiant barrier	$450	$565	0.3x
		Use concrete filling to block walls	$30	$190	5.3x
		Install double glazed windows	$104	$545	4.3x
	SME - Warehouse	Prodex 10mm insulation and radiant barrier	$123	$9,180	73.8x
		3/4" gypsum board lining	$17,700	$3,475	-0.8x
		Install double glazed windows	$194	$545	1.8x

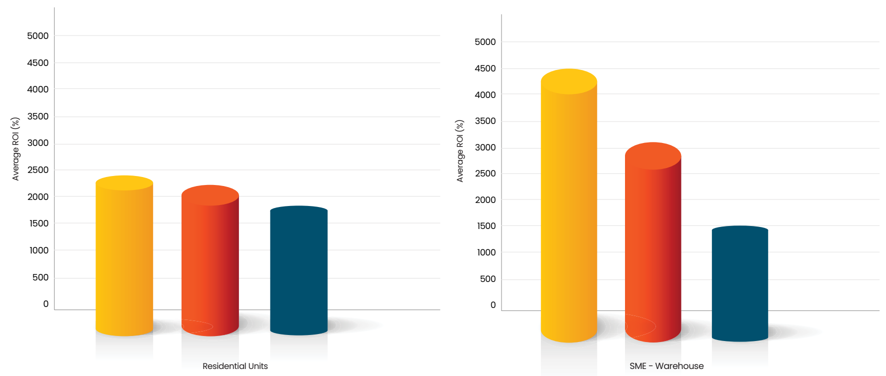
5.1.4 Summary and Conclusion

Climate change resilience measures are generally economically viable. Resilience measures for all four prioritised hazards of flooding, hurricane winds, drought and extreme heat have an ROI of 21x for residential units and 30x for SMEs across Barbados, Jamaica and Trinidad and Tobago. The average returns over five years for residential and SME architypes are 24x and 45.5x for Barbados, 22x and 300x for Barbados and 18x and 16x for Trinidad and Tobago.

Across all countries, ROI averages are generally greater for SME warehouses than residential units. This is principally due to some of the measures already covered by existing building codes where enforcement is usually stricter for commercial buildings. The derived benefits of each measure are significantly more for warehouses than residential units due to the value of the goods protected. In terms of ranking, the returns for implementing mitigation measures for all four hazards are generally greater for Barbados (34.7x), followed by Jamaica (26x) and then Trinidad and Tobago (17x) over five years.

Additionally, it was determined that all measures with a positive ROI would provide a positive return within the first year. That means that for all positive ROI investments, only one year would be required to recover the respective investments.

Figure 5.1 Average ROI estimates on Resilience Measures for the residential and commercial sectors for Barbados, Jamaica and Trinidad and Tobago.



5.2 Impact on Operational Costs

Flood resilience measures included filling and raising floors and raising equipment. Hurricane resilience measures included roofs, shutters, and impact windows. Marginally more maintenance is required, given the nature of the resilience measures proposed. For example, shutters need additional storage space if they are detachable and non-permanent. However, further maintenance measures or costs are not anticipated for the actions most likely to be employed.

5.3 Financial Opportunities

Currently, there are various financing mechanisms available to support climate-resilient solutions for heat, drought, flood, and hurricane-resistant measures including:

International Climate Funds: International funds such as the Green Climate Fund (GCF) and the Adaptation Fund provide financial resources to developing countries for climate change adaptation and resilience projects. These funds aim to support initiatives that address the impacts of climate change, including heatwaves, droughts, floods, and hurricanes.

Multilateral Development Banks (MDBs): MDBs, such as the Inter-American bank Group (IDBG) offer financing and technical assistance for climate resilience projects. They provide loans, grants, and guarantees to support climate adaptation measures, including infrastructure projects focused on heat, drought, flood, and hurricane resilience.

National Climate Funds: Many countries have established their own climate funds to finance climate resilience initiatives. These funds may be supported by public finance, international grants, or private sector contributions. They provide financial support for projects that enhance climate resilience and can include measures to address heatwaves, droughts, floods, and hurricanes.

Public-Private Partnerships (PPPs): PPPs bring together public and private sector entities to jointly finance and implement climate resilience projects. Private sector partners can contribute financial resources, technical expertise, and innovation to develop and deploy heat, drought, flood, and hurricane-resistant measures. These partnerships can help leverage additional investment and optimize the use of public funds.

Insurance and Risk Transfer Mechanisms: Insurance products and risk transfer mechanisms, such as catastrophe bonds, can provide financial protection against climate-related risks. These mechanisms help transfer the financial burden associated with heatwaves, droughts, floods, and hurricanes from individuals, businesses, and governments to insurance providers or financial markets.

Climate Finance Innovation: Innovative financing mechanisms are emerging to support climate resilience solutions. For example, green bonds and climate-focused impact investments attract capital from investors interested in supporting sustainable and resilient projects. Crowdfunding platforms and community-led financing initiatives can also play a role in mobilizing funds for local climate resilience initiatives.

It is important to note that the availability and accessibility of these financing mechanisms varies between countries and regions. Governments, development institutions, and private sector actors are continuously working to enhance and expand the range of financial instruments available to support climate-resilient solutions. Current opportunities for the introduction of financial products targeting climate-resilient infrastructure are more likely to be in the areas of Agricultural warehousin, Distribution goods warehousing; and Provision of low-income and affordable housing.

The target market viewed these opportunities as an entry point to the SARs-CoV-2 recovery to strengthen food security in countries and fulfil housing gaps across all three countries.

5.4 Opportunities in SME Sector

Several opportunities exist based on the gap between possible resilience solutions and those currently employed. Opportunities exist for:

1. Retailing certain materials such as hurricane shutters, radiant barriers, and low-flow water fixtures.
2. Providing design and installation services for less popular resilience measures such as rainwater harvesting systems, flood barriers and photovoltaic systems.

6 Market Demand

Key Findings:

1. The 5-year potential for residential property development market in Barbados, Jamaica, and Trinidad and Tobago is estimated at US$6.25B, US$14.8B and US$10B, respectively.
2. The 5-year potential for commercial property in Barbados, Jamaica, and Trinidad and Tobago, the market is US$1.15, US$2.2 and US$2.5 billion, respectively.
3. Of the four hazards, heat was highlighted as posing the most significant challenge, as the phenomenon was experienced daily by a larger number of respondents.
4. Access to financing, affordability and cost were among the top motivating factors when purchasing residential and commercial property in all three countries.
5. People were more willing to pay for heat mitigation measures.
6. Financial institutions do not offer products incorporating climate resilience measures into developing new infrastructure. However, mortgage financiers are willing to include resilience add-ons/products in mortgage financing to deal with drought and heat/cooling to new buildings or retrofit existing infrastructure.
7. Insurance agents, risk assessors and sellers noted that the impact of climatic events is not solely factored in assessing risks for coverage.
8. Insurance is mainly sought on a compulsory basis, and coverage lags property values. Hurricanes have resulted in reinsurance cost increases of up to 25%.

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6.1 Methodology

The study used secondary and primary data sources and qualitative and quantitative approaches to triangulate the assessment. In addition, a semi-structured tool was developed to guide the qualitative evaluation. At the same time, two surveys were implemented in each of the three countries targeting current and potential residential and commercial property owners.

The study analysed willingness to pay (WTP) for climate-resilient infrastructure or to integrate the same into existing infrastructure. The study further examined the use of insurance as a resiliency measure and the cost, affordability, and extent to which insurance is factored into risk management and influences premiums and reinsurance capacity. Current financing products targeted at climate resilience were also examined. The data was then used to estimate the market size in each of the three countries.

6.2 Market Size Estimate (MSE)

When the gap between demand and supply in the three When the gap between demand and supply in the three countries was calculated, mathematical and economic calculations of a suitable market sizing approach were employed to analyse the impact of different variables on the total addressable and serviceable market. In addition, data from the WTP survey that examined willingness, affordability, and income was cross-referenced to identify suitable market sizing based on current market conditions. Data from financial institutions on mortgages, financing bands, the percentage of the mortgage that falls within each band, and the average duration of mortgages, among other indices, help compute MSE.

Market demand is the sum of the individual's demand in the specific market. The demand for climate-resilient residential buildings & demand for climate-resilient commercial buildings:

$$d = F(a\,,\, w) \quad \text{Equation 2}$$
$$a = F\,(yd - c - r - \pi) \quad \text{Equation 3}$$
$$W = F(ds) \quad \text{Equation 4}$$

Where:

d	is the Market Demand,	a	is ability,
W	is willingness,	yd	is disposable income,
c	is cost,	r	is interest rates,

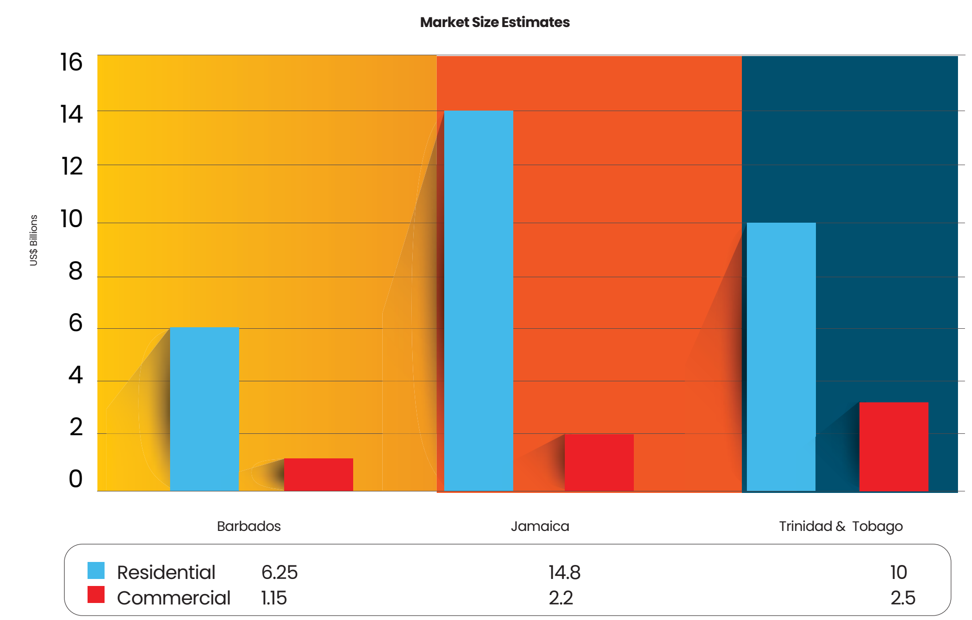
$-\pi$ is the inflation rate

Willingness is a function of desire (ds).

Market Demand

The 5-year potential for residential property in Barbados, Jamaica, and Trinidad and Tobago is estimated at US$6.25, US$14.8 and US$10 billion, respectively; while for commercial, the market is US$1.15B, US$2.2B and US$2.5B respectively. The most significant annual demand for residential units was for three bedrooms in Barbados (51,500) and Trinidad and Tobago (63,319), while for Jamaica, two bedrooms were in the highest demand (73,500). Where commercial units are concerned, on average most of the demand was for units between US$100,000 and US$250,000 - 58% of the 3,157 units (Barbados), 46% of the 7,466 units (Jamaica) and 87% of the 16,987 units (Trinidad).

Figure 6.1 Market size estimate for Barbados, Jamaica and Trinidad and Tobago



Willingness To Pay (WTP)

The Willingness to Pay (WTP) survey was administered to measure and quantify ability, readiness, and motivating factors when purchasing property; the impacts of climatic events on their property; the prioritisation of climatic events and the affordability of infrastructure, as well as their financing sources and insurance behaviours. A mix of purposive and snowball non-purposive sampling was used to target participants. Scenario analysis was further used to quantify WTP, which helped identify, define the market, and assess the demand for climate-resilient infrastructure and climate adaptation solutions. Therefore, willingness to pay is a function of the marginal utility derived from buying climate-resilient infrastructure.

Wp(i) = - a(1-p)cH-u Equation 5

Where:
p is the probability of no climate hazards

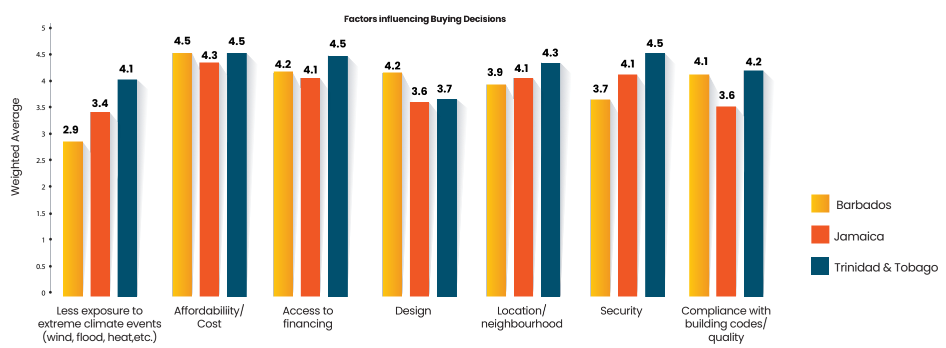
1-p is the probability of climate hazards occurring

cH is the marginal cost of housing expenses which is negative

-cH is the positive benefit of housing reinforcement in the case of a hurricane

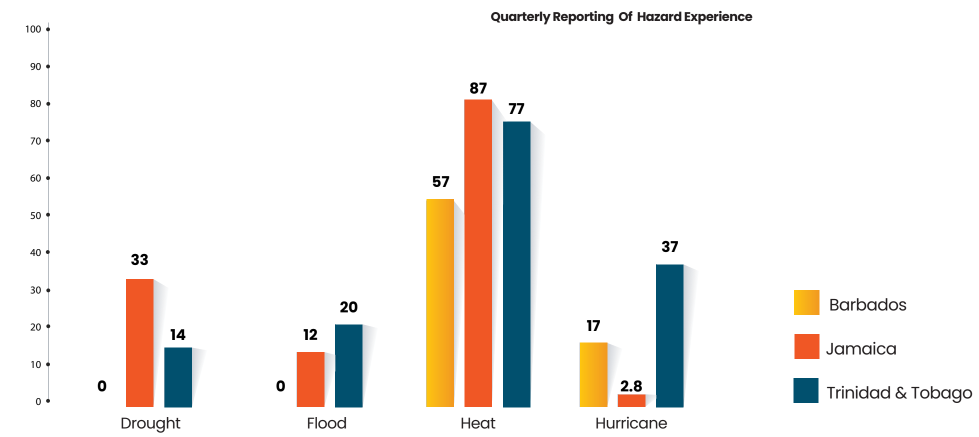
Access to financing, affordability and cost were among the top motivating factors when making purchasing decisions in all three countries. On the other hand, exposure to extreme weather events was among the lowest decision-making factors.

Figure 6.2 Factors influencing buying decisions of residential and commercial buildings for Barbados, Jamaica and Trinidad and Tobago



Of the four hazards, heat was highlighted as posing the most significant challenge, as the phenomenon was experienced daily by a larger number of respondents.

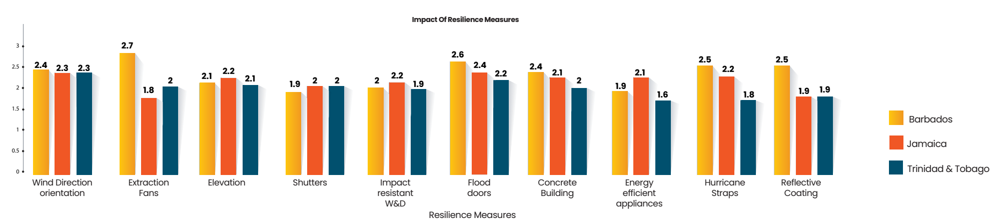
Figure 6.3 Quarterly Reporting of Hazard Experience in Barbados, Jamaica and Trinidad and Tobago.



Of the four hazards, heat was highlighted as posing the mos

Overall, the weighted scores for the impact of resilience measures were low. Still, the effect of heat was evident as those measures gained competitive scores and could create a market demand for retrofitting existing infrastructure.

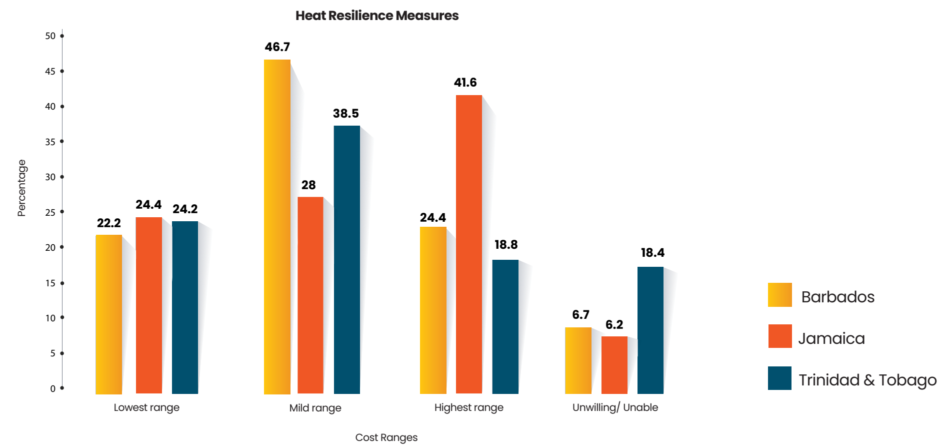
Figure 6.4 Impact of resilience measures on mitigating against hazards for Barbados, Jamaica and Trinidad and Tobago.



Of the four hazards, heat was highlighted as posing the mos

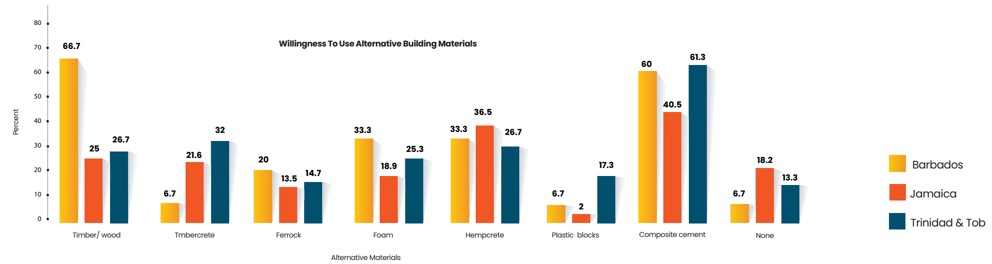
Cost and affordability issues again came to the fore regarding willingness to pay for various climate resilience measures. However, people were more willing to pay for heat mitigation measures, seemingly because those measures were also among the most cost-effective; heat was the hazard experienced more frequently.

Figure 6.5 Willingness of participants to pay for Heat Resilience measures in Barbados, Jamaica and Trinidad and Tobago.



Some amount of consideration was given to using alternative materials to construct outer walls. Timber and composite were the top two choices for Barbados, while Jamaicans seemed to prefer Hempcrete and composite cement, while Trinidad preferred Timbercrete and composite cement.

Figure 6.6 Willingness of participants to use alternative building materials in Barbados, Jamaica and Trinidad and Tobago.



6.4 Finance and Insurance

The recent increases in insurance premia have had a significant impact on the demand by companies and individuals for mortgage finance. The higher premia have coincided with higher interest rates and more conservative banking policies to reduce the demand for mortgages. This problem will impact housing and commercial property demand.

According to the market consultations, there is a market for integrating climate resilience into new and existing infrastructure. There is however, a reluctance from developers to take any action that would reduce profit margins and raise consumer prices.

To address this, capacity building is required to allow the construction industry to experiment with prototypes that meet purchasers' security and social needs as well as encourage developers to incorporate these measures in construction.

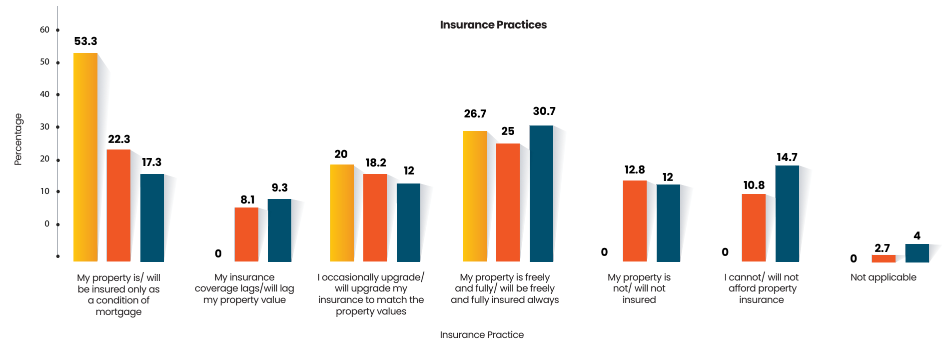
There is also a clear need to educate consumers on the importance of climate resilient infrastructure to reduce risks and potential losses as well as inform them on available mortgage financing options. Mortgage insurance is generally acquired as a mandatory requirement to obtain a mortgage, however, up to 15% of respondents found it unaffordable. This has been exacerbated by a decrease in reinsurance capacity regionally resulting in price increases for catastrophe insurance ranged from 5% to 25% in 2021/2022.

Although financial institutions do not specifically offer products incorporating climate resilience measures, there is a willingness to include resilience add-ons/products in mortgage financing for new buildings or retrofitting existing infrastructure.

As such, it would be helpful to create a resilient construction certification that outlines the required resiliency measures for the country in order for the property to be considered resilient in the face of local climate change threats. Such a certification would allow for certain real estate assets to be labeled green. Investors and financial institutions seeking to channel green funding would be incentivized to create specialized financial products and offerings for such projects.

IDB Invest, that has a mandate to advance private sector preparedness for climate change events, could also explore options to create schemes with financial institutions, to offer loans to certified resilient properties that are insured, where IDB Invest absorbs the upfront premium associated with resilient construction, with the assumption that there would be cost savings for the insurance company in the case of climate change trigger event (e.g. hurricane, heat wave, flooding).

Figure 6.7 Insurance practices of participants in Barbados, Jamaica and Trinidad and Tobago.



6.5 Conclusion and Recommendations of Market Consultations

There is a market to integrate climate resilience into new or existing commercial and residential infrastructure. As climate events are predicted to become more extreme, there is a need to build capacity among developers, contractors, and planners. Capacity building should focus on enabling the construction industry to experiment with various prototypes that will meet purchasers' security and social needs. This becomes important as developers expressed unwillingness to undertake any actions that reduce the profit margin and that would ultimately result in price increases for the consumer—for example, demonstrating proof of concept for low-income housing that can then be transitioned into higher income brackets.

Affordability issues in all three markets, as well as the differing social and economic dynamics, the IDB should approach the different economies methodically and design innovative lending arrangements that developers, SMEs, and financial institutions will find appealing to increase uptake.

For example, while Jamaica has the highest market potential regarding unit demand, its spending ability is lower than that of Barbados and Trinidad.

Given that heat was the most concerning hazard in all three markets, as well as the most willing to pay for given lower investment costs, there is potential for retrofitting existing infrastructure with heat resilience measures. Water and energy consumption measures were less motivating in Trinidad and Tobago due to these supplies' lower cost than in Barbados and Jamaica. There is a need to raise consumer and public awareness about climate resilience infrastructure and mortgage financing options.

Caribbean insurance premia are driven by the cost of coverage by extra-regional reinsurers that are facing higher pay outs due to intensifying climate change. It could be viable for reinsurers to use their Corporate Social Responsibility (CSR) programs to offer lower prices to Caribbean insurance companies that are willing to pass on cost savings to individual clients who enhance resilience in the specific areas identified in this study.

7 Conclusions and Recommendations

The following are the conclusions from this assessment:

1. The SME landscape for Barbados, Jamaica and Trinidad and Tobago is estimated at over 60,000 SMEs in total and typically accounts for up to 56% of the labour force. The preferred industries appear to be trade, accommodation, food services, social and personal services, manufacturing, building and professional services. The residential landscape prefers detached housing units and current demands outstrip market supply in all three countries with annual residual demands of 25,000 across the three countries.

2. Climate trends and projections strongly suggests decreasing rainfall, increased rainfall intensities and worsening drought conditions across the three countries. Increased intense hurricanes, hotter day and night-time temperatures and higher sea levels are expected in the ture climate

3. Both catastrophic and slow onset damage assessment indicate that generally Hurricane winds and floods are the most expensive hazards followed by drought and heat waves. Prioritization, by number of persons affected and AAL, resulted in Hurricane winds and floods typically being ranked 1st and either extreme heat or flooding typically being ranked 2nd. The ranking generally aligns with national rankings.

4. Architypes and resilience measures were proposed for residential and commercial buildings and include hurricane wind, heat, drought, and flooding mitigation measures.

5. Climate change resilience measures are generally economically viable for all four prioritized hazards in residential and SME developments. Resilience measures for all four prioritized hazards of flooding, hurricane winds, drought and extreme heat have an average ROI of 21x for residential units and 31x for SMEs across Barbados, Jamaica and Trinidad and Tobago. The average returns over 5 years for residential and SME architypes are 24x and 46x for Barbados, 22x and 300x for Barbados and 18x and 16x for Trinidad and Tobago.
6. Market demand surveys suggest that there are 121,429 formally registered SMEs across the three countries mostly involved in the wholesale/retail trade in rented or leased premises. SMEs contribute 60%-70% to GDP[42] in the Caribbean which brings the estimated contribution for all three countries to 25.9billion US$.
7. There is a market for incorporating climate resilience into new or preexisting commercial and residential infrastructure with the greatest willingness to pay for heat resilience measures.
8. Insurance agents, risk assessors, sellers noted that the impact of climatic events is not solely factored in the assessment of risks for coverage. Additionally, insurance is mostly sought on a compulsory basis and coverage lag property values. Hurricanes have resulted in reduced reinsurance capacity and consequent cost increases up to 25%.
9. Building capacity among developers, contractors, and planners is necessary as it is predicted that climate events will become more severe. Capacity building should concentrate on giving the construction industry the ability to test various prototypes that will satisfy the social and security needs of customers. This is crucial because developers have stated that they are unwilling to take any measures that would lower their profit margin and ultimately lead to consumer price increases.

[42]Maharaj. (2021, July 29). Supporting Micro, Small and Medium Enterprises, the Backbone of Caribbean Economies. CARICOM Today. Retrieved November 11, 2022, from https://today.caricom.org/2021/07/27/supporting-micro-small-and-medium-enterprises-the-back-bone-of-caribbean-economies/

The recommendations are as follows:

1. It is worthwhile for developers, architects and home and commercial property owners to consider investments in resilience measures for the hazards of hurricane winds, floods, extreme heat, and drought as the analysis shows average returns exceed 100%.
2. Capacity building is recommended to enable the construction industry to experiment with various prototypes that will meet the security and social needs of purchasers.
3. The three different economies must be approached in a systematic manner where innovative lending arrangements are designed so that developers, SMEs, and financial institutions will find favourable to increase uptake.
4. Initial lending products can be targeted at heat resilience measures as heat hazard was of the greatest concern in all three markets and was also the most willing to pay for given the lower investment costs. There is potential for the retrofitting of existing infrastructure with the heat resilience measures.
5. There is need to be general awareness building among consumers and the public on climate resilience infrastructure and mortgage financing options.
6. A review and update of the building codes in the three target countries is recommended to increase their capacity to mitigate growing climate risk. Making the codes more stringent would increase adaptation.
7. Reinsurers can use their CSR programs to offer lower prices to Caribbean insurance companies who can then pass on cost savings to individual clients who enhance climate resilience.
8. Engage registered architecture, engineering, project managment and construction companies for building design and construction as this will increase the likelihood that building codes and international best practices are followed.

8 Appendices

8.1 Climatology and Trends

8.1.1 Rainfall and Temperature

Figure A: Mean temperature and rainfall climatology for Barbados, Jamaica and Trinidad and Tobago for the period 1999 to 2020

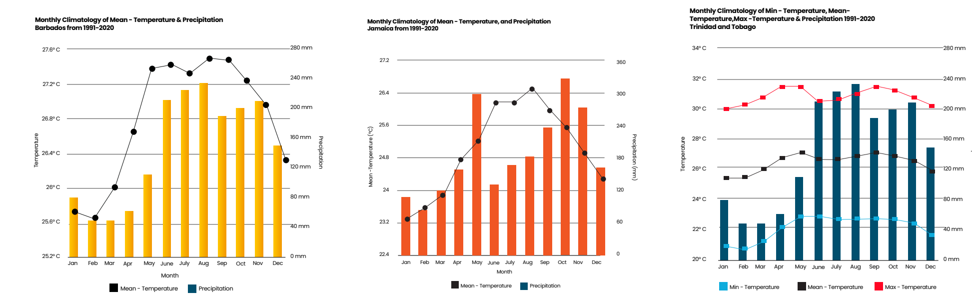


Figure B: Trends in temperature and rainfall for Barbados, Jamaica and Trinidad and Tobago for the period 1951 to 2020

Figure C: Trends in maximum of maximum daily (top row) and minimum of minimum daily (bottom row) air temperature for Barbados, Jamaica and Trinidad and Tobago for the period 1951 to 2020

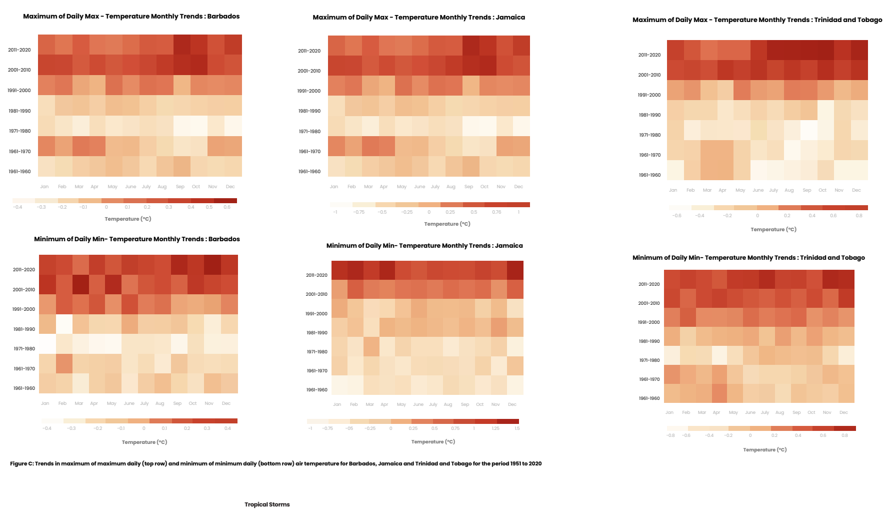
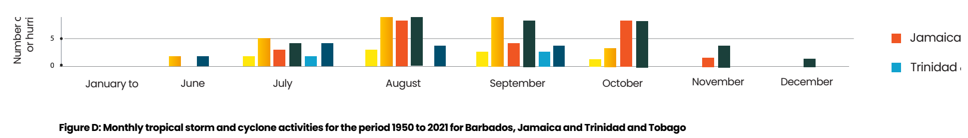


Figure D: Monthly tropical storm and cyclone activities for the period 1950 to 2021 for Barbados, Jamaica and Trinidad and Tobago



Appendices

8.2 Climate Projections

8.2.1 Precipitation

Table A: Projected Change in Seasonal [RX1] and {RX5} Precipitation as Percentage for Barbados, Jamaica and Trinidad and Tobago from SSP 2 for the period 2040 to 2059.

PRECIPITATION	DJF	MAM	JJA	SON
Barbados	-6.88 (-26.97,5.23)	-8.53 (-29.08,9.62)	-7.12 (-27.82,5.40) **[20%]**	-3.98 (-16.37,6.30) **{16%}**
Jamaica	2.81 (-15.69,17.71)	0.69 (-14.56,14.95)	-4.11 (-20.45,6.96) **[12%]**	1.82 (-10.15,15.74) **{33%}**
Trinidad and Tobago	-12.17 (-27.03,0.38)	-7.52 (-35.71,8.67)	-5.26 (-20.13,9.06) **[13%]**	-4.16 (-27.95,12.15) **{15%}**

Figure E: Projected annual precipitation and climatology mean for Barbados, Jamaica and Trinidad and Tobago for the period 2040 to 2059, from SSP 2 (RCP 4.5) ensemble means.

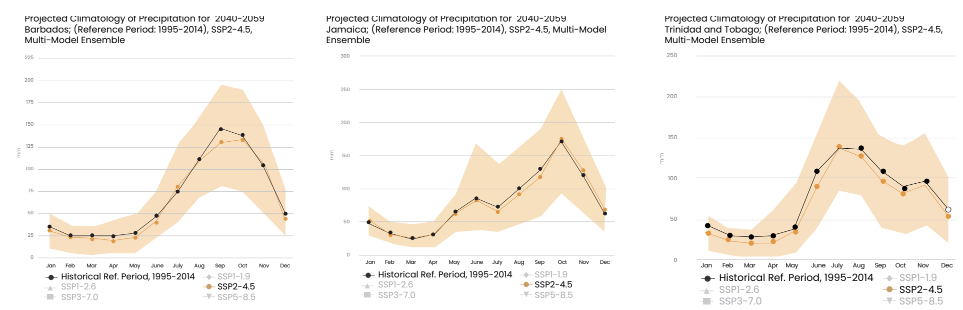
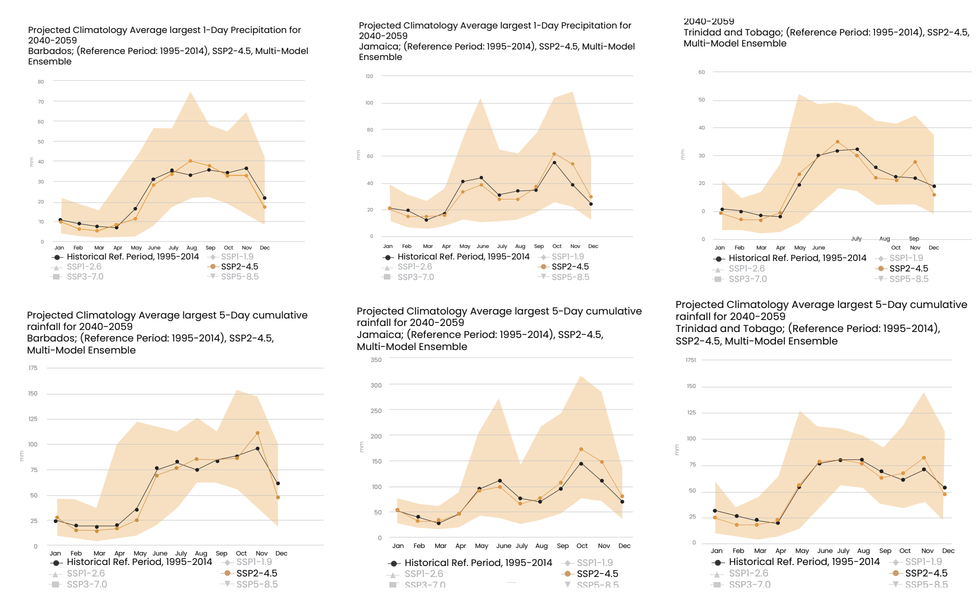


Figure F: Projected 1 and 5-day precipitation for Barbados, Jamaica and Trinidad and Tobago for the period 2040 to 2059, from SSP 2 (RCP 4.5) ensemble means.



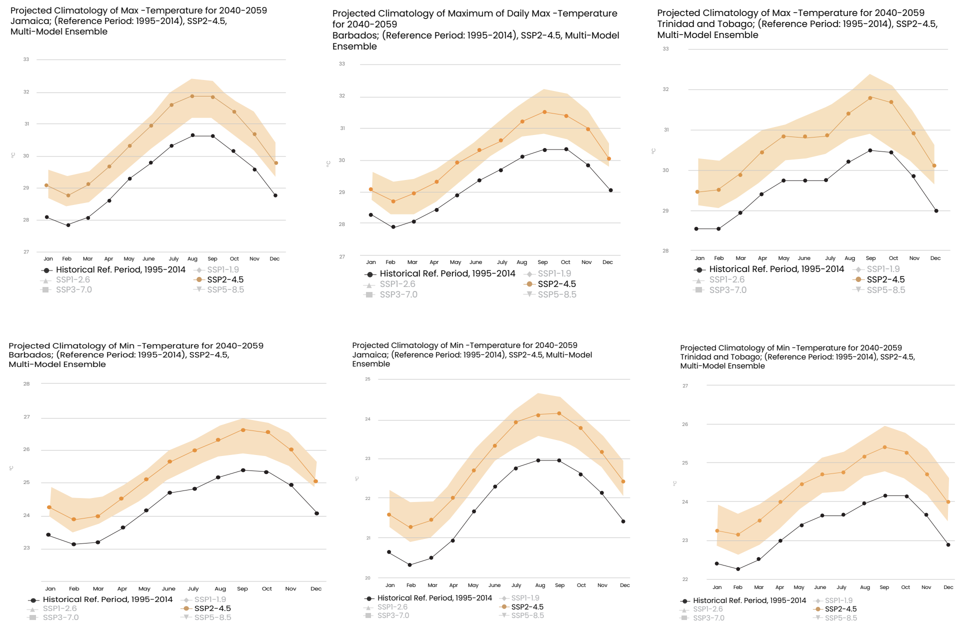
8.2.2 Air Temperature

Table B: Projected temperatures for Barbados, Jamaica and Trinidad and Tobago from SSP 2 for the period 2040 to 2059.

8.2.2 AIR TEMPERATURE

	DJF	MAM	JJA	SON
Barbados	29.26 (28.91,29.82	29.34 (28.74,29.76)	30.70 (30.31,31.26)	31.28 (30.57,31.88)
Jamaica	30.04 (29.50,30.43)	30.42 (29.91,31.02)	32.24 (31.10,32.78)	32.15 (31.36,32.67)
Trinidad and Tobago	30.41 (29.95,31.08)	31.14 (30.47,31.93)	31.83 (31.34,32.45)	32.31 (31.21,32.95)

Figure G: Projected mean, max of maximum and min of minimum climatology in air temperature for Barbados, Jamaica and Trinidad and Tobago for the period 2040 to 2059, from SSP 2 (RCP 4.5) ensemble means.



8.2.3 Drought

Table C: Projected SPEI percentage change for Barbados, Jamaica and Trinid

8.2.3 DROUGHT

	SPEI 10% limits from 2021 to 2059	% change in Discharge
Barbados	-1.0 to -1.53	-31 (-10, -35)
Jamaica	-1.0 to -1.1	-16 (-7, -23)
Trinidad and Tobago	-1.0 to -2.0	-35 (-18, -40)

8.3 Questionnaire

8.3.1 Methodology

A stakeholder survey through a questionnaire-based tool was used to better understand the hazard and prioritization knowledge, attitudes, perceptions, interests, and experiences. Findings were used to make informed decisions as to the prioritization and resilience measures. The approach included:

1. A stakeholder mapping exercise was undertaken to sample persons across the region according to their function (industry practitioner, disaster management agencies, developers, etc.) and by influence (decision making at the national level)
2. A total of 37 samples were envisaged to give a confidence of over 80% given the relatively small landscape across the three counties.
3. Designing the survey instrument considered:
   a. The mixed online and interview type collection method (i.e., self-administered and administered by an interviewer). One questionnaire was designed to cover the range of stakeholder groups and diversity amongst stakeholder groups.
   b. Question-response format with a mixture of open ended and rating scale response, with multiple choice answers, to shorten the interview time.
   c. Flow and layout that starts out general and becomes more engaging and with specific quantitative questions.
   d. A review and pre-testing were done internally to identify how clear the questions are, problems in coding, whether the questions yield the expected data, skip patterns, continuity, and flow of the questions.

The survey was implemented across the three countries and the results were analysed to determine the representative architypes for residence and SME, hazard experience and prioritization of resilience measures.

8.3.2 Instrument

Climate Risk and Resilience Measures Identification

CEAC Solutions Company Limited is developing a publication on interventions to increase climate resilient investments in Barbados, Jamaica and Trinidad and Tobago.

The survey will take about 10-15 minutes of your time to complete. The results will then be shared with team members and aid in guiding the publication and deriving mitigation measures for future construction of climate resilient residential homes and Small and Medium Enterprises (SME's).

Thank you for taking the survey and we appreciate your input.

1. **Contact Information**

   Name
   Company
   Email Address
   Phone Number

2. **Country**

3. **What type of entity do you operate?**

   - ☐ Disaster Risk Management
   - ☐ Construction/ Developers (Residential)
   - ☐ Construction/ Developers (SME Developers)
   - ☐ SME Business Group
   - ☐ Insurance/ Adjusters
   - ☐ Architects

4. Do the current building codes and guidelines adequately address resilience and mitigation measures for residential and SME buildings?

   ☆ ☆ ☆ ☆ ☆

5. **From the images below, select the most common type of residential infrastructure constructed in your country?**

6. **From the images below, select the most common type of Small and Medium size Enterprises (warehouses etc) constructed in your country?**


affordable-income- 750 - 1100 sq ft


middle income 550-800 sq ft


middle income 550-800 sq ft


low income- timber and gable roof


low-income 300-550 sq ft

☐ None of the above

6. From the images below, select the most common type of Small and Medium size Enterprises (warehouses etc) constructed in your country?

Flex-warehouse- 1000- 2000 sq ft

Warehouse- 2,000- 5000 sq ft

Office Space- 500- 2000 sq ft

☐ None of the above

7. State the top three hazards (foods, droughts, hurricane extreme temperature) that you have experienced and the associated damage

Event 1:
Nature of damage and cost ($USD)

Event 2:
Nature of damage and cost ($USD)

Event 3:
Nature of damage and cost ($USD)

Other:

8. Bank the natural hazard that has caused the greatest impact on the Residential Sector?

	No Impact	Minimal Impact	Moderate Impact	Significant Impact
Flooding	○	○	○	○
Drought	○	○	○	○
Hurricane (Winds)	○	○	○	○
Extreme Temperature	○	○	○	○
Sea Level Rise	○	○	○	○

9. Rank the natural hazards that caused the greatest impact on SME sector

	No Impact	Minimal Impact	Moderate Impact	Significant Impact
Flooding	○	○	○	○
Drought	○	○	○	○
Hurricane (Winds)	○	○	○	○
Extreme Temperature	○	○	○	○
Sea Level Rise	○	○	○	○

10. Are there any mitigation measures currently being employed to mitigate the hazards?

- ○ Yes
- ○ No

11. If yes, state the hazard and the mitigation measure/s being used

12. Which flood mitigation measure do you regard as the most feasible and cost efficient?

- ○ Drainage and Flood Control Measures
- ○ Detention and Retention Ponds
- ○ Permeable Pavement
- ○ Green Roofs/ Rainwater Harvesting
- ○ Elevated Site and floor levels
- ○ Other (please specify)

13. State the additional cost per unit ($USD) that will be associated with implementing the measure selected above in the construction process?

- ○ <$1000
- ○ $1000 - $10,000
- ○ $10,000 - $100,000
- ○ > $100,000

14. **Which drought mitigation measure do you regard as the most feasible and cost efficient?**

- ◯ Water Harvesting
- ◯ Grey water system
- ◯ Low flow water closets and faucets
- ◯ On site water storage

Other (please specify)

15. **State the additional cost per unit ($USD) that will be associated with implementing the measure selected above in the construction process**

- ◯ <$1000
- ◯ $1000 - $10,000
- ◯ $10,000 - $100,000
- ◯ > $100,000

16. **Which hurricane winds mitigation measure do you regard as the most feasible and cost efficient?**

- ◯ Roof straps
- ◯ Storm Shutters
- ◯ Impact Resistant Windows
- ◯ Wind Resistant Frames
- ◯ Other (please specify)

17. **State the additional cost per unit ($USD) that will be associated with implementing the measure selected above in the construction process?**

- ◯ <$1000
- ◯ $1000 - $10,000
- ◯ $10,000 - $100,000
- ◯ > $100,000

18. **Which extreme temperature mitigation measure do you regard as the most feasible and cost efficient?**

- ◯ Solar shaders
- ◯ Improved Glazing System
- ◯ Climate walls (conditioned barrier between internal and external walls)
- ◯ Reducing roof loads (green or high-albedo roofs)
- ◯ Energy efficient HVAC System
- ◯ Other (please specify)

19. **State the additional cost per unit ($USD) that will be associated with implementing the measure selected above in the construction process?**

- ◯ <$1000
- ◯ $1000 - $10,000
- ◯ $10,000 - $100,000
- ◯ > $100,000

20. **Which hurricane winds mitigation measure do you regard as the most feasible and cost efficient?**

- ◯ Roof straps
- ◯ Storm Shutters
- ◯ Impact Resistant Windows
- ◯ Wind Resistant Frames
- ◯ Roof Selection
- ◯ Other (please specify)

21. **Which sea level rise mitigation measure do you regard as the most feasible and cost efficient?**

- ◯ <$1000
- ◯ $1000 - $10,000
- ◯ $10,000 - $100,000
- ◯ > $100,000

22. **Which sea level rise mitigation measure do you regard as the most feasible and cost efficient?**

- ◯ Increase Floor Levels
- ◯ Shoreline Stabilisation
- ◯ Increased setbacks from Shoreline
- ◯ Other (please specify)

23. **State the additional cost per unit ($USD) that will be associated implementing the mitigating measure selected above in the construction process?**

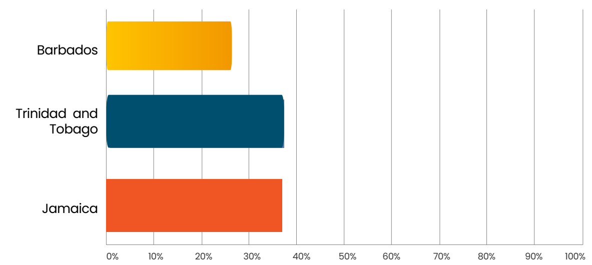
- ◯ <$1000
- ◯ $1000 - $10,000
- ◯ $10,000 - $100,000
- ◯ > $100,000

24. **Suggest specialized person/s that you would recommend for further review**

8.3.3 Responses

Q2 Country

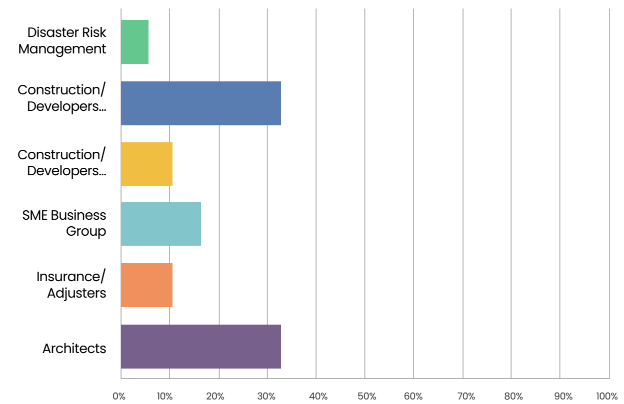
Answered: 19 Skipped:0



ANSWER CHOICES	RESPONSES	
Barbados	26.32%	5
Trinidad and Tobago	36.84%	7
Jamaica	36.8%	7
TOTAL		**19**

Q3 What type of entity do you operate?

Answered: 18 Skipped:1

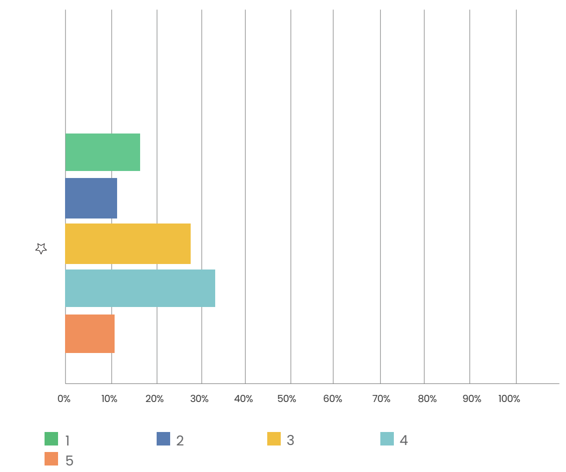


ANSWER CHOICES	RESPONSES	
Disaster Risk Management	5.56%	1
Construction/ Developers (Residential)	33.33%	6
Construction/ Developers (SME Developers)	11.11%	2
SME Business Group	16.67%	3
Insurance/ Adjusters	11.11%	2
Architects	33.33%	6
TOTAL Respondents: 18		

Appendices

Q4 Do the current building codes and guidelines adequately address resilience and migration measures for residential and SME buildings?

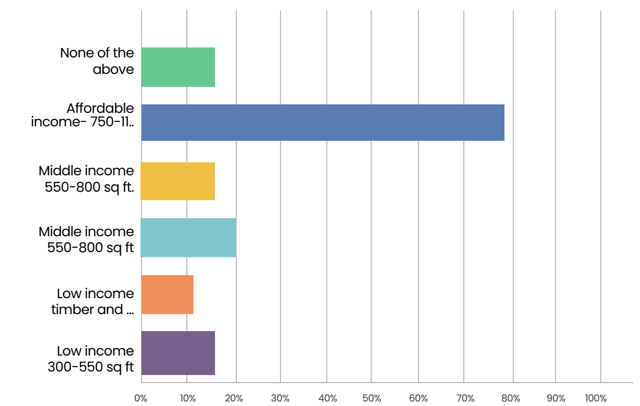
Answered: 18 Skipped:1



	1	2	3	4	5	TOTAL	WEIGHTED AVERAGE
☆	16.67% 3	11.11% 2	27.78% 5	33.33% 6	11.11% 2	18	3.11

Q5 From the images below, select the most common type of residential infrastructure constructed in your country

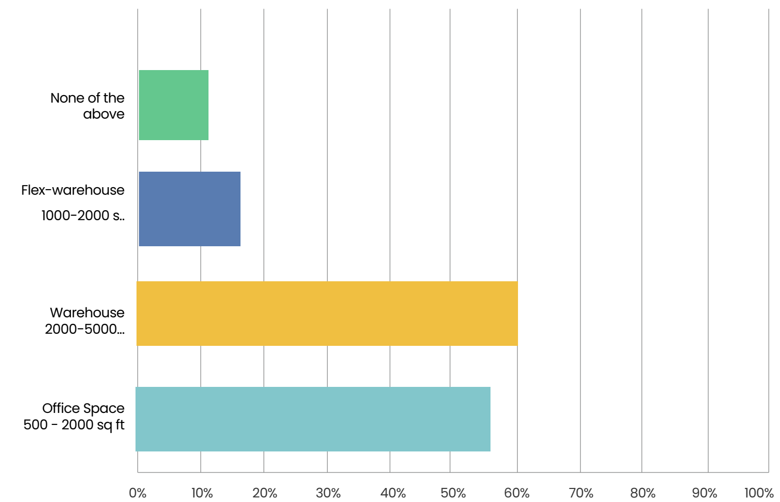
Answered: 19 Skipped: 0



ANSWER CHOICES	RESPONSES	
None of the above	15.79%	3
Affordable income 750-1100 sq ft	78.95%	15
Middle income 550-800 sq ft	15.79%	3
Middle income 550-800 sq ft	21.05%	4
Low income 550-800 sq ft	10.53%	2
Low income 300-550 sq ft	15.79%	3
TOTAL Respondents: 19		

Q6 From the images below, select the most common type of Small and Medium Size Enterprises (warehouses etc.) constructed in your country

Answered: 18 Skipped: 1



ANSWER CHOICES	RESPONSES	
None of the above	11.11%	2
Flex-warehouse - 1000 -2000 sq ft	16.67%	3
Warehouse - 2,000 - 5000 sq ft	61.11%	11
Office Space 500 - 2,000 sq ft	55.56%	10
TOTAL Respondents: 18		

Q7 State the top three hazards (flood, drought, hurricane, extreme temperature) that you have experienced and the associated damage

Answered:18 Skipped:1

ANSWER CHOICES	RESPONSES	
Event 1:	100.00%	18
Year	0.00%	0
Nature of damage and cost ($USD)	72.22%	13
Event 2:	72.22%	13
Year	0.00%	0
Nature of damage and cost ($USD)	55.56%	10
Event 3:	38.89%	7
Year	0.00%	0
Nature of damage and cost ($USD)	27.78%	5
Other	5.56%	1

#	EVENT 1:
1	Hurricane
2	Hurricane
3	Flood
4	Hurricane Elsa (2021)
5	Hurricane
6	Flooding
7	Flood
8	Flood
9	Hurricane Elsa
10	Drought
11	Flooding
12	Hurricane
13	Hurricane
14	Flood
15	Flood
16	Flood
17	Flood
18	Flood and hurricanes

#	YEAR
	There are no response

#	NATURE OF DAMAGE AND COST ($USD)	DATE
1	Damage to building roofs, and power and telephone transmission infrastructure (Cost estimate unknown)	
2	$0.00	
3	Significant impact	
4	Unable to quantify	
5	Loss of productive time	
6	600 Houses damaged-$10,000.00	
7	Content and foundation Damage	
8	$100'000'000.00	
9	Housing- $100,000 - $150,000	
10	20,000	

11	$$
12	5,000,000.00
13	The organisation no specific information to share on these. From floods our parking lot has been affected, leaks from heavy rains but cost not significant

#	EVENT 2:
1	Flooding
2	Hurricane
3	Ivan (2004)
4	Flooding
5	Storm
6	Annual Flooding at random locations
7	Flood
8	Hurricane
9	Volcanic Ash
10	Flood
11	Hurricane
12	Tropical storms/ hurricane
13	n/a
#	YEAR:
	There are no responses
#	Nature of Damage and cost ($USD):
1	Damage to roadways and buildings within flood zones (estimate of damage uknown)

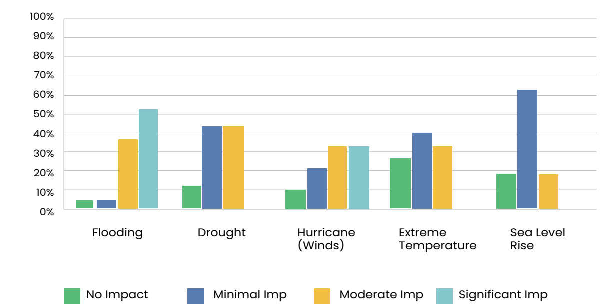
#	Nature of Damage and cost ($USD:) cont'd.
2	$0.00
3	Significant
4	$5,000,000
5	Roof Damages
6	$30'000'000.00
7	Drought
8	20,000
9	$$$$
10	n.a

Appendices

#	EVENT 3:
1	Temperature
2	Earthquake
3	Hurricane
4	Drought
5	Flood
6	Coastal erosion
7	n/a
#	YEAR:
	There are non responses
#	Nature of Damage and Cost ($USD);
1	Moderate impact
2	$4'000'000.00
3	Extreme temperature
4	$$$
5	n/a
#	OTHER
1	Fire

Q8 Rank the natural hazard that has caused the greatest impact on the Residential Sector

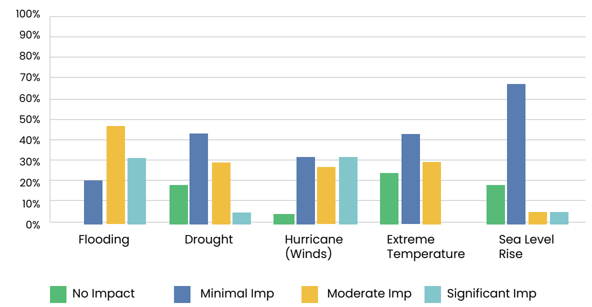
Answered: 19 Skipped: 1



	NO IMPACT	MINIMAL IMPACT	MODERATE IMPACT	SIGNIFICANT IMPACT	TOTAL	WEIGHTED AVERAGE
Flooding	5.26% 1	5.26% 1	36.84% 7	52.63% 10	19	2.67
Drought	12.50% 2	43.75% 7	43.75% 7	0.00% 0	16	2.31
Hurricane (Winds)	11.11% 2	22.22% 4	33.33% 6	33.33% 6	18	2.33
Extreme Temperature	26.67% 4	40.00% 6	33.33% 5	0.00% 0	15	2.07
Sea Level Rise	18.75% 3	62.50% 10	18.75% 3	0.00% 0	16	2.00

Q9 Rank the natural hazard that has caused the greatest impact on SME Sector

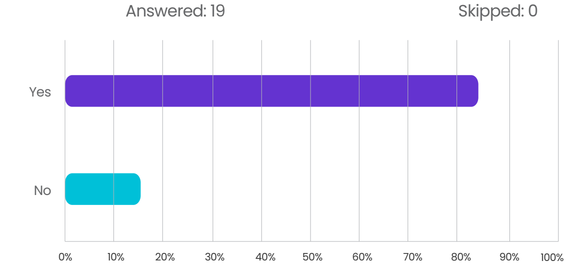
Answered: 19 Skipped: 0



	NO IMPACT	MINIMAL IMPACT	MODERATE IMPACT	SIGNIFICANT IMPACT	TOTAL	WEIGHTED AVERAGE
Flooding	0.00% 0	21.05% 4	47.37% 9	31.58% 6	19	2.69
Drought	18.75% 3	43.75% 7	31.25% 5	6.25% 1	16	2.13
Hurricane (Winds)	5.56% 1	33.33% 6	27.78% 5	33.33% 6	18	2.33
Extreme Temperature	25.00% 4	43.75% 7	31.25% 5	0.00% 0	16	2.06
Sea Level Rise	18.75% 3	68.75% 11	6.25% 1	6.25% 1	16	1.87

Q10 Are there any mitigation measures currently being employed to mitigate the hazards?

Answered: 19 Skipped: 0



ANSWER CHOICES	RESPONSES	
Yes	84.21%	16
No	15.79%	3
TOTAL		19

Appendices

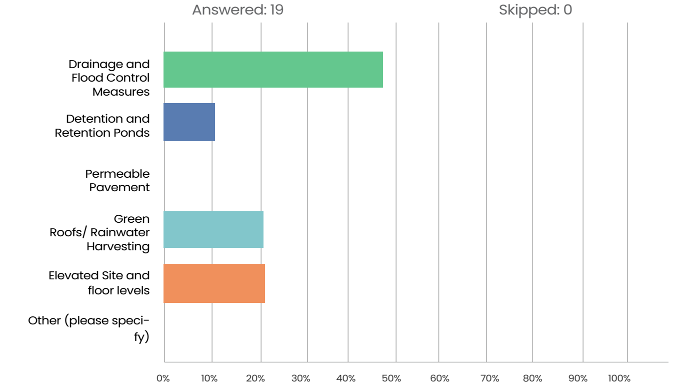
Q11 If yes, state the hazard and the mitigation measure/s being used

Answered:16 Skipped:3

#	RESPONSES
1	Hurricane - regular public education on use of hurricane straps in roof construction
2	Hurricane straps,increase floor elevation, adequately sized storm water drains compliance with material standards
3	Cleaning drains
4	Flooding,exclusion zones for residential construction; drought, rainwater harvesting watershed protection, well rehabilitation; hurricane, new building code
5	Flooding - Business places in flood prone areas install flood protection devices on buildings. Government intervention by implementing desilting and other drainage programmes
6	Residential/ Commercial flooding impact reduced by flood gates to property and clearing of drainage channels albeit not always timely
7	FLOOD - PUMPS, CLEARING OF WATER COURSES
8.	More resilient roofing and building envelope designs
9	Hurricanes, Government has embark on the building of resilient housing
10	Flooding - discourage building in flood prone areas
11	Encroachment of residential properties on waterways,and not cleaning waterways by the sea. Enforce setback from waterways and clean waterways
12	Floodng - Drainage Control
13	Enhancement of operations to withstand hazard
14	Widening river banks,maintenance of rivers/drains,minimize deforestation
15	Building to updated codes and standards
16	Flooding,sea wall construction, drain retrofitting,cleaning,mangrove rehabilitation. Hurricanes: promoted construction measure to include straps; publc education Campaigns

Q12 Which flood mitigation measure do you regard as the most feasible and cost effective?

Answered: 19 Skipped: 0

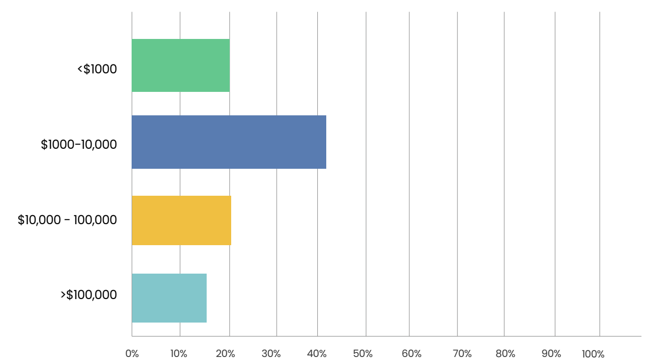


ANSWER CHOICES	RESPONSES	
Drainage and Flood Control Measures	47.37	9
Detention and Retention Ponds	10.53%	2
Permeable Pavement	0.00%	0
Green Roofs/ Rainwater Harvesting	21.05%	4
Elevated Site and floor levels	21.05%	4
Other (please specify)	0.00%	0
TOTAL Respondents:		**19**

#	Other (Please Specify)	DATE
	There are no responses.	

Q13 State the additional cost per unit ($USD) that will be associated with implementing the measure selected above in the construction process

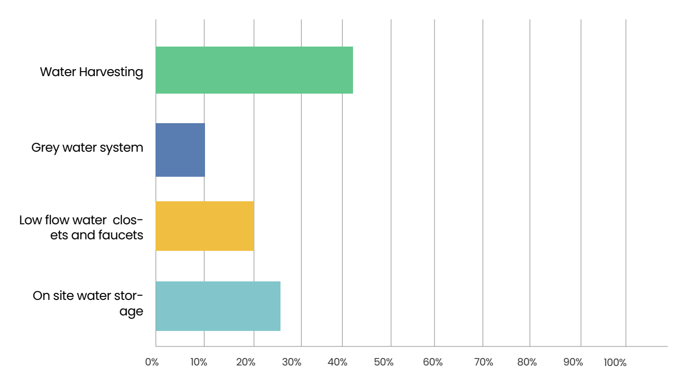
Answered: 19 Skipped: 0



ANSWER CHOICES	RESPONSES	
<$1000	21.05%	4
$1000-10,000	42.11%	8
$10,000 - 100,000	21.05%	4
>$100,000	15.79%	3
TOTAL Respondents:		**19**

Q14 State the additional cost per unit ($USD) that will be associated with implementing the measure selected above in the construction process

Answered: 19 Skipped: 0



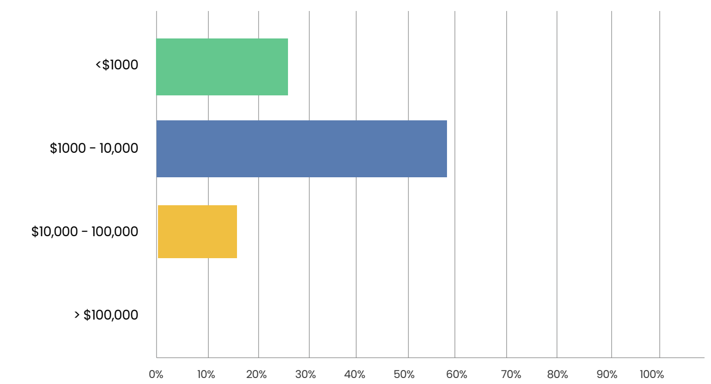
ANSWER CHOICES	RESPONSES	
Water Harvesting	42.11%	8
Grey water system	10.53%	2
Low flow water closets and faucets	21.05%	4
On site water storage	26.32%	5
TOTAL		**19**

#	OTHER (PLEASE SPECIFY)
1	And toilets as well as on site storage
2	Rainwater harvesting is a must do for a water scarce country

Appendices

Q15 State the additional cost per unit ($USD) that will be associated with implementing the measure selected above in the construction process

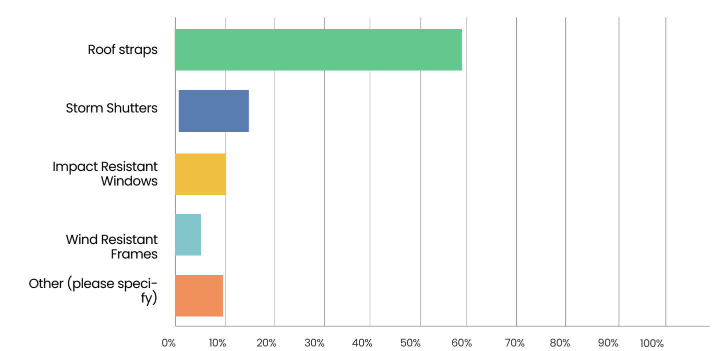
Answered: 19 Skipped: 0



ANSWER CHOICES	RESPONSES	
<$1000	26.32%	5
$1000 - 10,000	57.89%	11
$10,000 - 100,000	15.79%	3
> $100,000	0.00%	0
TOTAL		**19**

Q16 Which hurricane winds mitigation measure do you regard as the most feasible and cost efficient?

Answered: 19 Skipped: 0

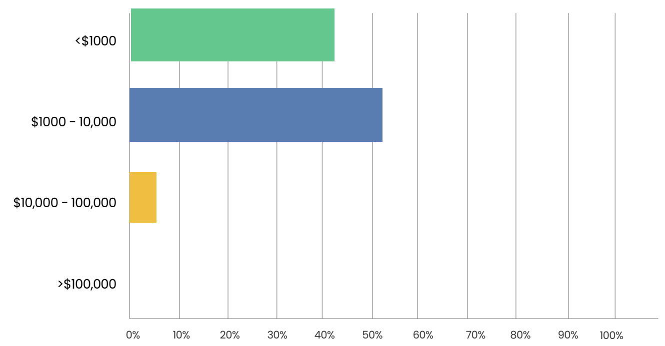


ANSWER CHOICES	RESPONSES	
Roof straps	57.89%	11
Storm Shutters	15.79%	3
Impact Resistant Windows	10.53%	2
Wind Resistant Frames	5.26%	1
Other (please specify)	10.53%	2
TOTAL		**19**

#	OTHER (PLEASE SPECIFY)
1.	Slab roofs
2.	Roof straps and bracing

Q17 State the additional cost per unit ($USD) that will be associated with implementing the measure selected above in the construction process

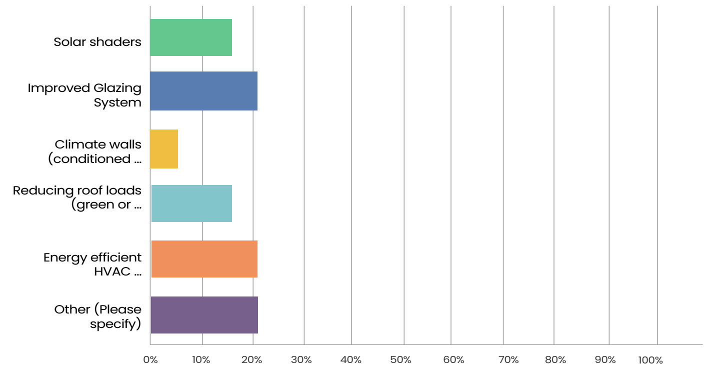
Answered: 19 Skipped: 0



ANSWER CHOICES	RESPONSES	
<$1000	42.11%	8
$1000-10,000	52.63%	10
$10,000 - 100,000	5.26%	1
>$100,000	0.00%	0
TOTAL		19

Q18 Which extreme temperature mitigation measure you regard as the most feasible and cost efficient

Answered: 19 Skipped: 0

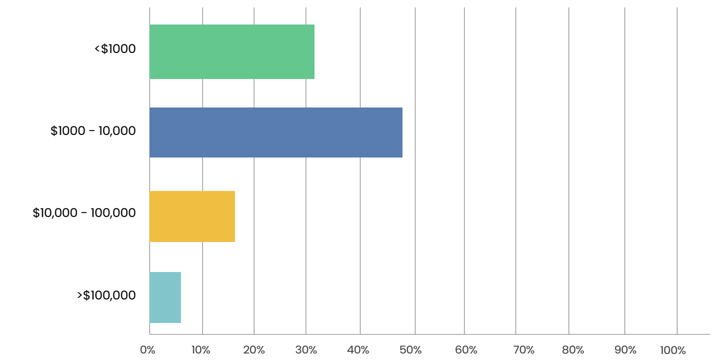


ANSWER CHOICES	RESPONSES	
Solar shaders	15.79%	3
Improved Glazing System	21.05%	4
Climate walls (conditioned barrier between internal and external walls)	5.26%	1
Reducing roof loads (green or high-albedo roofs)	15.79%	3
Energy efficient HVAC System	21.05%	4
Other (Please specify)	21.05%	4
TOTAL		19

#	OTHER (PLEASE SPECIFY)
1.	Painting building envelope in a more reflective colour
2.	Solar shades and energy efficient
3.	Improved Natural Ventilation
4.	Trees and windows

Q19 State the additional cost per unit($USD) that will be associated with implementing the mitigating measure selected above in the construction process

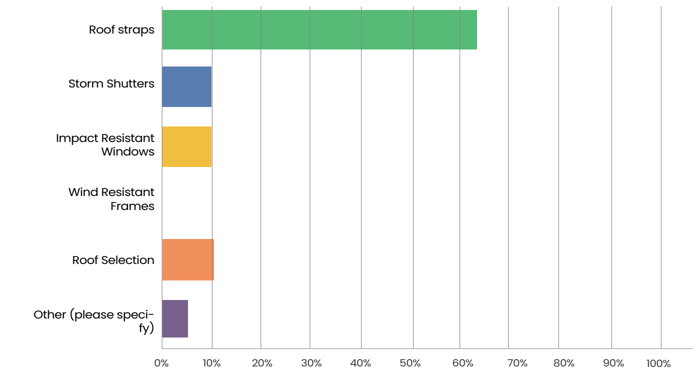
Answered: 19 Skipped: 0



ANSWER CHOICES	RESPONSES	
<$1000	31.58%	6
$1000-10,000	47.37%	9
$10,000 - 100,000	15.79%	3
>$100,000	5.26%	1
TOTAL		19

Q20 Which hurricane winds mitigation measure do you regard as the most feasible and cost efficient?

Answered: 19 Skipped: 0

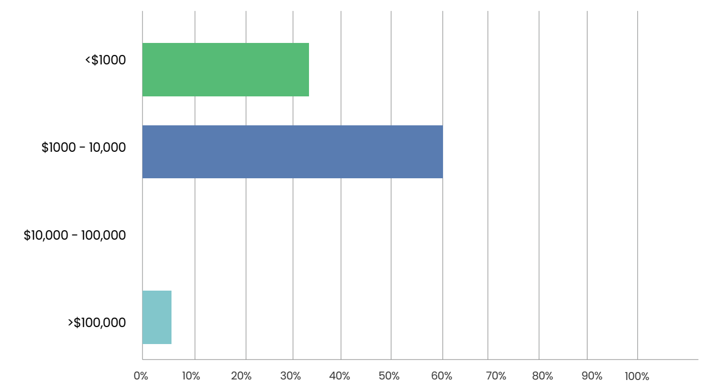


ANSWER CHOICES	RESPONSES	
Roof straps	63.16%	12
Storm Shutters	10.53%	2
Impact Resistant Windows	10.53%	2
Wind Resistant Frames	0.00%	0
Roof Selection	10.53%	2
Other (please specify)	5.26%	1
TOTAL		19

#	OTHER (PLEASE SPECIFY)	DATE
1.	Straps and bracing	5/31/2022 3:03 PM

Q21 State the additional cost per unit ($USD) that will be associated with implementing the mitigating measure selected above in the construction process

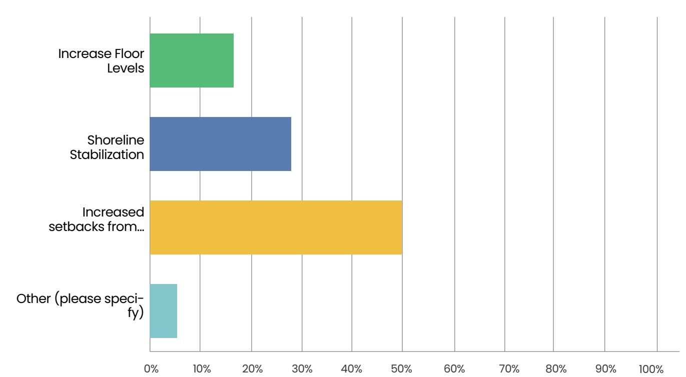
Answered: 18 Skipped: 1



ANSWER CHOICES	RESPONSES	
<$1000	33.33%	6
$1000-10,000	61.11%	11
$10,000 - 100,000	0.00%	0
>$100,000	5.56%	1
TOTAL		18

Q22 Which sea level rise mitigation measure do you regard as the most feasible and cost efficient?

Answered: 18 Skipped: 1



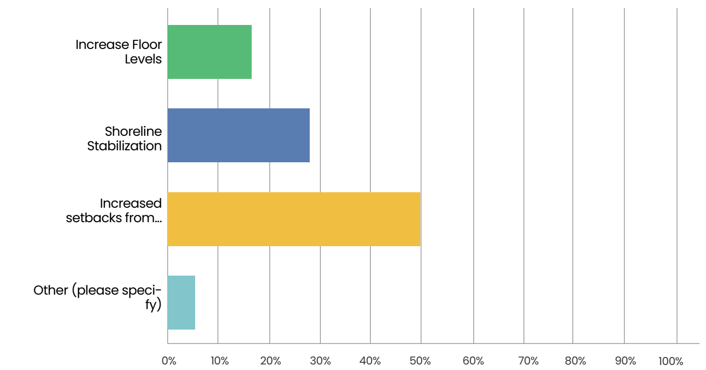
ANSWER CHOICES	RESPONSES	
Increased Floor Levels	16.67%	11
Shoreline Stabilization	27.78%	3
Increased setbacks from shoreline	50.00%	2
Other (please specify)	5.56%	2
TOTAL		19

#	OTHER (PLEASE SPECIFY)
1.	Not a problem at this time

Appendices

Q22 Which sea level rise mitigation measure do you regard as the most feasible and cost efficient?

Answered: 18 Skipped: 1

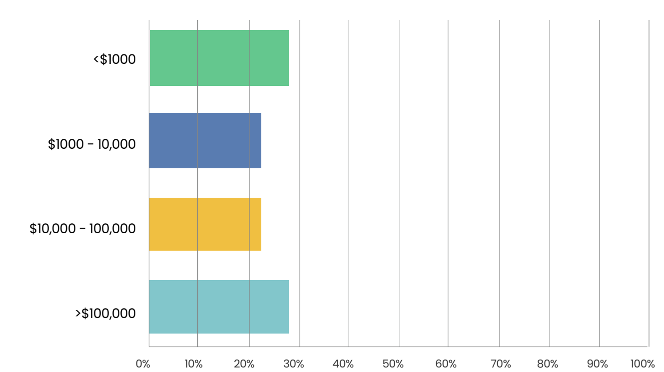


ANSWER CHOICES	RESPONSES	
Increased Floor Levels	16.67%	11
Shoreline Stabilization	27.78%	3
Increased setbacks from shoreline	50.00%	2
Other (please specify)	5.56%	2
TOTAL		19

#	OTHER (PLEASE SPECIFY)
1.	Not a problem at this time

Q23 State the additional cost per unit ($USD) that will be associated with implementing the mitigating measure selected above in the construction process

Answered: 18 Skipped: 1



ANSWER CHOICES	RESPONSES	
<$1000	27.78%	5
$1000-10,000	22.22%	4
$10,000 - 100,000	22.22%	4
>$100,000	27.78%	5
TOTAL		18

8.4 Catastrophic Disasters Profile of Meteorological, Drought and Floods that have affected Barbados, Jamaica and Trinidad and Tobago since 1955 (EMDAT)

YEAR	COUNTRY	LOCATION	TOTAL DEATHS	NUMBER INJURED	NUMBER AFFECTED	NUMBER HOMELESS	TOTAL AFFECTED	TOTAL DAMAGES ADJUSTED ('000 US$)
1955	Barbados		57					
1970	Barbados	Entire Isl.	3	10	200		210	3490
1980	Barbados			7		5000	5007	4932
1984	Barbados					100	100	
1987	Barbados					230	230	238477
1995	Barbados							
2002	Barbados	St. Andrew, St. George, St. James, St. John, St. Joseph, St. Lucy, St. Michael, St. Peter, St. Philip, St. Thomas, Christ Church provinces				2000	2000	301
2004	Barbados	St. Andrew, St. George, St. James, St. John, St. Joseph, St. Lucy, St. Michael, St. Peter, St. Philip, St. Thomas, Christ Church provinces	1			880	880	7173
2010	Barbados	St. John, St. Andrew, St. Joseph, St. Michael, St. George provinces			2500		2500	
2010	Barbados	Christ Church, St. Andrew, St. George, St. James, St. John, St. Joseph, St. Lucy, St. Michael, St. Peter, St. Phillip, St. Tomas provinces						
2017	Barbados	St. David's Christ Church, Weston St. James, Cattlewash St Joseph	1					
2021	Barbados				3114	186	3300	
1900	Jamaica	Saint James	300					
1903	Jamaica	North coast	65					
1912	Jamaica	West Jamaica, Savanna-La-Mar	142			94820	94820	
1917	Jamaica	Northern areas	57					
1923	Jamaica	St Thomas, Portland	4			1300	1300	
1933	Jamaica	Kingston, St Andrew	53					
1933	Jamaica	Western Parishes	10					
1935	Jamaica							39440
1937	Jamaica	Northern areas	111					
1940	Jamaica	St Mary, Port, St Thomas	125			2000	2000	
1944	Jamaica	Northern Parishes	32			2000	2000	
1951	Jamaica	South coast	154	200	20000		20200	583302
1963	Jamaica		11					101973
1968	Jamaica	Nationwide			100000		100000	3895
1973	Jamaica	Entire Island, Kingston	6	10	2500		2510	10375
1979	Jamaica	Western	4		40000		40000	
1979	Jamaica	Western regions	40		160000	50000	210000	
1980	Jamaica	North coast	6	9	30000		30009	210441
1981	Jamaica							
1985	Jamaica	Southern, Central (Clarendon, Manchester, St, Elizabeth)	7			300	300	13099
1986	Jamaica	Entire Island, especially the Parishes of Westmoreland, Clarendon and St. Catherine	54		40000		40000	187884
1987	Jamaica		9		26000		26000	73928
1988	Jamaica	Entire country	49		810000		810000	2291337
1988	Jamaica	Linstead area of St Catherine						1008
1991	Jamaica	Kingston, St. Catherine	15		550000	1340	551340	59689
1993	Jamaica	Clarendon, Portland, St Catherine, Kingston, St Thomas, St Andrew, Westmoreland, Trelawny	9		4290	82	4372	20633
1996	Jamaica					800	800	5183
2000	Jamaica	Clarendon, Hanover, Manchester, Portland, Saint Ann, Saint Catherine, Saint Elizabeth, Saint James, Saint Thomas, Trelawny, Westmoreland provinces						9441
2001	Jamaica	Clarendon, Hanover, Manchester, Portland, Saint Andrew And Kingston, Saint Ann, Saint Catherine, Saint Elizabeth, Saint James, Saint Mary, Saint Thomas, Trelawny, Westmoreland provinces	1			200	200	84913

Appendices

8.4 Catastrophic Disasters Profile of Meteorological, Drought and Floods that have affected Barbados, Jamaica and Trinidad and Tobago since 1955 (EMDAT)

YEAR	COUNTRY	LOCATION	TOTAL DEATHS	NUMBER INJURED	NUMBER AFFECTED	NUMBER HOMELESS	TOTAL AFFECTED	TOTAL DAMAGES ADJUSTED ('000 US$)
2002	Jamaica	Manchester, Saint Andrew And Kingston, Clarendon, Saint Catherine, Saint Thomas, Saint Ann, Portland, Saint Elizabeth provinces	9		25000		25000	30129
2002	Jamaica	Saint Thomas, Saint Andrew And Kingston, Saint Elizabeth, Clarendon, Westmoreland provinces	4		1500		1500	45
2002	Jamaica	Westmoreland, Clarendon, Hanover provinces						1506
2004	Jamaica	Clarendon, Westmoreland, Saint Catherine, Saint Elizabeth, Saint Thomas, Saint Ann, Trelawny, Saint Andrew And Kingston provinces	15		350000		350000	853580
2004	Jamaica	Saint Elizabeth province	1	6	120		126	430376
2005	Jamaica	Saint Thomas, Saint Catherine, Trelawny, Saint Andrew And Kingston provinces	1		100		100	4856
2005	Jamaica	Portland, Saint Andrew And Kingston, Saint Mary, Saint Thomas provinces	1		8000		8000	41625
2005	Jamaica	Trelawny, Saint Catherine, Saint James, Manchester, Saint Elizabeth provinces	4		2296		2296	1388
2006	Jamaica	Saint Ann, Saint Mary, Portland provinces	1		5000		5000	
2007	Jamaica	Clarendon, Saint Thomas, Saint James, Saint Andrew And Kingston provinces	4		32000	1188	33188	392061
2007	Jamaica	Saint Catherine, Clarendon, Manchester provinces	1					
2008	Jamaica	Saint Catherine, Saint Andrew And Kingston, Portland, Saint Thomas, Saint Mary provinces	12		4000		4000	83314
2008	Jamaica	Clarendon, Hanover, Manchester, Portland, Saint Andrew And Kingston, Saint Ann, Saint Catherine, Saint Elizabeth, Saint James, Saint Mary, Saint Thomas, Trelawny, Westmoreland provinces	1					
2010	Jamaica	Clarendon, Saint Catherine, Saint James, Hanover, Saint Mary, Saint Elizabeth, Saint Ann, Saint Andrew And Kingston, Westmoreland provinces	15	26	2480		2506	186400
2012	Jamaica	Clarendon, Hanover, Manchester, Portland, Saint Andrew And Kingston, Saint Ann, Saint Catherine, Saint Elizabeth, Saint Mary, Saint Thomas, Trelawny, W estmoreland provinces	1		215850		215850	19523
=2014	Jamaica	Saint Thomas, Saint Mary, Portland, Clarendon, Manchester, Saint Catherine, Saint Andrew And Kingston provinces			91545		91545	
2016	Jamaica	St. Thomas and Portland			125000		125000	

8.4 Catastrophic Disasters Profile of Meteorological, Drought and Floods that have affected Barbados, Jamaica and Trinidad and Tobago since 1955 (EMDAT)

YEAR	COUNTRY	LOCATION	TOTAL DEATHS	NUMBER INJURED	NUMBER AFFECTED	NUMBER HOMELESS	TOTAL AFFECTED	TOTAL DAMAGES ADJUSTED ('000 US$)
1933	Trinidad and Tobago		13					62657
1963	Trinidad and Tobago		24					265440
1974	Trinidad and Tobago	Central	2		50000		50000	27477
1990	Trinidad and Tobago				1000		1000	
1993	Trinidad and Tobago	Spain, St Ann's port	5			10	10	131
1993	Trinidad and Tobago	South						107
1996	Trinidad and Tobago	From California to Claxton Bay			200		200	
2004	Trinidad and Tobago	Caparo, Tumpuna villages (Couva/Tabaquite/Talparo province), Caroni village (Tunapuna/Piarco province)	1		560		560	1435
2005	Trinidad and Tobago	Arima, Chaguanas, Couva/ Tabaquite/Talparo, Diego Martin, Penal/Debe, Point Fortin, Port Of Spain, Princes Town, Rio Claro/Mayaro, San Fernando, San Juan/Laventille, Sangre Grande, Siparia, Tobago, Tunapuna/Piarco provinces						
2010	Trinidad and Tobago	Arima, Chaguanas, Couva/Tabaquite/ Talparo, Diego Martin, Penal/Debe, Point Fortin, Port Of Spain, Princes Town, Rio Claro/Mayaro, San Fernando, San Juan/Laventille, Sangre Grande, Siparia, Tobago, Tunapuna/Piarco provinces						
2018	Trinidad and Tobago	Sangre Grande, Tunapuna/Piarco, Couva/Tabaquite/Talparo, Mayaro/Rio Claro regions			150000		150000	3993

8.5 Selection of Architypes for residential and SME

Consultations were used to define the architypes most representative of the landscape of the three countries. Additionally, architypes are also estimated to have significant exposures to hazards and represent a considerable market share for residential and SME buildings. The architypes contemplated are shown in. The characteristics are as follows:

Residential	SME
350 to 1,100 sq ft (32.5 to 92.9 m^2) Low and affordable-income housing solutions Concrete walls and hip or slab roofs	500-5,000 sq. ft. (46.5 to 465 m^2) 50-100 employees Warehouses with mezzanine floors and steel sheeting cladding, or masonry walls office type buildings

8.5.1 Residential

Table D: Architypes for residential buildings to be used as a basis in this study

Representation	Description
	Low-income housing with a floor area of 350 to 500 ft2 (32.5 to 46.5 m^2), constructed of raft foundation, reinforced concrete walls and roof slab.
	Affordable-income housing with a floor area of 750 to 1,100 ft2 (69.7 to 92.9 m^2), constructed of raft foundation, reinforced concrete walls and hip roof from timber rafters and roof sheeting.
	Middle-income housing with a floor area of 550 to 800 ft2 (51.1 to 74.3m^2), constructed of raft foundation, reinforced concrete walls and hip roof from metal studs and roof sheeting.

8.5.2 SME

Table E: Architypes for SME buildings to be used as a basis in this study.

Representation	Description
	Warehouse with a floor area of 2,000 to 5,000 ft2 (185.8 to 464.5m^2), constructed of pad foundations, ground beams, steel frame, masonry infill walls and hip roof from metal frame and purlins and roof sheeting.
	Flex-warehouse space with mezzanine and a floor area of 1,000 to 2,000 ft2 (92.9 to 185.8m^2), constructed of pad foundations, masonry walls and concrete slab.
	Office space with a floor area of 500 to 2,000 ft2 (46.5 to 185.8 m^2), constructed of masonry units and concrete slabs.

8.6 List of Building Codes Reviewed

8.6.1 General Codes

1. Barbados National Code 2013 Edition.
2. Jamaican Building Code 2020.
3. Small Building Code of Trinidad and Tobago.
4. CARICOM Regional Energy Efficiency Building Code (CREEBC) 2020 – International Code Council publication.
5. CARICOM Regional Standard CRS 59 Energy Labelling – Air Conditioners
6. National Plumbing Code – The Water & Sewage Authority of Trinidad & Tobago

7. Guidelines for Design and Construction of Water and Wastewater Systems -Board of Engineering & The Water & Sewage Authority of Trinidad & Tobago
8. BNS SP1 Part 13- 2013- Barbados National Building Code – Energy Efficiency
9. Adopted Standard – ISO 12655:2013 – Energy Performance of Buildings
10. BNS CP 16 Part 1:1981 – Barbados National Building Code – Plumbing
11. BNS SP1:2013 - Barbados National Building Code – Plumbing

The International Building Code 2009, adopted by all three countries, was also reviewed to determine mitigation measures implemented. Additional relevant information obtained included the following:

8.6.2 Flooding

1. Mitigation Ideas, A Resource for Reducing Natural Hazards, January 2013, FEMA.
2. Preparing for Floods-Interim Guidance for improving the flood resistance of domestic and small business properties, October 2003
3. Coastal Flood Resilience Design Guidelines, Boston Planning & Development Agency, Sept. 2019
4. Reducing Flood Losses through the International Codes, Coordinating Building Codes and Floodplain Management Regulations, FEMA, 5th Edition, October 2019.

8.6.3 Hurricanes

1. Hurricane Shutters and Doors -Smart Hospital Project, Pan American Health Organization.
2. https://emilms.fema.gov/IS321/HM01summary.html#l3t0
3. http://www.hurricanescience.org/society/risk/currentandemergingtech/
4. Hurricane Mitigation, A Handbook for Public Facilities, FEMA, May 2005.
5. https://dfes.wa.gov.au/site/recoveryandresiliencegrants/documents/Tech-Spec-1-Sheet-Roofs.pdf

8.6.4 Barbados

The following building Codes were reviewed for Barbados:

1. Barbados National Building Code[43]
2. Building Regulations for Resilience Managing Risks for Safer Cities (World Bank, 2010)[44]
3. The CARICOM Regional Energy Efficient Building Code (CREEBC)
4. Physical Development Plan (Draft)

8.6.4.1 Hurricane/Wind

1. ASCE 7: Wind loads/maps etc.,
2. IRC: other codes R30l.2.l.l
3. IBC: "1504.8 Aggregate. Aggregate used as surfacing for roof coverings and aggregate, gravel or stone used as ballast shall not be used on the roof of a building located in a hurricane-prone region as defined in Section 1609.2, or on any other building with a mean roof height exceeding that permitted by Table 1504.8 based on the exposure category and basic wind speed at the site."
4. CUBiC: "Where high winds are a consideration, separate attention must be given to lateral wind pressure and shear on walls and uplift on roofs for buildings in hurricane prone areas. Vertical dowel reinforcement from roof to foundation shall be not less than one 12 mm diameter bar fully grouted at l.2 m centres, notwithstanding any minimum provisions stated in the foregoing. Roofs shall be tied to the top of walls by a minimum 12 mm diameter mild steel bolts at no greater than 1.2 m centres."
5. IBC: "1504.8 Aggregate. Aggregate used as surfacing for roof coverings and aggregate, gravel or stone used as ballast shall not be used on the roof of a building located in a hurricane-prone region as defined in Section 1609.2, or on any other building with a mean roof height exceeding that permitted by Table 1504.8 based on the exposure category and basic wind speed at the site."
6. Storm and screen doors shall be permitted to swing overall exterior stairs and landings.

[43] Barbados National Standards Institution. (2020). BNSI Standards Catalogue 2020. https://commerce.gov.bb/wp-content/uploads/2020/08/BNSI-Standards-Catalogue-2020-.pdf

[44] https://openknowledge.worldbank.org/bitstream/handle/10986/24438/Building0regul0ss0for0safer0cities.pdf

7. No mention of the hurricane ties or roof anchorage to walls was observed in the Barbados National Code.
8. No codes were identified in the Barbados National Code for Impact resistant doors and windows, hurricane shutters, concrete roofs, and minimum eaves on buildings.
9. The International Building Code indicates in Section 1604.8.1 that the anchorage of the roof to the walls and columns etc., shall be able to resist uplift and sliding forces resulting from applying the relevant loads as calculated from the ASCE 7.
10. The International Building Code adopted by all three countries indicates in Section 1604.8.1 that the anchorage of the roof to the walls and columns etc., shall be able to resist uplift and sliding forces resulting from applying the relevant loads as calculated from the ASCE 7.
11. International Building Code adopted by all three countries, section 1609.2 recommends that glazing be impact resistant or protected in wind-borne areas with an impact resistant covering to the approved impact-resistant standard.
12. The International Building Code does not mention concrete roofs and minimum eaves.

8.6.4.2 Flooding

1. Barbados National Code does not contain information on elevating the structure or equipment as a flood mitigation measure.
2. No mention of flood doors or permanent flood barriers is made in the Barbados National Code.
3. The Barbados National Code does not mention green roofs and rainwater harvesting.
4. The International Building Code (IBC 2009), adopted by all three countries, gives guidelines in Section 1107.75 on the design of flood elevation in which structures should be elevated to or above.
5. IBC 2009 Code adopted by all three countries has no floodgate guidelines. However, Section 1612 gives guidelines on flood damage-resistant materials capable of withstanding direct and prolonged contact with the floodwaters. (pg. 338.)

6. The International Building code adopted by all three countries, Section G101.1 recommends flood barriers as a mitigation measure for flooding as they can divert flood waters.
7. The International Building Code adopted by all three countries also doesn't have provisions for this mitigation measure.
8. Elevation of Equipment (Mostly relevant to SME): Mechanical and electrical equipment around buildings shall be elevated from the ground level in flood-prone areas. This measure can be done by placing the equipment on raised platforms or frames above the design flood level, as this can prevent fire and electrocution hazards during a flooding event.
9. The International Building Code (adopted by all three countries) Section G103 refers to the ASCE 24 in which Chapter 7.1 indicates that the equipment shall be elevated above or at design flood elevation or base flood elevation, whichever is higher.
10. The International Building Code does not mention green roofs and rainwater harvesting.

8.6.4.3 High Temperatures

1. CARICOM Regional Energy Efficiency Building Code (CREEBC) 2020 – International Code Council publication.
2. CARICOM Regional Standard CRS 59 Energy Labelling – Air Conditioners
3. BNS SP1 Part 13- 2013 – Barbados National Building Code – Energy Efficiency
4. Adopted Standard – ISO 12655:2013 – Energy Performance of Buildings

8.6.4.4 Drought – Water Conservation

1. BNS CP 16 Part 1:1981 – Barbados National Building Code – Plumbing
2. BNS SP1:2013 - Barbados National Building Code – Plumbing

8.6.4.5 Barbados National Building Code – Plumbing

The code provides guidelines on plumbing installation and fixture selection. It was revised in 2013 and referenced the British Standards, which do not accurately reflect the present efficient fixtures selection. Designers in Barbados usually refer to the IBC codes for guidance on the performance of plumbing fixtures.

8.6.6 Jamaica

The following building Codes have considered for Jamaica:

1. Jamaica: Building Act (2018)[45] that references the series of International Building Codes (IBC).
2. The CARICOM Regional Energy Efficient Building Code (CREEBC) provides guidelines on reducing heat gain to both SME (Commercial) Buildings and Residential buildings.
3. Guidelines for preparing hydrologic design. Reports for drainage systems of proposed developments, provided by the Ministry of Transport, Works and Housing, National Works Agency & Ministry of Local Government and Community Development.

   Guideline provided within this document, outline areas where residential structures should be constructed with design flood elevations for 100-year level for developments. Provisions for the design of storm water drains and detention pond buffers are also outlined as well as drainage design calculations required for approval by the relevant authorities.

8.6.6.1 Flooding

1. Section 1107.7.5 of the Jamaica Building Code gives guidelines for the Design Flood Elevation in which structures should be elevated to or above this level.
2. No mention of flood doors is made in the Jamaica Building Code.
3. The Jamaica Building Code Section G101.1 recommends flood barriers to minimise loss during flood conditions since it would divert floodwaters.
4. The Jamaica Building Code Section G401 refers to the ASCE 24: Flood Resistant Design and Construction, Chapter 7.
5. The Jamaica Building Code Section G103 references the ASCE 24, which states in Chapter 7 that the equipment shall be elevated to or above the design or base flood level, whichever is higher.
6. No guidelines on green roofs or rainwater harvesting were noted in the Jamaica Building Code.

[45] https://japarliament.gov.jm/attachments/article/339/The%20Building%20Act,%202018.pdf

7. The International Building Code (IBC 2009) adopted by all three countries gives guidelines in Section 1107.75 on the design of flood elevation in which structures should be elevated to or above.
8. IBC 2009 Code adopted by all three countries does not have any floodgates guidelines. However, Section 1612 gives guidelines on flood damage-resistant materials capable of withstanding direct and prolonged contact with the floodwaters. (pg. 338.)
9. The International Building code adopted by all three countries, Section G101.1 recommends flood barriers as a mitigation measure for flooding as they can divert flood waters.
10. The International Building Code adopted by all three countries also doesn't have provisions for this mitigation measure.
11. Elevation of Equipment (Mostly relevant to SME): Mechanical and electrical equipment around buildings shall be elevated from the ground level in flood-prone areas. This measure can be done by placing the equipment on raised platforms or frames above the design flood level, as this can prevent fire and electrocution hazards during a flooding event.
    i. The International Building Code (adopted by all three countries) Section G103 refers to the ASCE 24 in which Chapter 7.1 indicates that the equipment shall be elevated above or at design flood elevation or base flood elevation, whichever is higher.
12. The International Building Code does not mention green roofs and rainwater harvesting.

8.6.6.2 Hurricane/Wind

1. The Jamaica Building Code indicates in Section 1604.8.1 that the connection between the roof and walls must resist the uplift and sliding forces from the applied loads as per ASCE 7.
2. The Jamaica Building Code indicates in Section 1604.8.1 that the connection between the roof and walls must resist the uplift and sliding forces from the applied loads as per ASCE 7.
3. Jamaica Building Code Section 1609.2 recommends that in wind-borne areas glazing in buildings be impact resistant or protected with an impact resistant covering to the approved standard.

4. Jamaica Building Code Section 1609.2 recommends that wind-borne areas glazing in buildings be impact-resistant or protected with an impact-resistant covering to the approved standard.
5. The Jamaica Building Code contains no guidelines regarding concrete roofs and minimum eaves on buildings.
6. The International Building Code indicates in Section 1604.8.1 that the anchorage of the roof to the walls and columns etc., shall be able to resist uplift and sliding forces resulting from applying the relevant loads as calculated from the ASCE 7.
7. The International Building Code adopted by all three countries indicates in Section 1604.8.1 that the anchorage of the roof to the walls and columns etc., shall be able to resist uplift and sliding forces resulting from applying the relevant loads as calculated from the ASCE 7.
8. International Building Code adopted by all three countries, section 1609.2 recommends that glazing be impact resistant or protected in wind-borne areas with an impact resistant covering to the approved impact-resistant standard.
9. International Building Code adopted by all three countries, section 1609.2 recommends that wind-borne areas glazing be impact resistant or protected with an impact resistant covering to the approved impact-resistant standard.
10. The International Building Code does not mention concrete roofs and minimum eaves.

8.6.7 Trinidad

Building codes of Trinidad have been reviewed, including:

1. Trinidad and Tobago – Small Building Code 2004 addresses basic building systems and the Organization of Eastern Caribbean States Build Code (1992) prepared by the OECS Secretariat and based on the Caribbean Uniform Building Code (CUBIC)[46] that was revised in 2016, is still in everyday use by regulatory bodies.
2. Building Regulations for Resilience Managing Risks for Safer Cities (World Bank, 2010)[47].
3. Requirements for Drainage Design Approval (Land Developments) provided by the Ministry of Works and Transport: Drainage Division.

[46] https://www.caribank.org/publications-and-resources/resource-library/guides-and-toolkits/caribbean-uniform-building-code
[47] https://openknowledge.worldbank.org/bitstream/handle/10986/24438/Building0regul0sks0for0safer0cities.pdf

The Ministry of Works and Transport drainage division outlines the requirements for the drainage design approval for land development. The guidelines specify the return period (1:25 yrs.) of conveyance systems and detention ponds. Outlines of relevant calculations, such as the predevelopment and post-development peak discharges required for the approval, are also stated within the guidelines.

8.6.7.1 Flooding

1. ASCE 7: Flood Loads and flood elevation guidelines are given in this code.
2. IRC: Flood elevation
3. Section 3.3.26.1.3 & 3.3.26.2.1 are references from the Small Building Code of Trinidad and Tobago that contain guidelines on establishing the design flood level and elevation requirements for structures. The code recommends that the lowest floor of structures in flood-prone areas be elevated to or above the design flood elevation.
    i. Section 3.3.26.1.3: "The design flood elevation shall be used to define areas prone to flooding, and shall describe, at a minimum, the base flood elevation at the depth or peak elevation of flooding (including wave height) which has a 1% (100-year flood) or greater chance of being equated or exceeded in any given year. The physical planning standards should determine this level."
    ii. Section 3.3.26.2.1: "Buildings and structures shall have the lowest floor elevated to or above the design flood elevation: In areas of shallow flooding, buildings and structures shall have the lowest floor (including basement) elevated at least as high above the highs natural adjacent grade as the depth number specified in metre, or at least 600mm if a depth number is not specified; Basement floors that are below grade on all sides shall be elevated to or above the design flood elevation."
4. The Small Building Code of Trinidad and Tobago does not mention flood doors or permanent flood barriers.
5. There aren't any provisions in the Small Building Code about infiltration basins and stormwater retention.
6. Small Building Code of Trinidad and Tobago recommends that all mechanical and electrical equipment be located at or above the design flood elevation.

7. The Small Building Code of Trinidad and Tobago noted no green roofs or rainwater harvesting guidelines.
8. The International Building Code (IBC 2009) adopted by all three countries gives guidelines in Section 1107.75 on the design flood elevation in which structures should be elevated to or above.
9. IBC 2009 Code adopted by all three countries has no floodgate guidelines. However, Section 1612 gives guidelines on flood damage-resistant materials capable of withstanding direct and prolonged contact with the floodwaters. (pg. 338.)
10. The International Building code adopted by all three countries, Section G101.1 recommends flood barriers as a mitigation measure for flooding as they can divert flood waters.
11. The International Building Code adopted by all three countries also doesn't have provisions for this mitigation measure.
12. Elevation of Equipment (Mostly relevant to SME): Mechanical and electrical equipment around buildings shall be elevated from the ground level in flood-prone areas. This measure can be done by placing the equipment on raised platforms or frames above the design flood level, as this can prevent fire and electrocution hazards during a flooding event.
13. The International Building Code (adopted by all three countries) Section G103 refers to the ASCE 24 in which Chapter 7.1 indicates that the equipment shall be elevated above or at design flood elevation or base flood elevation, whichever is higher.
14. The International Building Code does not mention green roofs and rainwater harvesting.

8.6.7.2 National Plumbing Code

This code provides guidelines for designing and installing a plumbing system to guide potable water consumption in buildings. The Code has existed for many years without any updates, and the water and wastewater system design guidelines have not been updated recently. The engineering advice is adequate. However, water consumption rates are based on occupancy numbers and do not guide the performance of plumbing fixtures and fittings, which is found in other international codes such as the Universal Plumbing Code and International Plumbing Code. As there is no guidance on the performance of fixtures, many installed fixtures are considered inefficient compared to other countries. Designers in Trinidad usually refer to the IBC codes for guidance on fixture performance.

The Trinidad & Tobago Bureau of Standards and The Water and Sewage Authority of Trinidad are presently working on revising the National Plumbing Code by making some comparisons to the International Plumbing code. This is expected to outline using water-efficient fixtures and fitting to reduce potable water consumption.

8.6.7.3 High Temperatures

1. CARICOM Regional Energy Efficiency Building Code (CREEBC) 2020 – International Code Council publication.
2. CARICOM Regional Standard CRS 59 Energy Labelling – Air Conditioners

8.6.7.4 Drought – Water Conservation

1. National Plumbing Code – The Water & Sewage Authority of Trinidad & Tobago
2. Guidelines for Design and Construction of Water and Wastewater Systems – Board of Engineering & The Water & Sewage Authority of Trinidad & Tobago

8.6.7.5 Hurricane/Wind

1. The Small Building Code Section 7.1.2.2.2 indicates that hurricane clips should be used to fasten rafters to the plates, purlins, etc. Additionally, section 3.1.8.1.1.1 suggests that the recommended details must be adhered to for hurricane-resistant structures to ensure safe construction.
2. The Small Building Code section 3.1.8.1.1.1 & 3.1.9.6 makes mention of the roof anchorages. Section 3.1.8.1.1.1 indicates that for hurricane-resistant structures, the recommended details must be adhered to, to ensure safe construction. Section 3.1.9.6 indicates that the roof shall be fastened to the ring and ridge beams.
3. The Small Building Code of Trinidad and Tobago does not mention impact resistance doors and windows.
4. The Small Building Code of Trinidad and Tobago recommends that glazed windows and doors be fitted with shutters for safety during a hurricane.
5. The Small Building Code does not contain any guidelines regarding this mitigation measure.
6. The Small Building Code of Trinidad and Tobago, Section 3.1.9.4, recommends that the roof overhangs be kept to a minimum or strengthened due to the high pressures from the wind loads.

7. The International Building Code indicates in Section 1604.8.1 that the anchorage of the roof to the walls and columns etc., shall be able to resist uplift and sliding forces resulting from applying the relevant loads as calculated from the ASCE 7.
8. The International Building Code adopted by all three countries indicates in Section 1604.8.1 that the anchorage of the roof to the walls and columns etc., shall be able to resist uplift and sliding forces resulting from applying the relevant loads as calculated from the ASCE 7.
9. International Building Code adopted by all three countries, section 1609.2 recommends that glazing be impact resistant or protected in wind-borne areas with an impact resistant covering to the approved impact-resistant standard.

8.6.8 General Codes

8.6.8.1 CARICOM Regional Energy Efficient Building code

CARICOM Regional Energy Efficiency Building Code (CREEBC) 2020 – International Code Council publication

The CARICOM Regional Energy Efficiency Building Code (CREEBC) 2020 is a recent code published in 2020. The Editing Committee consisted of representatives from all the member states that evaluated its relevance to their specific environmental condition. The code matches international performance guidelines and is considered as up to date. Barbados, Jamaica and Trinidad & Tobago have committees working on the National adoption of the code. The code is regarded as a reference document for any building in the CARICOM States.

The CREEBC provides guidelines for attaining an energy-efficient building within the CARICOM States. For example, higher temperatures require increased cooling of internal space within buildings; the code provides guidelines to reduce the cooling requirement of Internal building spaces, reflecting reduced energy consumption and the associated global emission with energy consumption.

Barbados and Trinidad reference the IBC Codes and ASHRAE Standards to attain energy efficiency when designing and operating buildings. The CREEBC is part of the ICC code suite and refers to ASHRAE standards. It is expected that the CREEBC will be the adopted code for CARICOM countries.

8.6.8.2 CARICOM Regional Standard CRS 59 Energy Labelling – Air Conditioners

This Standard references air conditioning units and their proper labelling, indicating the units' Energy Efficiency Ratio (EER/SEER) Rating and the energy consumption performance (KWH). The standard also guides the acceptance range of the ratings and performance. The standard aims only to import energy-efficient air condition units.

8.7 Cooling Costs Estimates for Present and Future Climates

Table F: Estimate cooling costs in the present and future climate for Barbados, Jamaica and Trinidad and Tobago.

	BARBADOS	JAMAICA	TRINIDAD AND TOBAGO
Total Annual consumption (GWH)	996	4356	9324
Cost per KWH (USD/KWH)	$0.25	$0.28	$0.05
% residential	33%	37%	33%
% Cooling to total consumption	10%	10%	10%
Present climate cooling costs - residential (USD, Millions)	$8.2	$45.1	$15.4
T-baseline	29.7	30.7	30.7
T-projected	31.0	32.0	32.0
ΔC	1.3	1.3	1.3
Increase factor relative to 24C	4%	4%	4%
Future climate cooling costs - residential (USD)	$10	$54	$18
Climate change impact	$1.9	$8.8	$3.0
% commercial	21%	43%	11%
% Cooling to total consumption	15%	15%	15%
Present climate cooling costs - commercial (USD)	$7.8	$78.7	$7.7
T-baseline	30.2	31.2	31.2
T-projected	31.0	32.0	32.0
ΔC	0.8	0.8	0.8
Increase factor relative to 24C	3%	3%	3%
Future climate cooling costs - commercial (USD)	$8.9	$87.4	$8.5
Climate change impact	$1.0	$8.7	$0.9
Total cooling costs- present climate	$16.1	$123.8	$23.1
Total cooling costs- future climate	$18.9	$141.3	$26.9
Δ Cooling cost (USD Millions)due to climate change	$1.4	$8.7	$1.9

8.8 Cost of Resilience Measures with Respect to Climate Change

HAZARDS	ARCHITYPE	MITIGATION MEASURE	ROI TIMELINE (YRS)	SQ FT	UNIT BASE COST (USD)	COST OF RESILIENCE MEASURE	COST OF RESILIENCE MEASURE CONSIDERED BY EXISTING BUILDING CODES	COST OF EACH RESILIENCE MEASURE WITH RESPECT TO CLIMATE CHANGE	DERIVED BENEFITS	DERIVED BENEFITS OVER 5 YEARS	ROI
			BARBADOS								
Flood	Residential - Affordable income	Using fill to make up levels contained with block basewalls	10	750	$60,000.00	$4,000	$3,360	$640	$4,000	$2,000	525%
		Installing flood doors	10	750	$60,000.00	$1,800	$0	$1,800	$4,000	$2,000	122%
	SME - Warehouse	Water retention and infiltration	10	750	$60,000.00	$650	$546	$104	$4,000	$2,000	3746%
		Elevating structures	10	5000	$525,000.00	$2,300	$1,932	$368	$25,750	$12,875	6897%
		Elevation of equipment	10	5000	$525,000.00	$11,400	$9,576	$1,824	$25,750	$12,875	1312%
Hurricane Winds	Residential - Affordable income	Installation of hurricane/wind roof clips and ties	20	750	$60,000.00	$180	$171	$9	$4,412	$1,103	48920%
		Installation of hurricane shutters	10	750	$60,000.00	$1,900	$0	$1,900	$2,847	$1,424	50%
	SME - Warehouse	Installation of hurricane/wind roof clips and ties	20	5000	$525,000.00	$1,200	$1,140	$60	$4,240	$1,060	6967%
		Installation of impact resistant windows and doors	10	5000	$525,000.00	$1,800	$1,710	$90	$4,240	$2,120	4611%
Drought	Residential - Affordable income	Install high efficiency toilets	10	750	$60,000.00	$1,200	$400	$800	$1,200	$600	50%
		Install water efficient faucets and shower heads	10	750	$60,000.00	$90	$30	$60	$1,200	$600	1900%
		Install tanks for rainwater collection	10	750	$60,000.00	$240	$80	$160	$84	$42	-48%
	SME - Warehouse	Install high efficiency toilets	10	5000	$525,000.00	$1,200	$400	$800	$10,800	$5,400	1250%
		Install water efficient faucets and shower heads	10	5000	$525,000.00	$1,900	$633	$1,267	$4,500	$2,250	255%
		Install tanks for rainwater collection	10	5000	$525,000.00	$8,600	$2,867	$5,733	$24,000	$12,000	319%
Heat	Residential - Affordable income	Prodex 10mm insulation and radiant barrier	10	750	$60,000.00	$450	$0	$450	$7,300	$3,650	1522%
		Use concrete filling to block walls	20	750	$60,000.00	$1,100	$1,070	$30	$4,980	$1,245	16500%
		Install double glazed windows	20	750	$60,000.00	$3,800	$3,696	$104	$11,500	$2,875	10996%
	SME - Warehouse	Prodex 10mm insulation and radiant barrier	10	5000	$525,000.00	$4,500	$4,377	$123	$96,780	$48,390	78758%
		3/4" gypsum board lining	20	5000	$525,000.00	$17,700	$0	$17,700	$55,600	$13,900	214%
		Install double glazed windows	20	5000	$525,000.00	$3,800	$3,696	$104	$11,500	$2,875	10996%
			JAMAICA								
Flood	Residential - Affordable income	Using fill to make up levels contained with block basewalls	10	750	$60,000.00	$2,000	$1,680	$320	$6,750	$3,375	2009%
		Installing flood doors	10	750	$60,000.00	$1,800	$0	$1,800	$4,000	$2,000	122%
		Water retention and infiltration	10	750	$60,000.00	$650	$546	$104	$6,750	$3,375	6390%
	SME - Warehouse	Elevating structures	10	5000	$525,000.00	$2,300	$1,932	$368	$25,750	$12,875	6897%
		Elevation of equipment	10	5000	$525,000.00	$11,400	$9,576	$1,824	$25,750	$12,875	1312%
Hurricane Winds	Residential - Affordable income	Installation of hurricane/wind roof clips and ties	20	750	$60,000.00	$180	$171	$9	$4,412	$1,103	48920%
		Installation of hurricane shutters	10	750	$60,000.00	$1,900	$0	$1,900	$2,847	$1,424	50%
	SME - Warehouse	Installation of hurricane/wind roof clips and ties	20	5000	$525,000.00	$1,200	$1,140	$60	$4,240	$1,060	6967%
		Installation of impact resistant windows and doors	10	5000	$525,000.00	$1,800	$1,710	$90	$4,240	$2,120	4611%
Drought	Residential - Affordable income	Install high efficiency toilets	10	750	$60,000.00	$1,200	$400	$800	$700	$350	-13%
		Install water efficient faucets and shower heads	10	750	$60,000.00	$90	$30	$60	$700	$350	1067%
		Install tanks for rainwater collection	1	750	$60,000.00	$240	$80	$160	$113	$563	-30%
	SME - Warehouse	Install high efficiency toilets	10	5000	$525,000.00	$1,200	$400	$800	$1,800	$900	125%
		Install water efficient faucets and shower heads	10	5000	$525,000.00	$1,900	$633	$1,267	$750	$375	-41%
		Install tanks for rainwater collection	10	5000	$525,000.00	$8,600	$2,867	$5,733	$4,000	$2,000	-30%
Heat	Residential - Affordable income	Prodex 10mm insulation and radiant barrier	10	750	$60,000.00	$450	$0	$450	$4,215	$2,108	837%
		Use concrete filling to block walls	20	750	$60,000.00	$1,100	$1,070	$30	$1,780	$445	5833%
		Install double glazed windows	20	750	$60,000.00	$3,800	$3,696	$104	$6,840	$1,710	6500%
	SME - Warehouse	Prodex 10mm insulation and radiant barrier	10	5000	$525,000.00	$4,500	$4,377	$123	$57,570	$28,785	46809%
		Use of light weight concrete walls instead of blocks	20	5000	$525,000.00	$7,100	$6,906	$194	$1,950	$488	907%
		Install double glazed windows	20	5000	$525,000.00	$7,100	$6,906	$194	$6,890	$1,723	3458%

8.8 Cost of Resilience Measures with Respect to Climate Change

HAZARDS	ARCHITYPE	MITIGATION MEASURE	ROI TIMELINE (YRS)	SQ FT	UNIT BASE COST (USD)	COST OF RESILIENCE MEASURE	COST OF RESILIENCE MEASURE CONSIDERED BY EXISTING BUILDING CODES	COST OF EACH RESILIENCE MEASURE WITH RESPECT TO CLIMATE CHANGE	DERIVED BENEFITS	DERIVED BENEFITS OVER 5 YEARS	ROI
			Trinidad and Tobago								
Flood	Residential - Affordable income	Using fill to make up levels contained with block basewalls	10	750	$60,000.00	$4,000	$3,360	$640	$4,000	$2,000	525%
		Installing flood doors	10	750	$60,000.00	$1,800	$0	$1,800	$4,000	$2,000	122%
		Water retention and infiltration	10	750	$60,000.00	$650	$546	$104	$4,000	$2,000	3746%
	SME - Warehouse	Elevating structures	10	5000	$525,000.00	$2,300	$1,932	$368	$25,750	$12,875	6897%
		Elevation of equipment	10	5000	$525,000.00	$11,400	$9,576	$1,824	$25,750	$12,875	1312%
Hurricane Winds	Residential - Affordable income	Installation of hurricane/wind roof clips and ties	20	750	$60,000.00	$180	$171	$9	$4,412	$1,103	48920%
		Installation of hurricane shutters	10	750	$60,000.00	$1,900	$0	$1,900	$2,847	$1,424	50%
	SME - Warehouse	Installation of hurricane/wind roof clips and ties	20	5000	$525,000.00	$1,200	$1,140	$60	$4,240	$1,060	6967%
		Installation of impact resistant windows and doors	10	5000	$525,000.00	$1,800	$1,710	$90	$4,240	$2,120	4611%
Drought	Residential - Affordable income	Install high efficiency toilets	10	750	$60,000.00	$1,200	$400	$800	$200	$100	-75%
		Install water efficient faucets and shower heads	10	750	$60,000.00	$90	$30	$60	$200	$100	233%
		Install tanks for rainwater collection	1	750	$60,000.00	$240	$80	$160	$141	$705	-12%
	SME - Warehouse	Install high efficiency toilets	10	5000	$525,000.00	$1,200	$400	$800	$1,800	$900	125%
		Install water efficient faucets and shower heads	10	5000	$525,000.00	$1,900	$633	$1,267	$750	$375	-41%
		Install tanks for rainwater collection	10	5000	$525,000.00	$8,600	$2,867	$5,733	$4,000	$2,000	-30%
Heat	Residential - Affordable income	Prodex 10mm insulation and radiant barrier	10	750	$60,000.00	$450	$0	$450	$1,130	$565	151%
		Use concrete filling to block walls	20	750	$60,000.00	$1,100	$1,070	$30	$760	$190	2433%
		Install double glazed windows	20	750	$60,000.00	$3,800	$3,696	$104	$2,180	$545	2004%
	SME - Warehouse	Prodex 10mm insulation and radiant barrier	10	5000	$525,000.00	$4,500	$4,377	$123	$18,360	$9,180	14860%
		3/4" gypsum board lining	20	5000	$525,000.00	$17,700	$0	$17,700	$13,900	$3,475	-21%
		Install double glazed windows	20	5000	$525,000.00	$7,100	$6,906	$194	$2,180	$545	1026%

Appendices

8.9 Capital Costs and Rates of Return for resilience measures

REF	MEASURES	IMPLICATIONS/BENEFITS	BARBADOS			JAMAICA			TRINIDAD		
			Capital Cost $US	Derived Benefits $US	Rate of Return	Capital Cost $US	Derived Benefits $US	Rate of Return	Capital Cost $US	Derived Benefits $US	Rate of Return
A	**MEASURES AGAINST HIGH TEMPERATURES**										
1.00	SINGLE FAMILY RESIDENTIAL										
1.01	Resiliency measures on roof										
1.01.1	Add 1" insulation to concrete roof	Saving in energy consumption throughout the life of the measure - 10yr life @ 610.00 per annum	1,102.94	6,100.00	453.07	1,102.94	3,520.00	219.15	1,102.94	940.00	-14.77
1.01.2	Prodex 10mm insulation and radiant barrier	Saving in energy consumption throughout the life of the measure - 10 yr life @ $730.00 per annum	441.18	7,300.00	1,554.67	441.18	4,215.00	855.40	441.18	1,130.00	156.13
1.01.3	Metal roof with prodex 10mm and 1/2" ceiling insulation	Saving in energy consumption throughout the life of the measure - 20 yr life @ $541.00 per annum	1,029.41	10,820.00	951.09	1,029.41	6,250.00	507.14	1,029.41	1,680.00	63.20
1.01.4	Clay tiles with 3/4" plyboard sheet	Saving in energy consumption throughout the life of the measure - 20 yr life @ $591.00 per annum	6,617.65	11,820.00	78.61	6,617.65	6,820.00	3.06	6,617.65	1,820.00	-72.50
1.01.5	Wooden tiles on 3/4" plyboard sheet	Saving in energy consumption throughout the life of the measure - 20 yr life @ $591.00 per annum	7,352.94	11,820.00	60.75	7,352.94	6,820.00	-7.25	7,352.94	1,820.00	-75.25
1.01.6	Paint concrete roof with reflective coating	Saving in energy consumption throughout the life of the measure - 5 yr life @ $341.40 per annum	514.71	1,707.00	231.65	514.71	1,066.88	107.28	514.71	426.75	-17.09
1.02	Resiliency measures on [external] walls										
1.01.8	3/4" gypsum lining and 1" of insulation	Saving in energy consumption throughout the life of the measure - 20 yrs @ $249.00 per annum	4,632.35	4,980.00	7.50	4,632.35	2,870.00	-38.04	4,632.35	760.00	-83.59
1.01.9	3/4" plywood lining	Saving in energy consumption throughout the life of the measure - 20 yrs @ $249.00 per annum	3,308.82	4,980.00	50.51	3,308.82	2,870.00	-13.26	3,308.82	760.00	-77.03
1.01.10	Use of light weight concrete walls instead of blocks	Saving in energy consumption throughout the life of the measure - 20 yrs @ $154.00 per annum	1,058.82	3,080.00	190.89	1,058.82	1,780.00	68.11	1,058.82	480.00	-54.67
1.01.11	Use concrete filling to block walls	Saving in energy consumption throughout the life of the measure - 20 yrs @ $154.00 per annum	1,058.82	3,080.00	190.89	1,058.82	1,780.00	68.11	1,058.82	480.00	-54.67
1.01.12	Shade walls with trees or other structures	Saving in energy consumption throughout the life of the measure - 10 yrs @ $95.00 per annum	441.18	950.00	115.33	441.18	640.00	45.07	441.18	330.00	-25.20
1.03	Resiliency measures on windows										
1.03.1	Add blinds to curtains	Saving in energy consumption throughout the life of the measure - 5 yrs @ $86.00 per annum	1,235.29	430.00	-65.19	1,235.29	250.00	-79.76	1,235.29	70.00	-94.33
1.03.2	Install double glazed windows	Saving in energy consumption throughout the life of the measure - 20 yrs @ $575.00 per annum	3,764.71	11,500.00	205.47	3,764.71	6,840.00	81.69	3,764.71	2,180.00	-42.09
1.03.3	Install external shading overhangs	Saving in energy consumption throughout the life of the measure - 10 yrs @ $111.00 per annum	635.29	1,110.00	74.72	635.29	640.00	0.74	635.29	170.00	-73.24
1.04	Resiliency measures on lights										
1.04.1	Replace incandescent lighting with LED	Saving in energy consumption throughout the life of the measure - 3 yrs @ $349.12 per annum	147.06	1,047.36	612.20	147.06	654.60	345.13	147.06	261.84	78.05
1.05	Resiliency measures on AC equipmenet										
1.05.1	Replace window and mini-split units with inverter AC units - say for two units in bedroom areas	Saving in energy consumption throughout the life of the measure - usefull life taken as 10 years @ $305.00 per annum	882.35	3,050.00	245.67	882.35	1,760.00	99.47	882.35	470.00	-46.73
2.00	SME WAREHOUSE										
2.01	Resiliency measures on roof										
2.01.1	Prodex 10mm insulation and radiant barrier	Saving in energy consumption throughout the life of the measure 10 yrs @ $9,678.00 per annum	4,411.76	96,780.00	2,093.68	4,411.76	57,570.00	1,204.92	4,411.76	18,360.00	316.16
2.01.2	1" insulation board with radiant barrier	Saving in energy consumption throughout the life of the measure 10 yrs @ $9,678.00 per annum	10,294.12	96,780.00	840.15	10,294.12	57,570.00	459.25	10,294.12	18,360.00	78.35
2.01.3	Install a 60KW photovoltaic system on the sheet metal roof to generate renewable elctricity absorb and emit solar heat	Saving in energy consumption throughout the life of the measure - 10yr life @ $34,239.00 per annum	220,000.00	342,390.00	55.63	193,548.39	216,060.00	11.63	220,000.00	89,730.00	-59.21
2.01.4	Paint concete roof with reflective coating	Saving in energy consumption throughout the life of the measure - 5 yr life @ $7,344.00 per annum	5,147.06	36,720.00	613.42	5,147.06	22,950.00	345.89	5,147.06	9,180.00	78.35
2.02	Resiliency measures on walls										
2.02.1	3/4" gypsum board lining	Saving in energy consumption throughout the life of the measure - 20 yr life @ $2,780.00 per annum	17,647.06	55,600.00	215.07	17,647.06	34,750.00	96.92	17,647.06	13,900.00	-21.23
2.02.2	Use of light weight concrete walls instead of blocks	Saving in energy consumption throughout the life of the measure - 20 yr life @ $156.00 per annum	7,058.82	3,120.00	-55.80	6,507.35	1,950.00	-70.03	7,058.82	780.00	-88.95
2.02.3	Shade walls with trees or other structures	Saving in energy consumption throughout the life of the measure - 10 yrs @ $144.00 per annum	2,941.18	1,440.00	-51.04	2,941.18	900.00	-69.40	2,941.18	360.00	-87.76
2.03	Resiliency measures on windows										
2.03.1	Add blinds - office areas only	Saving in energy consumption throughout the life of the measure - 5 yrs @ $72.00 per annum	1,764.71	360.00	-79.60	1,764.71	225.00	-87.25	1,764.71	90.00	-94.90
2.03.2	Install double glazed windows	Saving in energy consumption throughout the life of the measure - 20 yrs @ $580.00 per annum	7,058.82	11,600.00	64.33	7,058.82	6,890.00	-2.39	7,058.82	2,180.00	-69.12
2.03.3	Install external shading overhangs	Saving in energy consumption throughout the life of the measure - 10 yrs @ $88.00 per annum	1,882.35	880.00	-53.25	1,882.35	550.00	-70.78	1,882.35	220.00	-88.31
2.04	Resiliency measures on lights										
2.04.1	Replace fluroscent lighting with LED	Saving in energy consumption throughout the life of the measure - 3 yrs @ $4,244.00 per annum	2,941.18	12,732.00	332.89	2,941.18	7,957.50	170.56	2,941.18	3,183.00	8.22
2.05	Resiliency measures on AC equipmenet										
2.05.1	Replace packaged AC units with VRF Inverter AC units	Saving in energy consumption throughout the life of the measure - useful life taken at 10 years	12,205.88	34,720.00	184.45	12,205.88	21,645.00	77.33	12,205.88	8,570.00	-29.79
B	**MEASURES AGAINST DROUGHT**										
1.00	SINGLE FAMILY RESIDENTIAL										
1.01	Install high efficiency toilets	Reduces water consumption- 100m3 per annum over a 10 year period at $1.20 per m3	1,176.47	1,200.00	2.00	1,176.47	700.00	-40.50	1,176.47	200.00	-83.00
1.02	Install water efficient faucets and shower heads	Reduces water consumption - 100m3 per annum over a 10 year useful life	88.24	1,200.00	1,260.00	88.24	700.00	693.33	88.24	200.00	126.67
1.03	Install tanks for rainwater collection	Efficiency in use of water; measure saves 70m3 of water per annum @ $1.20 per m3	235.29	84.00	-64.30	235.29	112.51	-52.18	235.29	141.03	-40.06
1.04	Use grey water for landscaping	Efficiency in use of water; measure saves 50m3 of water per annum @ $1.20 per m3	235.29	600.00	155.00	235.29	350.00	48.75	235.29	100.00	-57.50
1.05	Reduce water use for landscaping	Efficiency in use of water; suggestion only; no investment	0.00	n/a	n/a	0.00	n/a	n/a	0.00	n/a	n/a
1.06	Reduce water use for washing down premises	Efficiency in use of water; suggestion only; no investment	0.00	n/a	n/a	0.00	n/a	n/a	0.00	n/a	n/a

8.9 Capital Costs and Rates of Return for resilience measures

REF	MEASURES	IMPLICATIONS/BENEFITS	BARBADOS			JAMAICA			TRINIDAD		
			Capital Cost $US	Derived Benefits $US	Rate of Return	Capital Cost $US	Derived Benefits $US	Rate of Return	Capital Cost $US	Derived Benefits $US	Rate of Return
A	**MEASURES AGAINST HIGH TEMPERATURES**										
2.00	SME WAREHOUSE										
2.01	Install high efficiency toilets	Reduces water consumption; measure saves 900m3 of water per annum @ $1.20/m3	1,176.47	10,800.00	818.00	1,176.47	1,800.00	53.00	1,176.47	1,800.00	53.00
2.02	Install water efficient faucets and shower heads	Reduces water consumption; measure saves 375m3 of water per annum @ $1.20/m3	1,852.94	4,500.00	142.86	1,852.94	750.00	-59.52	1,852.94	750.00	-59.52
2.03	Install tanks for rainwater collection	Efficiency in use of water; measure saves 2000m3 of water [if conventional wc] per annum over 10 years @ 1.20 per m3	8,529.41	24,000.00	181.38	8,529.41	4,000.00	-53.10	8,529.41	4,000.00	-53.10
2.04	Use grey water for landscaping	Efficiency in use of water; measure saves 1500m3 of water [if conventional wc] per annum over 10 years @ 1.20 per m3	1,588.24	18,000.00	1,033.33	1,588.24	3,000.00	88.89	1,588.24	3,000.00	88.89
2.05	Reduce water use for landscaping	Efficiency in use of water; suggestion only; no investment	0.00	n/a	n/a	0.00	n/a	n/a	0.00	n/a	n/a
2.06	Reduce water use for washing down premises	Efficiency in use of water; suggestion only; no investment	0.00	n/a	n/a	0.00	n/a	n/a	0.00	n/a	n/a
C	**FLOOD MITIGATION**										
1.00	SINGLE FAMILY RESIDENTIAL										
1.01	Elevating structures										
1.01.1	Using columns and suspended slab	Say replacement of kitchen and bedroom cabinets twice every 10 year life at $2,000 per replacement Avoids possible damage to foundations based on soil type. Avoids damage to external infrastructure, on lot sewage treatment & parked vehicles Structural damage Damage to building internal fabric, finishings and engineering services Loss/Damage to Furniture and personal items Damage/Loss Perimeter Fencing,plants/vegetation	9,794.12	4,000.00	-59.16	9,794.12	4,000.00	-59.16	9,794.12	4,000.00	-59.16
1.01.2	Using fill to make up levels contained with block basewalls	Say replacement of kitchen and bedroom cabinets twice every 10 year life Avoids possible damage to foundations based on soil type. Avoids damage to external infrastructure, on lot sewage treatment & parked vehicles Structural damage Damage to building internal fabric, finishings and engineering services Loss/Damage to Furniture and personal items Damage/Loss Perimeter Fencing,plants/vegetation	3,947.06	4,000.00	1.34	1,935.48	6,750.00	248.75	3,947.06	4,000.00	1.34
1.02	Installing flood doors	Say replacement of kitchen and bedroom cabinets twice every 10 year life Damage to building internal fabric, finishings and engineering services Loss/Damage to Furniture and personal items	1,764.71	4,000.00	126.67	1,764.71	4,000.00	126.67	1,764.71	4,000.00	126.67
1.03	Permanent barriers	Say replacement of kitchen and bedroom cabinets twice every 10 year life Possible damage to foundations based on soil type. Damage to external infrastructure, on lot sewage treatment & parked vehicles Structural damage Damage to building internal fabric, finishings and engineering services Loss/Damage to Furniture and personal items Damage/Loss Perimeter Fencing,plants/vegetation	2,205.88	4,000.00	81.33	2,205.88	6,750.00	206.00	2,205.88	4,000.00	81.33
1.04	Water retention and infiltration	Say replacement of kitchen and bedroom cabinets twice every 10 year life Possible damage to foundations based on soil type. Damage to external infrastructure, on lot sewage treatment & parked vehicles Structural damage	647.06	4,000.00	518.18	647.06	6,750.00	943.18	647.06	4,000.00	518.18

8.9 Capital Costs and Rates of Return for resilience measures

REF	MEASURES	IMPLICATIONS/BENEFITS	BARBADOS Derived Cost $US	BARBADOS Rate of Benefits $US	BARBADOS Capital Return	JAMAICA Derived Cost $US	JAMAICA Rate of Benefits $US	JAMAICA Capital Return	TRINIDAD Derived Cost $US	TRINIDAD Rate of Benefits $US	TRINIDAD Return
C	FLOOD MITIGATION(cont'd)										
1.05	Rainwater harvesting	Damage to building internal fabric, finishings and engineering services Loss/Damage to Furniture and personal items Damage/Loss Perimeter Fencing,plants/vegetation Say replacement of kitchen and bedroom cabinets twice every 10 year life Reduction in run off and downstream flooding	235.29	4,000.00	1,600.00	235.29	6,750.00	2,768.75	235.29	4,000.00	1,600.00
2.00	SME WAREHOUSE										
2.01	Elevating structures	Replacing manufacturing equipment not taken; say replacement of furnishings in the reception area ground floor only twice every 10 year life [reception desk, chairs, filing cabinets] Possible damage to foundations based on soil type. Damage to external infrastructure, on lot sewage treatment & parked vehicles Structural damage Damage to building internal fabric, finishings and engineering services Loss/Damage to Furniture and personal items Loss or damage to process equipment and inventory Damage/Loss Perimeter Fencing,plants/vegetation	1,000.00	25,750.00	2,475.00	1,000.00	25,750.00	2,475.00	1,000.00	25,750.00	2,475.00
2.02	Installing flood doors	Replacing manufacturing equipment not taken; say replacement of furnishings in the reception area ground floor only twice every 10 year life [reception desk, chairs, filing cabinets] Damage to building internal fabric, finishings and engineering services Loss/Damage to Furniture and personal items Loss or damage to process equipment and inventory Damage/Loss Perimeter Fencing,plants/vegetation	7,058.82	25,750.00	264.79	7,058.82	25,750.00	264.79	7,058.82	25,750.00	264.79
2.03	Permanent barriers	Replacing manufacturing equipment not taken; say replacement of furnishings in the reception area ground floor only twice every 10 year life [reception desk, chairs, filing cabinets] Possible damage to foundations based on soil type. Damage to external infrastructure, on lot sewage treatment & parked vehicles Structural damage Damage to building internal fabric, finishings and engineering services Loss/Damage to Furniture and personal items Loss or damage to process equipment and inventory Damage/Loss Perimeter Fencing,plants/vegetation	8,823.53	25,750.00	191.83	8,823.53	25,750.00	191.83	8,823.53	25,750.00	191.83
2.04	Water retention and infiltration	Replacing manufacturing equipment not taken; say replacement of furnishings in the reception area ground floor only twice every 10 year life [reception desk, chairs, filing cabinets] Possible damage to foundations based on soil type. Damage to external infrastructure, on lot sewage treatment & parked vehicles Structural damage Damage to building internal fabric, finishings and engineering services Loss/Damage to Furniture and personal items Loss or damage to process equipment and inventory Damage/Loss Perimeter Fencing,plants/vegetation	11,764.71	25,750.00	118.88	11,764.71	25,750.00	118.88	11,764.71	25,750.00	118.88
2.05	Elevation of equipment	Loss or damage to process equipment and inventory - not taken; equipment would be specific to SME operations	11,311.76	25,750.00	127.64	11,311.76	25,750.00	n/a	11,311.76	25,750.00	n/a
2.06	Green roofs	Retain rainfall and so reduce rate of run off	0.00	n/a	n/a	0.00	n/a	n/a	0.00	n/a	n/a
2.07	Rainwater harvesting	Replacing manufacturing equipment not taken; say replacement of furnishings in the reception area ground floor only twice every 10 year life [reception desk, chairs, filing cabinets] Reduction in run off and downstream flooding	8,529.41	25,750.00	201.90	8,529.41	25,750.00	201.90	8,529.41	25,750.00	201.90
D	HURRICANE MITIGATION MEASURES										
1.00	SINGLE FAMILY RESIDENTIAL										
1.01	Installation of hurricane/wind roof clips and ties	Mitigate need for replacing roof or repairing roof periodically - say repairs to roof twice in 20 yr life of installation each repair requiring 50% replacement of roof structure and frame	176.47	4,411.76	2,400.00	176.47	4,411.76	2,400.00	176.47	4,411.76	2,400.00
1.02	Installation of impact resistant windows and doors	Mitigate need for replacing windows and doors; say one storm per 10 yr life of installation requiring full replacement of windows and glazed doors only	3,764.71	2,847.06	-24.38	3,764.71	2,847.06	-24.38	3,764.71	2,847.06	-24.38
1.03	Installation of hurricane shutters	Mitigate need for replacing windows and doors; say one storm per 10 yr life of installation requiring full replacement of windows and glazed doors only	1,882.35	2,847.06	51.25	1,882.35	2,847.06	51.25	1,882.35	2,847.06	51.25
1.04	Construct roof out of concrete	Mitigate need for replacing roof or repairing roof periodically - say repairs to roof twice in 20 yr life of installation each repair requiring 50% replacement of sheeting only	8,823.53	2,647.06	-70.00	8,823.53	2,647.06	-70.00	8,823.53	2,647.06	-70.00
1.05	Reduce eaves	Mitigate need for replacing roof or repairing roof periodically	0.00	n/a	0.00	0.00	n/a	0.00	0.00	n/a	0.00
2.00	SME WAREHOUSE										
2.01	Installation of hurricane/wind roof clips and ties	Prevention of roof damage or total loss and water damage to building fabric and contents	1,176.47	4,240.00	260.40	1,176.47	4,240.00	0.00	1,176.47	4,240.00	0.00
2.02	Installation of impact resistant windows and doors	Mitigate need for replacing windows and doors; say one storm per 10 yr life of installation requiring full replacement of windows and glazed doors only	1,764.71	4,240.00	140.27	1,764.71	4,240.00	140.27	1,764.71	4,240.00	140.27
2.03	Installation of hurricane shutters	Mitigate need for replacing windows and doors; say one storm per 10 yr life of installation requiring full replacement of windows and glazed doors only	3,529.41	4,240.00	20.13	3,529.41	4,240.00	20.13	3,529.41	4,240.00	20.13
2.04	Construct roof out of concrete	Mitigate need for replacing roof or repairing roof periodically - say repairs to roof twice in 20 yr life of installation each repair requiring 50% replacement of sheeting only	57,345.59	26,470.59	-53.84	57,345.59	26,470.59	-53.84	57,345.59	26,470.59	-53.84

8.10 Climate Resilience Measure Reference Cards

8.10.1 Elevating of Structures

Typical Example:

Figure H: Completed single story unit elevated on sloping site in Trinidad and Tobago

Hazard Addressed: Flooding	FLOOD
Best Practice/ Recommendation:	• Useful for sloping sites • Assessment of floodplain
Other Considerations:	• Assessment of floodplain level • Design of the structure to consider the forces of the water, wind, and seismic forces • An additional staircase, ramp or elevator may be required to access the structure. • Increase in cost of construction for an elevated structure. • Additional cost for services such as plumbing and electrical to the structure.

8.10.2 Flood Doors

Typical Example:

Figure I: Installation of flood door in New York, USA.

Hazard Addressed: Flooding	FLOOD
Best Practice/ Recommendation:	• Assessment of floodplain • Useful for entrances of structures to prevent water intrusion.
Other Considerations:	• Proper installation of flood door to maximise its benefits. • Increase in cost for installation and maintenance.

8.10.3 Permanent Flood Barriers

Typical Example:

Figure J: Permanent Flood Barrier installed at a SME in Trinidad and Tobago.

Hazard Addressed: Flooding	FLOOD
Best Practice/ Recommendation:	• Assessment of floodplain • Useful for entrances/ driveways structures to prevent water intrusion.
Other Considerations:	• Proper installation of permanent flood barriers to maximize its benefits. • Additional cost for preparation, installation and maintenance

8.10.4 Permanent Flood Barriers

Typical Example:

Figure K: Permanent Flood Barrier installed at a SME in Trinidad and Tobago.

Hazard Addressed: Flooding	FLOOD
Best Practice/ Recommendation:	• Assessment of floodplain • Useful for entrances/ driveways structures to prevent water intrusion.
Other Considerations:	• Proper installation of permanent flood barriers to maximize its benefits. • Additional cost for preparation, installation and maintenance • Barriers may require activation during flooding activities.

8.10.5 Storm Water Retention & Infiltration Basins

Typical Example:

Figure L: Storm Water Retention Pond, Church Village Green, Bridgetown.

Hazard Addressed: Flooding	FLOOD
Best Practice/ Recommendation:	• Assessment of floodplain
Other Considerations:	• Requires acquisition of large areas of land • Increase in cost of construction and maintenance

8.10.6 Green Roofs

Typical Example:

Figure M: Green Roof of a residential facility in Singapore.

Hazard Addressed: Flooding, Heat Waves	FLOOD
Best Practice/ Recommendation:	• Assessment of floodplain
Other Considerations:	• Design of structure to consider seismic and wind forces. • Increase in cost of construction of roof. • Access to the roof required. • Increase in maintenan

8.10.7 Rainwater Harvesting

Typical Example:

Figure N: Rainwater collection from a roof top in Jamaica.

Hazard Addressed: Flooding, Drought	FLOOD DROUGHT
Best Practice/ Recommendation:	• Assessment of floodplain • Useful for water collection
Other Considerations:	• Requires space around the structure. • Increase in cost for installation and maintenance. • Limitation on storage capacity

8.10.8 Hurricane/Wind Roof Clips and Ties

Typical Example:

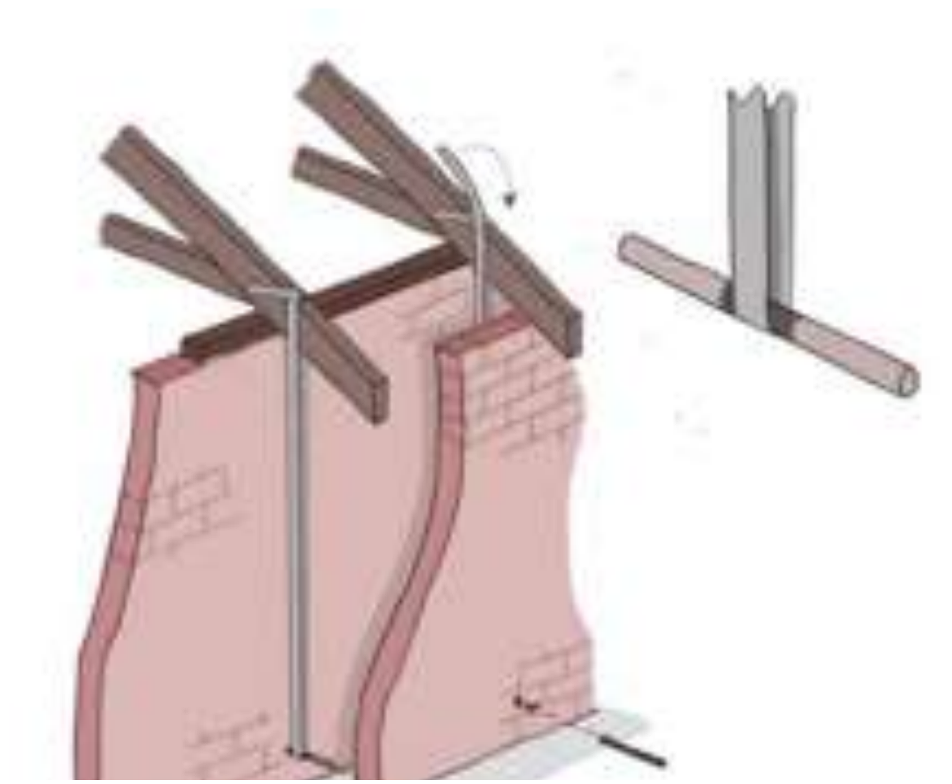
Figure O: Roof Clips and ties on a Timber Roof.

Hazard Addressed: Hurricanes	HURRICANE WINDS
Best Practice/ Recommendation:	• Useful for strengthening roof against high wind forces
Other Considerations:	• Proper installation is required. • Retrofitting of the straps/ties are costly.

8.10.9 Hurricane/Wind Roof Anchorage to Wall

Typical Example:

Figure P: Roof Members anchored to the wall using galvanized straps.



Hazard Addressed: Hurricanes	HURRICANE WINDS
Best Practice/ Recommendation:	• Useful for strengthening roof against high wind forces.
Other Considerations:	• Proper installation is required. • Retrofitting of the straps/ties are costly.

8.10.10 Impact Resistant Doors and Windows

Typical Example:

Figure Q: Glazing installed at Ministry of Works and Transport Office, Caroni, Trinidad and Tobago

Hazard Addressed: Hurricanes, Heat Wave	HURRICANE WINDS HEAT WAVE
Best Practice/ Recommendation:	• Useful for strengthening roof against high wind forces.
Other Considerations:	• Proper installation is required. • Retrofitting of the straps/ties are costly.

8.10.11 Hurricane Shutters

Typical Example:

Figure R: Rolling Shutters installed on structure.

Hazard Addressed: Hurricanes	HURRICANE WINDS
Best Practice/ Recommendation:	• Useful for strengthening roof against high wind forces
Other Considerations:	• Proper installation required to be effective. • Costly • Installation/Activation required during an event.

8.10.12 Concrete Roof Structures

Typical Example:

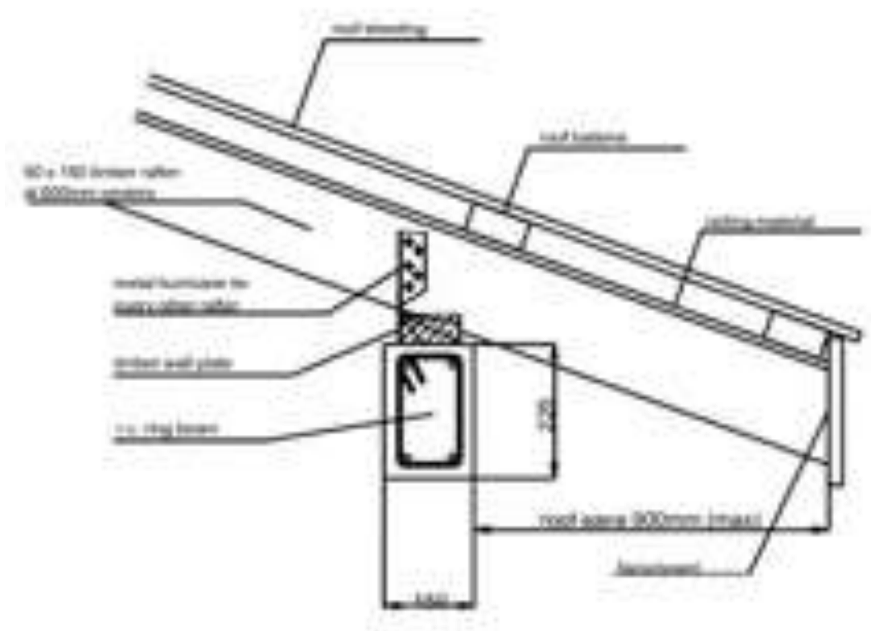
Figure S: Concrete Roof on SME, Eastern Washington, USA

Hazard Addressed: Hurricanes, Heat Waves	HURRICANE WINDS HEAT WAVE
Best Practice/ Recommendation:	• Useful for strengthening roof against high wind forces
Other Considerations:	• Design of structure to consider seismic forces and increase loads from the roof. • Increase in cost of construction of roof and maintenance. • Susceptible to leakage

8.10.13 Minimum Eaves on Buiildings

Typical Example:

Figure T: Diagram showing roof eaves.



Hazard Addressed: Hurricanes	HURRICANE WINDS
Best Practice/ Recommendation:	• Useful for strengthening roof against high wind forces.
Other Considerations:	• Increased heat inside structure.

8.10.14 Reducing Heat Gain on Building Envelopes – Roof

Typical Example:

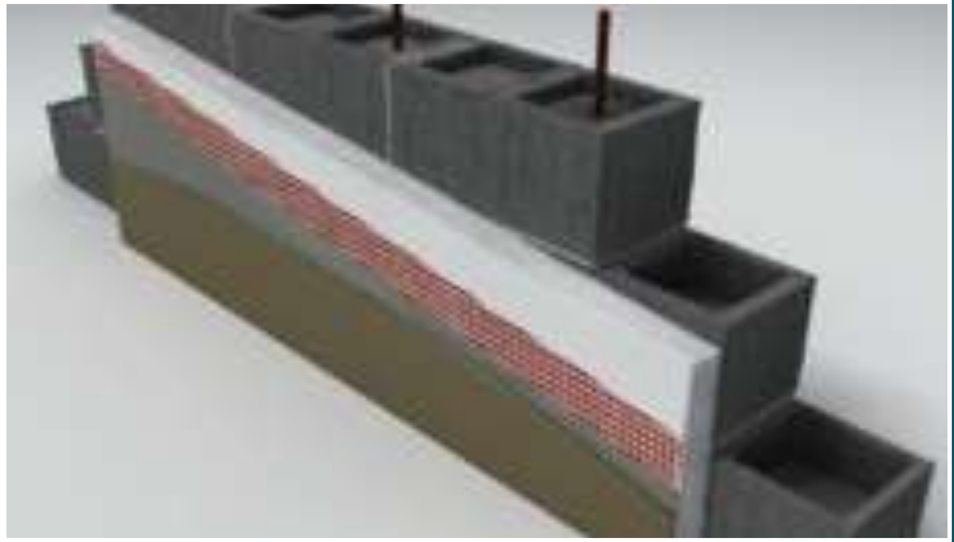
Figure U: Installation of the fiber installation on a concrete roof.

Hazard Addressed: Heat	HEAT WAVE
Best Practice/ Recommendation:	• Use of heat barriers such as fiber glass insulation, layer of radiant barrier with 10mm insulation, metal roof sheeting with insulative ceiling, wooden roof tiles with waterproofing sealant & installation of photovoltaic system on metal roof.
Other Considerations:	• Many different options available • Increase in cost for installation. • Maintenance may be required depending on the option selected.

8.10.15 Reducing Heat Gain on Building Envelopes – Walls

Typical Example:

Figure V: Insulation and gypsum plyboard on internal hollow block.



Hazard Addressed: Heat	HEAT WAVE
Best Practice/ Recommendation:	• Use of insulation for walls such as insulation with gypsum board attached to hollow blockwork, concrete filled blocks in lieu of hollow clay blocks, natural shading such as plants or radiant barrier with 10mm insulation.
Other Considerations:	• Many different options available • Increase in cost for installation. • Maintenance may be required depending on the option selected

8.10.16 Reducing Heat Gain on Building Envelopes – Windows

Typical Example:

Figure W: Internal blinds for windows.

Hazard Addressed: Heat	HEAT WAVE
Best Practice/ Recommendation:	• Use of internal blinds, external shading overhangs and blinds, Low E double glazed windows.
Other Considerations:	• Many different options available • Increase in cost for installation. • Maintenance may be required depending on the option selected. • Aesthetics of the structure

8.10.17 Energy Efficient Air Conditioning Units

Typical Example:

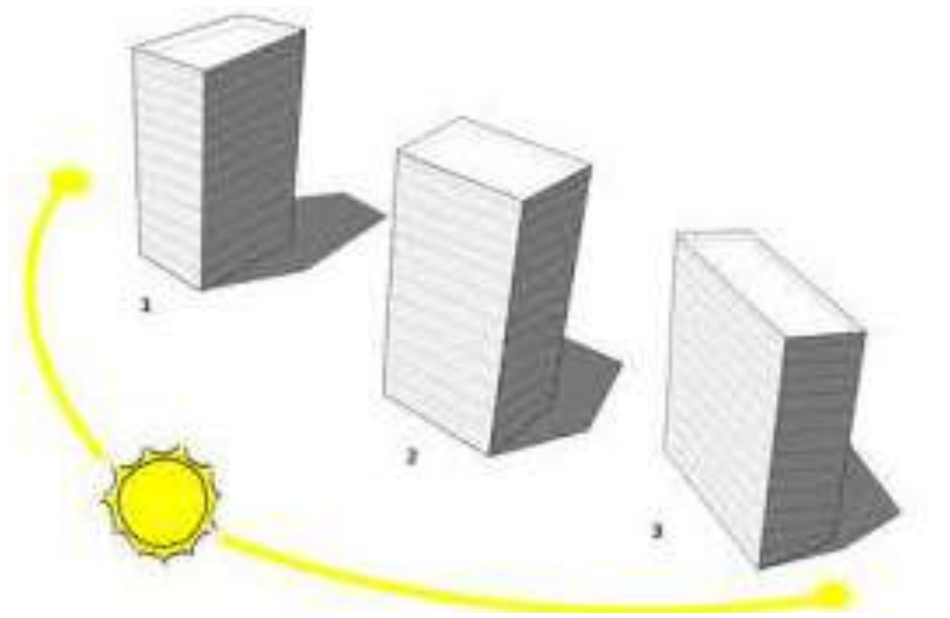
Figure X: Air conditioning units

Hazard Addressed: Heat	HEAT WAVE
Best Practice/ Recommendation:	• Useful for residential and SME
Other Considerations:	• Increase in cost for installation, maintenance. • Additional electrical requirements • Many options available

8.10.18 Orientation of the Building

Typical Example:

Figure Y: Orientation of the building



Hazard Addressed: Heat	HEAT WAVE
Best Practice/ Recommendation:	• Useful for reducing heat and wind to structures.
Other Considerations:	• Increase in cost for construction. • Aesthetics of the structure

8.10.19 Utilize Water Efficient Fixtures

Typical Example:

Figure Z: Water efficient faucet

Hazard Addressed: Drought	DROUGHT
Best Practice/ Recommendation:	• Use of sensor fixtures to reduce the amount of water being used. • Useful for reducing water consumption.
Other Considerations:	• Increase in cost for installation and maintenance. • May require additional electrical and plumbing.

8.10.20 Utilising Alternative Water

Typical Example:

Figure AA: Collection of water into water storage tanks.

Hazard Addressed: Drought	DROUGHT
Best Practice/ Recommendation:	• Useful for collection of AC condensate water.
Other Considerations:	•Increase in cost for installation and maintenance. • Storage space required. .

Appendices

8.10.21 Onsite Water Storage Tanks

Typical Example:

Figure BB: Water Storage Tanks

Hazard Addressed: Drought	DROUGHT
Best Practice/ Recommendation:	• Useful for storage of water
Other Considerations:	• Increase in cost for installation and maintenance. • Storage space required.

8.10.22 Public Education on Water Conservation

Typical Example:

Figure CC: Signage of conserving water

Hazard Addressed: Drought	DROUGHT
Best Practice/ Recommendation:	• Useful for water conservation
Other Considerations:	• Increase in cost of producing and installing signage.

8.11 Market Demand Analysis: Sub-report

A complete sub-report for the Market Demand Analysis was prepared. This report details the method employed to collect data on Market Demand and Willingness to Pay for Climate Resilience Measures in Barbados, Jamaica and Trinidad and Tobago for both residential and SME sectors. Additionally, this report also details the current status and potential demands for Insurance, as well as the Market Size Estimates for residential and commercial buildings Barbados, Jamaica and Trinidad and Tobago. This report may be accessed at: Market Demand Analysis of Climate Resilient Infrastructure: Barbados, Jamaica and Trinidad and Tobago:

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