



**GREEN
BUILDING
TOOLKIT
2025
JAMAICA**

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Acknowledgments

This publication was made possible thanks to the generous contribution of the Canadian Accelerator for Net Zero and Climate Resilience. The authors are Malini Samtani (ICT/CLE), Pamela Castellan (ICT/CLE), Norman Thompson (ICT/FLI) from IDB Invest, and Laura Rojas, Andres Ospina, and Magdalena Cuadra from SUMAC.

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Background

Background

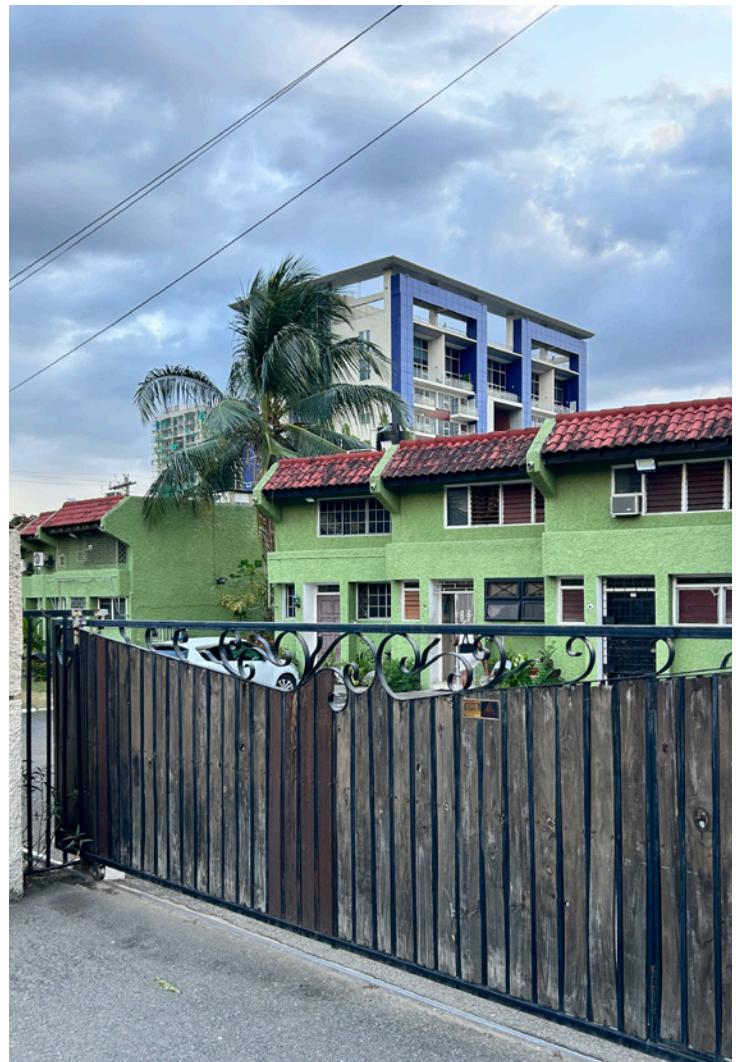
The built environment sector represents approximately one-third of global greenhouse gas emissions, primarily driven by operational energy consumption and embodied carbon from construction materials including cement and steel [1]. For Small Island Developing States (SIDS) like Jamaica, this sector presents a critical challenge: it simultaneously contributes to climate change while remaining highly vulnerable to its impacts. Caribbean SIDS face unique vulnerabilities due to their geographic isolation, exposure to natural hazards, and predominantly low-lying topographies, making them among the most vulnerable regions to adverse climate impacts despite their minimal contribution to global emissions [2][3].

Within SIDS contexts, built environment infrastructure typically concentrates in coastal zones without adequate climate-resilient design integration, resulting in elevated structural failure risks and service disruption vulnerabilities [3].

Jamaica exemplifies these challenges through its direct exposure to intensifying hurricanes, tropical storms, prolonged drought periods, sea level rise, and escalating risks to essential infrastructure [5][6]. The country's-built environment has experienced systematic climate-related damage patterns over the past two decades, providing extensive empirical evidence of climate-infrastructure vulnerabilities. Hurricane Ivan (2004) resulted in approximately 5,000 homes requiring rebuilding or major repairs, displaced 18,000 residents, and generated widespread damage across major transportation corridors, electrical infrastructure, and public facilities [7][8]. Subsequent major events including Hurricanes Dean (2007), Sandy (2012), and Elsa (2021) produced recurrent patterns of severe flooding, transportation network disruptions, and structural failures across multiple administrative parishes [8].

Hurricane Beryl (2024) inflicted extensive damage across southern and eastern regions, resulting in prolonged electrical service disruptions, potable water system failures, and compromised access to essential services including educational and healthcare facilities [9].

Beyond tropical cyclone impacts, Jamaica experiences significant built environment stresses from extreme precipitation events triggering flash flooding and slope



instability. The November 2023 tropical disturbance produced torrential rainfall causing major infrastructural damage and overwhelming existing drainage systems, with Norman Manley International Airport recording 315.4 mm of rain in 48 hours [10]. Conversely, prolonged drought conditions, exemplified by the severe 2023 event requiring government-implemented water restrictions and significantly impacting agricultural productivity, stress water supply infrastructure and elevate fire risks in peri-urban settlements [11].

Jamaica's historical development patterns have concentrated infrastructure and settlements in

climate-vulnerable locations, with residential structures, transportation networks, water management systems, and healthcare facilities exhibiting elevated exposure levels, particularly within low-income, informal, and coastal communities [3][5].

The global climate context underscores the urgency of building sector transformation. The year 2024 documented the highest global average temperature on record, reaching 1.5°C above pre-industrial levels, while extreme weather events previously classified as exceptional now occur with concerning frequency [12].

Jamaica demonstrates formal commitment to international climate frameworks through Paris Agreement participation and updated Nationally Determined Contributions establishing targets for 25.4% greenhouse gas emissions reduction by 2030 [14]. The country is also part of the Coalition for High Ambition Multilevel Partnerships CHAMP, an initiative launched at COP28 to strengthen cooperation between national and subnational governments in the fight against climate change, which seeks to improve planning, financing, implementation and monitoring of climate strategies [19]. Jamaica has advanced regulatory frameworks through the Building Act 2018 and National Building Code incorporating enhanced structural resilience standards [5]. However, implementation gaps persist in systematic integration of climate resilience requirements and energy efficiency specifications. These gaps encompass both deficiencies in the technical design of code requirements and compliance challenges where many construction projects, particularly residential self-build initiatives, proceed without formal code adherence or regulatory oversight. Current energy efficiency standards rely on outdated specifications, and transitional regulatory conditions limit systematic sustainable building practice adoption, particularly regarding municipal enforcement capacity and comprehensive climate-responsive design integration [5][6].

Despite recognition of the built environment's critical role in climate response, significant gaps persist in Jamaica's green building landscape. Technical capacity deficits limit availability of professionals trained in climate-resilient design and sustainable construction practices [5]. Financial mechanism constraints restrict access to sustainable building financing, particularly for vulnerable communities with elevated climate exposure levels. Information access barriers prevent

comprehensive understanding of locally-relevant green building strategies adapted to Jamaica's specific climatic and socioeconomic conditions [6].

Systemic integration difficulties persist in effectively connecting international technical standards with local material availability, construction traditions, and regulatory frameworks [5]. These documented challenges establish Jamaica's built environment sector as simultaneously a critical climate vulnerability and essential component of comprehensive climate response strategy. Strengthening the resilience of Jamaica's built environment represents both a climate imperative and a development priority that ensures continuity of essential services while supporting equitable and sustainable growth through low-carbon technologies and nature-based solutions.

Executive Summary

Executive Summary

Jamaica's building sector stands at a critical juncture. As a Small Island Developing State experiencing intensifying climate impacts from hurricanes, flooding, drought, and sea-level rise, the country faces the dual imperative of reducing greenhouse gas emissions while building resilience against unavoidable climate threats. The built environment sector, representing one-third of global emissions, offers substantial opportunities for climate action while addressing Jamaica's vulnerability to extreme weather events and structural inadequacies.

This toolkit provides a comprehensive framework for transforming Jamaica's construction sector toward low-carbon, climate-resilient development. Developed through an IDB Invest-led initiative, it addresses critical gaps in technical capacity, financial access, regulatory implementation, and locally-adapted green building knowledge.

Jamaica's green building transition presents significant opportunities for transformative change across multiple interconnected areas. The concentration of coastal infrastructure creates an urgent need for climate-resilient design approaches that can withstand intensifying hurricanes and flooding events, as demonstrated by recent experiences with hurricanes Ivan, Dean, and Beryl. While Jamaica has established progressive frameworks through the Building Act 2018 and National Building Code, there remains considerable potential to strengthen the systematic integration of climate resilience and energy efficiency throughout the sector. Growing the pool of professionals trained in climate-resilient design and sustainable construction practices will be essential to scaling these solutions across the country. Expanding access to sustainable building financing, particularly for vulnerable communities, represents a critical pathway to inclusive green development. Additionally, developing comprehensive, locally-relevant guidance on green building strategies specifically adapted to Jamaica's unique climatic and socioeconomic conditions will empower stakeholders to make informed decisions and implement effective solutions tailored to the Caribbean context.

The toolkit adopts complementary mitigation and adaptation strategies across six chapters:

Chapter 1 establishes green building foundations, defining sustainable construction principles and their relevance to Jamaica and the Caribbean region, including policy frameworks and international standards.

Chapter 2 addresses climate change mitigation through five strategic pillars: energy efficiency, renewable energy integration, low-carbon materials and construction methods, operational carbon reduction, and enabling regulatory frameworks and financial incentives.

Chapter 3 focuses on climate change adaptation strategies, covering community-based resilience, tropical cyclone and flood protection, heat and drought resilience, water efficiency and management, structural resilience to extreme events, and green-blue infrastructure for urban adaptation.

Chapter 4 explores net zero buildings and smart cities within the Caribbean context, examining Jamaica's energy profile, effective transition strategies, and the Caribbean Climate-Smart Accelerator framework.

Chapter 5 provides guidance on green building certification systems (LEED, EDGE, WELL, BREEAM, Envision), country-specific certifications, resiliency considerations, implementation costs, and Caribbean and Latin American success cases.

Chapter 6 demonstrates practical integration of mitigation and adaptation strategies through passive design, storm resilience, and flood resilience approaches.

Chapter 7 analyzes costs, savings, and financial returns from green building investments, including available policy support and incentives.

Chapter 8 (Annex) offers stakeholder analysis and mapping to support effective implementation across Jamaica's building sector.

Implementing the strategies outlined in this toolkit will yield multiple co-benefits:

- Enhanced contribution to global climate mitigation and improved resilience to local climate risks
- Strengthened technical and institutional capacities within the construction sector
- Improved access to green financing mechanisms
- Support for low-carbon economic development
- Advancement of Jamaica's regional leadership in climate sustainability

This toolkit serves diverse stakeholders across Jamaica's building sector transformation: policymakers and government agencies, developers and construction companies, architects and engineers, financial institutions and investors, community organizations, and educational institutions.

Successful deployment requires coordinated action across multiple fronts: integrating toolkit recommendations into building codes and development approvals, building technical capacity through training programs and professional development, mobilizing climate finance through innovative mechanisms, fostering institutional coordination among government agencies and private sector actors, and developing context-specific knowledge through demonstration projects and local research.

The toolkit represents a practical resource for navigating Jamaica's sustainable construction transition, balancing environmental imperatives with development priorities while positioning the country as a regional leader in climate-responsive building practices.

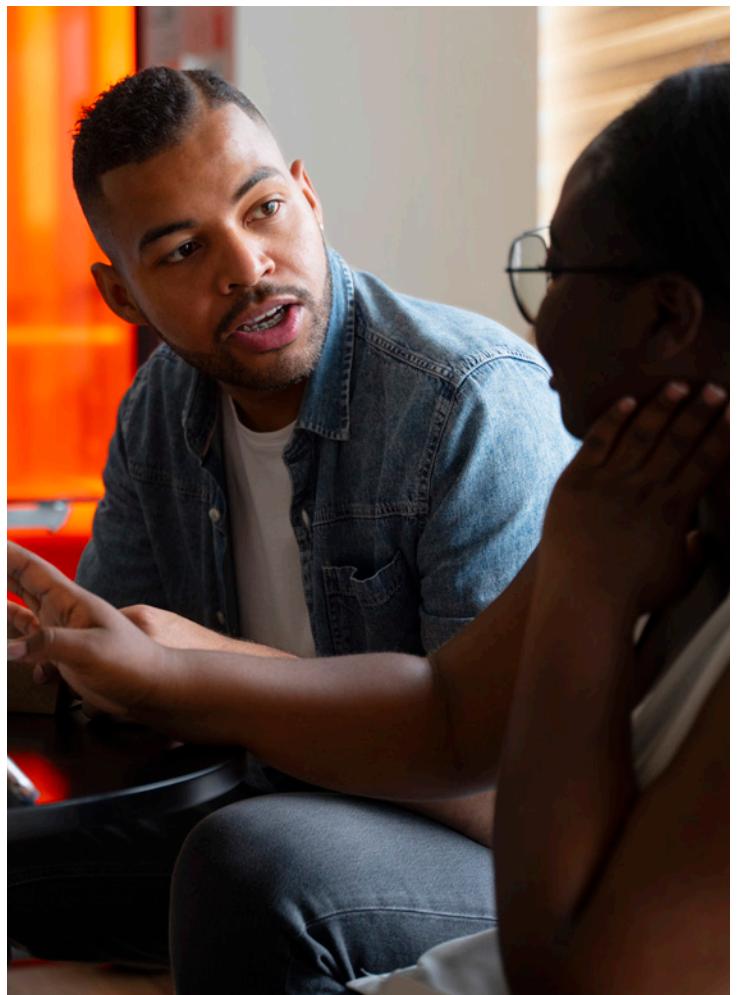


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Introduction

Introduction

This toolkit was created through an IDB Invest-led initiative, directly addressing the critical need to transform Jamaica's construction sector while navigating the dual challenges of reducing climate risk and addressing structural inadequacies. Its goal is to provide a practical guide to support the transition towards low-carbon and climate-resilient buildings, offering viable solutions for different actors across the urban and territorial development ecosystem and facilitating informed decision-making.

To achieve this, the document adopts two complementary approaches: mitigation and adaptation to climate change, addressing the dual challenge faced by Jamaica, actively contributing to the global climate solution while protecting its communities from inevitable impacts [4][14]. These approaches are aligned with national targets, international commitments, and existing regulatory frameworks, aiming to generate environmental, social, and economic co-benefits [6][14][15].

In addition to mitigation and adaptation strategies, the toolkit includes key elements to support practical implementation. These comprise certification mechanisms and green building rating systems, targeted recommendations for new and existing buildings, business and climate finance opportunities, Caribbean case studies, and a stakeholder map of Jamaica's sustainable construction ecosystem. This comprehensive approach allows the toolkit to be adapted to different technical and institutional profiles, enhancing its applicability and scalability.

The development of this toolkit is grounded in a multisectoral diagnostic that highlights the main barriers to a sustainable transition of the built environment in Jamaica. Despite regulatory progress and public policies oriented toward low carbon and resilient development, there are still gaps in technical capacity, access to finance, institutional coordination, and context-specific knowledge [6][5]. These limitations become more critical in the current context of intensified extreme weather events, rapid urban growth, and increased territorial vulnerability [3].

This toolkit provides practical guidance for stakeholders involved in Jamaica's building sector transformation. The strategies and approaches outlined support the

transition toward sustainable construction practices that address both environmental objectives and national development priorities. Effective implementation of these measures can yield multiple benefits:

- Enhanced contribution to global climate mitigation and improved resilience to local climate risks;
- Strengthened technical and institutional capacities within the construction sector;
- Improved access to green financing mechanisms;
- Support for low-carbon economic development;
- Advancement of Jamaica's regional leadership in climate sustainability.



Chapter 1. What Constitutes a Green Building

Buildings remain one of the largest contributors to global climate change, accounting for 34% of energy-related CO₂ emissions as of 2023. Despite commitments to reduce environmental impact, the sector's emissions have increased by 5% since 2015 significantly off-track from the 28% reduction needed by 2030 to meet Paris Agreement targets. While positive trends include increased renewable energy adoption and green certifications (growing from 15% to 20% in commercial buildings across developed nations), critical challenges persist. Embodied carbon from construction materials contributes 18% of building-related emissions, and implementation of supportive policies has been insufficient. The financing gap for energy efficiency stands at US\$1.1 trillion, highlighting the urgent need for coordinated action. [16] For Jamaica, transitioning to green building practices represents not just an environmental imperative but an economic opportunity of reducing operational costs, increasing resilience to climate impacts, and creating sustainable development pathways aligned with global.

Jamaica emitted 7.064 Mt CO₂ from fuel combustion in 2022, representing 0% of global CO₂ emissions, with per capita emissions of 2.499 tCO₂ per person. The country experienced a 28% decrease in total emissions from 2000-2022, and per capita emissions fell by 34% over the same period. Oil dominates Jamaica's energy-related emissions at 78% of total fuel combustion CO₂, followed by natural gas (19%) and coal (4%). Transport is the largest emitting sector at 36.8% of energy-related CO₂ emissions, closely followed by electricity and heat production at 32.9%. Jamaica ranks 19th in CO₂ emissions within Central & South America and 8th in regional per capita emissions. (120).

Figure 1. CO₂ emissions by sector, Jamaica, 2022



Source: International Energy Agency. Licence: CC BY 4.0

1.1. Green Buildings and Sustainable Construction

Green building is widely understood as the process of planning, designing, constructing, and operating buildings with several fundamental priorities: optimizing energy consumption, managing water resources efficiently, ensuring superior indoor environmental quality, selecting appropriate materials, and minimizing the building's effects on its surrounding site. [17] This can be achieved by incorporating sustainable materials, renewable energy systems, and innovative design strategies that work in harmony with the local climate and ecosystem.

The oversight of such sustainable building practices in Jamaica falls under the National Environment and Planning Agency (NEPA), which is an Executive Agency of the Ministry of Economic Growth and Job Creation. It establishes planning frameworks and guides for land use, influence property development plans and compliance with environmental regulations. The National Environment and Planning Agency (NEPA) of Jamaica do not use a single "comprehensive typology of buildings". Instead, NEPA recognizes building categories based on specific regulatory triggers, such as size and type of development, which determine whether a permit or license is required under the Natural Resources Conservation Authority (NRCA) Act and the Town and Country Planning Act (121).

Building classifications in Jamaica are primarily defined by the Jamaica Building Code (JBC) and the Building Act of 2018, which is enforced by local authorities. However, NEPA's oversight of the overall development process means that certain projects involving buildings fall under its mandate (122).

NEPA's involvement depends on specific thresholds and project types outlined in the NRCA (Permits and Licences) Regulations. For building-related developments, these "prescribed categories" include. (121).

- **Residential projects:** Housing developments of 10 houses or more require an environmental permit from NEPA.
- **Hotel/resort complexes:** These need an environmental permit if they have 10 or more rooms.
- **Office complexes:** These require a permit if they are 5,000 square meters or larger.
- **Industrial projects:** This is a broad category encompassing various plants and facilities, such as:
 - Power generation plants
 - Food and fish processing plants
 - Distilleries and breweries
 - Petroleum production and storage facilities
- **Commercial centers:** Shopping centers are a prescribed category under the regulations.
- **Ecotourism projects:** These require permits to ensure environmental sustainability.
- **Hospitals:** New hospital construction falls under the regulatory framework.

These regulatory requirements are essential for promoting sustainable construction, which encompasses the broader process of creating green buildings, refers to the practice of developing the built environment while minimizing resource consumption, reducing environmental degradation, and creating healthier spaces for occupants. It addresses the entire construction lifecycle, from planning and design through materials sourcing, construction methods, operation, maintenance, renovation, and eventual demolition or repurposing.

1.2. Relevance of Green Buildings for Jamaica and the Caribbean Region

Across the wider Caribbean, the convergence of climate vulnerability and urban expansion presents both challenges and opportunities for the construction sector. Island communities face unique environmental pressures; from rising sea levels and intensifying hurricanes to resource constraints, all while experiencing significant development growth.

Jamaica's diverse geography creates varying hazard exposure patterns, with rural coastal areas facing severe risks from sea level rise and storm surge, urban centers like Kingston confronting flooding challenges due to inadequate drainage systems, and mountainous regions dealing with landslides and variable wind conditions. Local planning authorities can implement green building principles through comprehensive risk mapping, zone-specific building regulations, and early warning networks that incorporate climate-resilient design standards, establish development guidelines based on geographic risk profiles, and deploy targeted adaptation measures tailored to each community's specific vulnerabilities.

Sustainable building practices have emerged as a vital response to these regional challenges. Throughout the Caribbean, forward thinking architects, engineers, and policymakers are pioneering construction approaches that harmonize with the tropical environment rather than working against it. These innovations incorporate renewable energy systems optimized for the abundant sunshine, utilize resilient local materials that withstand the climate extremes, and embrace design principles that celebrate the connection to nature. Across the region, landmark projects demonstrate how green building can be adapted to Caribbean realities. From hurricane resistant homes in Jamaica powered by solar energy to naturally ventilated commercial buildings in Trinidad that dramatically reduce cooling costs, these examples prove that sustainable construction can be both practical and economically viable in the regional context [18].

This toolkit aimed to explores how these Caribbean specific green building practices can transform the built environment while strengthening community resilience, preserving cultural identity, and supporting economic development. By adapting global sustainability principles to these unique regional circumstances, Jamaica can create buildings that not only minimize environmental impact but also enhance quality of life for generations of Caribbean people.

1.2.1. Core Elements of Green Buildings in the Caribbean Islands

Energy consumption in Caribbean buildings demands particular attention due to the tropical climate challenges. The combination of high humidity and elevated temperatures necessitates extensive use of mechanical cooling and dehumidification systems, while the indoor spaces often rely heavily on artificial lighting throughout the day. [18] These energy intensive requirements present a significant environmental impact and an opportunity for sustainable innovation in the Jamaican context.

Green buildings employ a strategic blend of passive and active design elements tailored to the environmental

conditions, building function, and occupant comfort requirements [18]:

- Passive design solutions harness natural energy flows, capturing prevailing trade winds for ventilation, utilizing sunlight for illumination, leveraging temperature differentials for cooling, and working with, rather than against natural forces, all without consuming electricity or fuel. These approaches represent the foundation of sustainable tropical architecture. The tropical climate in Jamaica is influenced by the sea and the northeast trade winds, which are dominant throughout the year. These prevailing winds are particularly strong during winter months and should guide building orientation decisions, with structures positioned to maximize cross-ventilation

from the northeast direction. Additionally, hurricane-resistant louver systems should be incorporated to ensure that ventilation strategies do not compromise storm safety during extreme weather events, utilizing impact-resistant materials and designs that can be secured during hurricane season while maintaining year-round ventilation benefits.

- Active design components complement these passive strategies by incorporating technologies that require or generate electricity, such as photovoltaic systems, energy-efficient HVAC equipment, and smart building controls.

The most effective green buildings achieve an optimal balance between these approaches, maximizing natural advantages while selectively deploying technology to enhance performance, resilience, and comfort in their unique context.



1.2.2. Why to prioritize passive design in Buildings in Jamaica from a Socioeconomic perspective

Jamaican building projects should prioritize passive design strategies as the foundation of their approach. These naturally-ventilated, climate-responsive solutions align perfectly with Jamaica's economic realities, offering lower initial construction costs, dramatically reduced energy bills in a country with high electricity rates, decreased dependence on imported components, and enhanced resilience during power outages.

Passive techniques also leverage traditional Jamaican architectural wisdom and locally available skills, making comfortable and efficient buildings accessible to more citizens across income levels. Rather than immediately implementing expensive active systems, a thoughtful integration of passive principles first as proper orientation, cross-ventilation, shading, and appropriate materials, represents the most cost-effective pathway to buildings that perform well in Jamaica's tropical climate while respecting the financial constraints of its people [19].

Examples of building design principles for tropical climates are shown below (Table 1) to improve a building's indoor comfort, enhance the energy efficiency, and to minimize energy use. Descriptions and analysis of these and more strategies are going to be displayed throughout this toolkit.

Table 1. Passive building design principles for tropical climates to improve a building's indoor comfort, to enhance the energy efficiency, and to minimize energy use. (Adapted from Bulbaai, R.; Halman, J.I.M. Energy-Efficient Building Design for a Tropical Climate: A Field Study on the Caribbean Island Curaçao).

A Building's orientation in the tropics is crucial	<p>Situate bedrooms at the side with the most wind.</p> <p>Restrooms and storage rooms can be located at the side with the least wind.</p> <p>Position the longest walls out of direct sunlight.</p>
Accommodate for natural ventilation	<p>Place windows in opposite walls, to create cross ventilation.</p> <p>Place ventilation openings at the occupant's upper body level.</p> <p>Interior walls and obstacles should not be hindering natural airflow.</p> <p>Encourage cross ventilation by using louver doors and louvered windows.</p> <p>Conceive air movement through placing low level inlets and high-level outlets on opposite sides.</p> <p>Apply solar chimneys to encourage convective air movement.</p> <p>Raise the building off the ground.</p> <p>Use open ventilation blocks.</p>
Make use of indirect instead of direct natural Light	<p>Overhangs, louvers, reflective coatings and tinted glass will reduce heat input through windows.</p> <p>Apply shaded atria and skylights that also allow hot air to escape.</p>
Reduce heat transmission through the roof	<p>Encourage natural ventilation between roof and ceiling, e.g., through ventilation openings.</p> <p>Lower the surface temperature of the roof through applying light surface colors, reflective surface layers or by covering the roof with green vegetation.</p>
Prevent the use of high thermal mass materials	<p>Lightweight materials with a low thermal mass are the recommended building materials in hot climates.</p> <p>Prevent in case of the use of bricks and concrete the exposure to direct sunlight.</p>
Reduce heat transmission through the exterior walls	<p>Apply light colors or reflective paints for external surfaces, solar shading elements and extensive vegetation outside the building.</p> <p>Apply internal insulation to minimize heat transmission.</p>
Create outdoor and transition spaces	<p>Balconies, terraces, atriums and corridors provide shading for the walls, windows and door and have a cooling effect on the entering air.</p>

Descriptions and analysis of these and additional strategies will be presented throughout this toolkit, including active strategies focused on climate change and resilience.

1.3. Local and global policy framework and standards for Green Buildings

1.3.1. Policy Framework and building codes in Jamaica

Jamaica's built infrastructure has faced persistent challenges from both natural hazards and human induced incidents throughout recent decades. This ongoing vulnerability highlighted a critical gap in the construction regulatory framework. Specifically, the absence of both contemporary building standards and the legal mechanisms required to enforce them. The development of updated building codes, alongside robust legislative enforcement provisions, emerged as essential components for safeguarding the structural integrity, resilience, and public safety of Jamaica's buildings and communities.

Therefore, recent legislative action has transformed Jamaica's building regulatory landscape. In a landmark development, Parliament enacted the Building Act of 2018, which took effect on January 15, 2019. This comprehensive legislation repealed the outdated Kingston and St. Andrew Building Act and Parish Councils Building Act, establishing a modernized national framework for Jamaica's construction industry. [19]

The Jamaica Building Code (JBC), first published in 2009 based on the 2003 International Building Code, finally gained mandatory legal status in January 2018 with the enactment of the Jamaica National Building Act. The 2023 edition, customized for Jamaican natural hazards and construction practices, represents a substantial improvement in the regulatory framework. This code is now maintained through six-annual reviews led by local consultants and scrutinized by the BSJ (Bureau Standards of Jamaica) Technical Review Committee, which includes representation from 17 key organizations spanning professional associations, government agencies, educational institutions, and industry bodies. The World Bank has supported financing for updating and amalgamating the building code documents, helping address previous implementation challenges [20]. The system now includes complementary codes like:

- The Jamaica Energy Conservation Code

- The Jamaica Existing Building Code
- The Jamaica Fire Code
- The Jamaica Fuel Code
- The Jamaica Mechanical Code
- and The Jamaica Pluming and Sewage Codes

this aims to improve construction quality, disaster resilience, and public safety while influencing insurance rates, tourism standards and educational curricula.

Additional policies include the National Energy Policy (2009-2030), which is designed to achieve a well-developed, vibrant and diversified renewable energy sector that contributes to Jamaica's energy security and a sustainable future [5]. (123). Supporting frameworks encompass Vision 2030's Energy Sector Plan establishing renewable energy benchmarks and sustainable development objectives [6] (124), and The National Policy for Trading Carbon Credits (2010-2030) facilitating carbon reduction programs [7]. (125).

1.3.2. International Green Building Standards and certifications

1.3.2.1. Building Standards

Standards are essential guidelines for evaluating products and building practices, typically developed through consensus processes by organizations like ANSI, ASTM, and ASHRAE. The International Standards Organization (ISO) provides global oversight, defining standards as consensus documents that establish rules and guidelines for repeated use. These standards may be either prescriptive (specifying methods) or performance-based (stating desired outcomes). Consensus based standards, developed through formal voluntary processes, enjoy immediate credibility, government support, and international recognition. [21]

A noteworthy example is ANSI/ASHRAE/USGBC/

IES Standard 189.1, which establishes minimum requirements for high-performance green buildings (excluding low-rise residential structures). This comprehensive standard provides mandatory, code-enforceable language covering site development, water usage, energy efficiency, indoor environmental quality, and materials selection, offering a complete framework for sustainable building design, construction, and operations. [22]

1.3.2.1. Building Standards

Green building codes are advancing sustainability standards in construction both domestically and internationally through three primary formats:

- Prescriptive (specifying exact requirements for materials and equipment),
- Performance-based (focused on achieving particular results rather than specific components), and the emerging,
- Outcome-based approach (establishing target energy use levels with ongoing measurement and verification). [21]

Unlike voluntary rating systems, codes are mandatory, giving them the potential for rapid and widespread environmental impact when adopted.

The International Green Construction Code (IgCC) stands as a comprehensive framework designed to reduce buildings' environmental impact while being administrable by code officials and adoptable by governmental bodies at any level. Developed by the International Code Council in collaboration with ASTM International and the American Institute of Architects, also supported by organizations like USGBC and the Green Building Initiative, the IgCC integrates with the ICC family of codes and applies to both new construction and existing building alterations. It includes residential occupancies by reference to the ICC 700 National Green Building Standard, while also allowing jurisdictions to adopt ANSI/ASHRAE/USGBC IES Standard 189.1 as a compliance option. [21]

1.3.2.3. Green Product Certifications

Green product certifications verify that products meet specific environmental standards, with ISO defining certification as "any activity concerned with determining directly or indirectly that relevant requirements are fulfilled." [23] These certifications may be:

- Multi-attribute (evaluating lifecycle parameters like energy use, recycled content, and emissions) or,
- Single-attribute (focusing on specific aspects like water efficiency or energy consumption).

The most respected certifications come from independent third parties that test products and award certifications without manufacturer influence, providing credibility to environmental claims and helping combat greenwashing in the marketplace.

ISO defines three certification types: Type I ISO 14024 (seal of approval for multi-attribute requirements), Type II ISO 14021 (verifiable single-attribute environmental claims), and Type III 14025 (comprehensive environmental product disclosures similar to Environmental Product Declarations). Major certification programs include:

- Energy Star (single-attribute government certification for energy-consuming products).
- Water Sense (EPA label for water-efficient products).
- Forest Stewardship Council (for sustainable forestry products).
- SCS Global Services (multi-attribute certification for diverse products).
- Green Seal (third-party ISO Type 1 certification for various sectors).
- Cradle to Cradle (evaluating materials, recyclability, energy, water, and social responsibility).
- GREENGUARD (focused on indoor air quality).
- Green Squared (for tiles and tile installations).

These certifications are increasingly recognized within comprehensive green building rating systems like LEED, Green Globes, and the National Green Building Standard, reflecting growing market demand for environmentally responsible products.

1.3.2.4. Green Building Rating and Certification System

Green building rating systems evaluate entire projects

throughout their lifecycle—from siting to demolition; requiring integrated design processes to earn certification, with systems ranging from single-attribute (focusing on water or energy) to comprehensive multi-attribute assessments addressing broader environmental impacts across diverse project types including new construction and existing buildings. These systems were developed to systematically define and measure “green,” and have been widely adopted by government agencies like GSA and EPA, with major cities incorporating them into building requirements. [21]

When selecting an appropriate certification system, stakeholders should consider whether the assessment comes from a first-party (self-assessment), second-party (trade association), or third-party (independent) source, while evaluating four essential principles:

The system should be

- Science-based (with reproducible results),
- Transparent (with standards open for examination),
- Objective (free from conflicts of interest),
- Progressive (advancing practices beyond business-as-usual). [21]

Sustainable design, often implemented through various standards and certification systems, delivers significant economic and environmental advantages as demonstrated by empirical research. USGBC studies of LEED-certified buildings document remarkable resource efficiencies (energy, carbon, water, and waste reductions of 30-97%), alongside compelling financial benefits including 8-9% lower operating costs, property value increases up to 7.5%, ROI improvements of 6.6%, occupancy increases of 3.5%, and rent premiums of 3% [21]. Beyond these quantifiable gains, green buildings promote enhanced productivity and occupant health through superior indoor environmental quality, natural daylighting, and healthier building materials. Corroborating these findings, a GSA analysis of 12 sustainable buildings revealed lower operational costs, superior energy performance, and higher occupant satisfaction compared to conventional commercial buildings across comprehensive metrics including energy, water, operations, waste management, and transportation [21]. While these benefits are compelling,

it's important to recognize that actual performance depends on variables such as climate, topography, timing, credit synergies, and local building standards.

1.4. Market Trend and Economic Consideration for Building Green in Jamaica

1.4.1. The Green Economy Strategy (GEIS)

The Green Economy Investment Strategy (GEIS) is a comprehensive strategic document developed to guide Jamaica's transition toward a low-carbon, climate-resilient economy and serve as a companion to the National Investment Policy for informing investment decisions.[24] The GEIS is important because it provides a strategic framework for Jamaica's sustainable economic transformation, building on previous green economy work from 2014, and emerged from the Plastic Waste Minimization Project to address broader environmental challenges while ensuring that economic development aligns with environmental sustainability and climate resilience goals.

The government has prioritized infrastructure development as a key component of its green economy strategy, with particular emphasis on partnerships with private investors for renewable energy development, especially wind and solar projects. Green building development receives direct support through the Urban Renewal (Tax Relief) Act of 1995, which provides incentives for development within designated Special Development Areas. The broader infrastructure investment program encompasses highway construction, road and bridge rehabilitation, fiber optic cabling, water and sewage systems, and airport development, all of which create opportunities for incorporating green building standards and sustainable construction practices [24].

1.4.2. The importance of Jamaica's Green Economy Investment Strategy (GEIS) for the construction and Energy Sector

The Green Economy Investment Strategy (GEIS) represents a cornerstone of Jamaica's national development approach, deriving its fundamental importance from the country's commitment to building a green economy as outlined in Vision 2030. This strategic framework aims to transform Jamaica into "the place of choice to live, work, raise families and do business" by establishing new jobs and industries

based on the sustainable use of natural resources and unique environmental assets. The GEIS encompasses the development of renewable energy sources, promotion of organic agriculture, and exploration of the genetic potential of endemic species, positioning Jamaica as a leader in sustainable development within the Caribbean region.

1.4.2.1. Energy Sector Transformation

The GEIS drives significant transformation in Jamaica's energy landscape through the National Energy Policy (2009-2030), which sets ambitious targets of achieving 20% renewable energy share and 30% renewable electricity share by 2030. The strategy encompasses substantial renewable technology development including 246-268 MW of solar/wind power, 36 MW of hydro-electric power, 18-40 MW from waste electric power, and 20 MW from biomass electric power. The integration of LNG as a cleaner fuel alternative has already demonstrated success, reducing petroleum consumption from 94,000 barrels per day in 2008 to 50,510 barrels per day in 2020—a remarkable 46% reduction over 12 years. The Ministry of Science, Energy and Technology's Integrated Resource Plan (IRP) further reinforces this commitment by mapping a 20-year electricity generation investment landscape, with the Generation Procurement Entity preparing to add 513.5 MW of new generation capacity while replacing 171.5 MW of existing capacity [24].

1.4.2.2. Construction Sector: A Critical Green Investment Priority

The construction sector emerges as a particularly critical component of the GEIS, with the document explicitly stating that "enhancing the rate of green investments in this sector should be a national priority" due to construction being "so integral to economic growth." The new National Building Code - Jamaica (NBC) and the Building Act 2018 have established comprehensive best practices to improve the efficiency of built works, with sustainability issues specifically addressed throughout the Code. Key green building elements include energy efficiency standards, sustainable material selection guidelines, water use efficiency requirements, and waste disposal protocols. The National Housing Trust (NHT) now offers homeowners loans to install solar

panels, demonstrating direct financial support for residential green building initiatives. This focus on green construction aligns with the broader infrastructure development goals while ensuring that new buildings contribute to the country's environmental objectives and energy efficiency targets [24].





Chapter 2. Strategies for Climate Change Mitigation in Buildings in Jamaica

Climate change mitigation refers to actions or activities that limit emissions of greenhouse gases from entering and/or reduce their levels in the atmosphere [25]. In the construction sector, mitigation involves reducing greenhouse gas emissions through modifications in building design, construction, operations, and retrofitting. This includes using low-carbon materials, transitioning to renewable energy, improving energy efficiency, and implementing supportive financial and regulatory mechanisms.

For island countries like Jamaica, building mitigation offers particularly compelling advantages as it simultaneously addresses critical vulnerabilities including high energy costs from fossil fuel dependence, aging infrastructure needs, and climate exposure. With over 85% of Jamaica's electricity generated from imported fossil fuels, building sector mitigation through energy efficiency and renewable integration provides substantial co-benefits in energy security, public health, and economic resilience [26]

In response to these imperatives this Chapter will address strategies target primarily three categories: **new buildings** (advanced technologies from design), **existing buildings** (cost-effective retrofitting), and **urban context** (territorial-scale interventions). Furthermore, successful implementation requires multisectoral coordination among government, private sector, academia, and financial institutions, with continuous monitoring and adjustment mechanisms.

Therefore, the approach centers on **five technical pillars**: energy efficiency, renewable energy integration, low-carbon materials, operational carbon reduction, and enabling mechanisms.

Table 2. Jamaica's Building Mitigation Framework – Five Pillars

Pillar	Focus Area	Key Strategies
Energy efficiency	 Building Performance	Passive and active strategies, smart systems.
Renewable energy integration	 Clean Power	Solar, wind and biomass integration.
Low-carbon materials	 Sustainable Construction	Bambo, E-Z blocks and local materials.
Operational carbon reduction	 Building Operations	Smart monitoring and optimization.
Enabling mechanisms	 Support Systems	Policy, Finance and incentives.

2.1. Pillar 1: Energy Efficiency

Energy efficiency provides some of the quickest and most cost-effective CO₂ mitigation options in clean energy transitions. This pillar emphasizes the importance of incorporating energy efficiency and low-carbon principles from the early stages of building design and construction. According to the Global Status Report for Buildings and Construction 2024/2025, buildings and construction sector consume 32% of global energy and contributes to 34% of global CO₂ emissions [27].

For instance, LED lighting technology provides significant energy efficiency benefits for commercial and residential buildings in Jamaica. According to the U.S. Department of Energy, residential LEDs use at least 75% less energy and last up to 25 times longer than incandescent lighting. For commercial applications, LED lighting can reduce lighting energy expenses to 4%-6% of the total energy bill due to lower power consumption and reduced heat output, which also decreases cooling costs. Commercial lighting can account for up to 20% of a building's electricity consumption annually, making LED conversion a high-impact efficiency measure. (126). Smart lighting controls and occupancy sensors can provide additional 20-30% energy savings by automatically adjusting artificial lighting based on natural light availability and space utilization patterns. (127).

Decisions made during the early stages of building design, such as optimizing orientation, selecting low-carbon materials, and planning for future technological upgrades, particularly in heating and cooling systems, are critical in shaping the building's long-term emissions trajectory [28]. And for energy efficiency measures to be effective, strategies must be tailored to context, taking into account local climate conditions, the type of building (residential, institutional, commercial, or mixed-use), and the urban environment, including the degree of urbanization and the availability of supporting infrastructure.

In the **residential sector**, energy consumption is typically spread throughout the day and is driven by lighting, appliance use, cooling, and cooking. Therefore, energy consumption represents a significant share of global energy use (25-30%), underscoring the importance of understanding the underlying drivers. In Caribbean regions such as Jamaica, this challenge is further exacerbated by high fossil fuel dependency and a steadily growing energy demand [29].

In this context, passive strategies; such as natural ventilation, strategic orientation, and external shading, are particularly effective due to their low cost and ease of implementation, making them particularly suitable for low-income households. Public awareness and access to energy-efficient appliances also play a critical role in reducing

household demand, because not all passive strategies are equally cost-effective; some, such as phase change materials or green roofs, may entail longer payback periods due to higher upfront costs. Therefore, careful selection based on building type, climate, and financial feasibility is essential [30].

Large-scale housing developments and apartment complexes present unique opportunities for comprehensive energy efficiency implementation through economies of scale. Multi-unit residential buildings can benefit from centralized energy management systems, shared renewable energy installations such as rooftop solar arrays, and coordinated HVAC systems. These developments enable building-wide energy monitoring, centralized hot water systems, and shared energy storage solutions, making energy efficiency measures more cost-effective per unit than individual residential.

To maximize their impact, targeting significant energy demand reductions by passive design measures, should be integrated into national planning frameworks, public housing programs, and construction permitting systems.

Additionally, energy efficiency requirements remain the most consistently adopted feature across both residential and non-residential sectors, underlining their effectiveness in reducing electricity use, lowering energy bills, and strengthening energy security [27][30].

Furthermore, in **commercial buildings**, including hotels, banks, and retail establishments, priority should be given to efforts aimed at improving energy efficiency, as these facilities typically have high energy consumption. For these buildings, active solutions such as high-efficiency HVAC units, automated LED lighting with motion sensors, and Building Management Systems (BMS) provide the most impactful savings, particularly for large buildings [28]. However, these often require upfront capital, making access to green credit lines and incentive mechanisms particularly for small and medium-sized enterprises (SMEs), to support the replacement of outdated and inefficient systems, mostly those located in urban centers or tourist zones of Jamaica [31].

However, to enhance energy efficiency in **public buildings**, it is recommended to conduct pilot interventions that evaluate economic savings and payback periods to optimize the cost-benefit ratio. These pilot projects help identify the most viable energy efficiency retrofitting alternatives based on the specific characteristics of each building and local constraints. Such

pilots provide valuable insights for decision-makers and public authorities who must select retrofitting measures, often within limited budgets, while ensuring alignment with the regulatory framework and the territorial context of the building in question [32].

Mixed-use buildings, combining residential, commercial, and/or institutional functions, face unique energy challenges due to their varied and simultaneous demands. Ensuring thermal and visual comfort across diverse occupancy patterns requires a holistic and integrated approach from the early design phase. These buildings benefit significantly from combining passive strategies, such as optimal orientation, cross-ventilation, and external shading, with intelligent systems like Building Energy Management Systems (BEMS), which centrally monitor and control HVAC, lighting, and ventilation services. This synergy not only enhances energy efficiency and reduces reliance on mechanical systems but also aligns energy use with the functional diversity of these spaces, while maintaining optimal indoor environmental quality and long-term performance [33].

In the Jamaican context, there is a key regulatory opportunity to integrate minimum energy efficiency standards for mixed-use buildings within national policies and green certification schemes. These could mandate measures such as LED lighting in new constructions and minimum thermal transmittance values for roofs and walls, ensuring consistent technical criteria for sustainable development. By prioritizing both human comfort and energy performance, these standards would support a coherent and climate-aligned pathway for urban transformation [34].

Beyond the performance of individual buildings, achieving resiliency and energy-efficiency in a city scale in Jamaica requires the integration of sustainability principles into urban planning. Given the diversity of urban environments, there is no universal solution; each context presents distinct characteristics that shape energy demand, ranging from urban form and the interplay between buildings and open spaces, to the choice of materials, microclimatic conditions, and socioeconomic dynamics [35]. In this context, optimizing urban morphology can substantially reduce energy needs by facilitating natural ventilation, enhancing shading, and mitigating the urban heat island effect.

Climate-responsive urban planning should integrate nature-based solutions that provide multiple co-benefits for energy efficiency and community resilience. Urban vegetation for microclimate regulation, green corridors that facilitate natural ventilation, and ecosystem services that support building performance can significantly reduce energy demands while enhancing community well-being. These interventions include strategic tree placement for building shading, green infrastructure for stormwater management, and urban forests that moderate ambient temperatures.

To this end, climate-responsive zoning regulations, the incorporation of green corridors, and the promotion of building typologies adapted to local climatic conditions are strongly recommended. In parallel, energy retrofit plans for existing public buildings should be prioritized, incorporating interventions such as thermal insulation, passive shading devices, and upgrades to HVAC systems. These measures must be supported by robust urban policy, targeted financial mechanisms, and regulatory frameworks that are consistent with Jamaica's international climate commitments [36].

2.2. Pillar 2: Integration of Renewable Energy

Recent government reports indicate accelerated progress toward renewable energy targets. As of May 2025, Jamaica has achieved 12.5% renewable energy in its electricity generation mix, with an additional 100 MW scheduled to come online during 2025/2026, representing 4.5% additional capacity and bringing the total to 17%. A further 220 MW will be procured in 2025 for commissioning in 2027/2028, adding approximately 10% and bringing the total renewable electricity generation to 27%. This trajectory demonstrates Jamaica's commitment to achieving its 50% renewable electricity target by 2030 (128), and reflects not only a global trend but also Jamaica's national commitment to diversifying its energy sources and reducing dependence on conventional fossil-based systems.

Despite this positive trajectory, the country still exhibits a strong structural reliance on fossil fuels. As of 2021, over 80% of Jamaica's electricity continued to be derived from fossil fuel combustion, leaving the island highly exposed to fluctuations in global energy prices and vulnerable to external supply shocks [37]. This dependence carries serious economic implications: in 2015, fossil fuel imports alone accounted for roughly 9% of Jamaica's Gross Domestic Product (GDP). In consequence, Jamaica is strategically seeking to reduce its dependence on imported petroleum by modernizing its energy systems and expanding the use of clean renewable sources, as outlined in its Vision 2030 National Development Plan [38][39].



Shifting toward a cleaner and more resilient energy matrix is therefore a strategic priority, not only to meet environmental goals but also to bolster energy security and reduce economic exposure to external shocks. By minimizing fuel imports, Jamaica can foster greater stability in its energy supply and create space for investment in localized, sustainable solutions. Although the Jamaica Public Service Company (JPS) retains exclusive rights to electricity distribution, generation is open to independent power producers, offering a critical entry point to accelerate the integration of renewables into the national grid and meet medium, term goals [38].

The Voluntary National Review (2022) indicates that the "NWC (National Water Commission) is the single largest electricity consumer in Jamaica. Consequently, the price of energy

weighs heavily on the extent to which universal access to water can be achieved. Therefore, trends towards the utilization of renewables as well as relatively cheaper energy sources should be pursued" [11]. (129). independent power producers can contribute to generation, representing a key mechanism to expand renewables and fulfill medium, term targets such as the updated official goal of 50% renewable electricity generation by 2030. This target was first announced in 2018 by Prime Minister Andrew Holness and reaffirmed in the Integrated Resource Plan (IRP-2) [40] and to achieve this, Jamaica has prioritized the following renewable energy sources and systems:

- Solar energy
- Wind energy
- Hydroelectric power
- Battery Energy Storage Systems (BESS)

In this context, both new constructions and existing buildings must progressively integrate renewable energy into their functional and architectural design. While **Solar PV energy** technologies are typically implemented at larger scales, they play a crucial enabling role in supporting renewable integration across the built environment, particularly in public infrastructure, institutional facilities, and critical service networks [40]. Particularly, harnessing solar power through photovoltaic (PV) systems presents significant potential for institutional facilities, commercial buildings, and single-family homes. Integrating these systems from the design stage helps maximize solar capture, reduce operating costs, and improve overall energy performance.

2.2.1. Hurricane Resistant Solar and Green Infrastructure

Nevertheless, despite these benefits, progress in PV roof research still faces several challenges but also key opportunities for improvement [41]:

Figure 2. Maximizing PV roof potential requires addressing key opportunities for improvement:



Economic Viability

High installation costs and long payback periods hinder widespread adoption in residential and commercial buildings, despite theoretical energy cost reductions.



Solution in Progress

Innovative financing models like solar leasing and Power Purchase Agreements (PPAs) are reducing upfront costs and accelerating adoption.



Architectural Integration

Many PV roof designs do not align with local architectural styles, potentially affecting public and professional acceptance.



Solution Strategy

Enhanced collaboration between architects and engineers is crucial for developing culturally appropriate, aesthetically integrated designs.



Limited Regional Coverage

Research and implementation tend to focus on urban areas with abundant solar resources, overlooking rural or vulnerable communities.



Expanding Reach

Targeted research and pilot programs are increasingly focusing on rural and vulnerable communities with appropriate financing mechanisms.

Moreover, many existing rooftops were not built to accommodate solar installations, creating technical and financial challenges for integration in existing buildings, a development of solar readiness assessments is recommended, rapid diagnostics that identify buildings suitable for PV installations, especially public buildings. These assessments could be supported through public-private co-financing schemes.

It is also recommended to install solar PV systems with battery storage in critical facilities, such as hospitals, schools, and administrative buildings, to secure uninterrupted energy supply during power outages or climate-related emergencies. These systems can be deployed using accessible financing mechanisms, including solar leasing or Power Purchase Agreements (PPAs), which are contractually regulated in Jamaica under the framework of the Office of Utilities Regulation (OUR) [40]. These models help attract private investment in renewable energy projects and allow implementation without the need for large upfront capital [41].

Renewable energy integration should also be approached systemically at the scale of urban infrastructure. The use of community solar systems with shared storage could promote the development of microgrids in off-grid or vulnerable communities. In

addition to improving energy security, these models strengthen resilience against climate disasters and central grid failures. Public policies could also promote solar-powered public lighting and charging stations for bicycles and electric vehicles in dense urban environments. Complementary urban master plans can explore the use of biodigesters to generate energy from organic waste and wastewater [40].

From a regulatory perspective, net billing and distributed generation are already permitted in Jamaica. However, widespread adoption is hampered by administrative and technical obstacles. Therefore, it is recommended to develop a centralized digital platform to manage applications, standardize requirements for installations under 10 kW, and expedite grid connection procedures. Additionally, it is essential to strengthen the monitoring of PV system performance and integrate this data into urban energy management tools.

Complementing solar technologies, bioenergy represents another viable renewable alternative, especially for rural and peri-urban buildings in Jamaica. Historically, in 2009, 81% of the country's renewable energy came from traditional biomass, such as firewood, charcoal, and sugarcane bagasse, used primarily for cooking and heat generation. Between 11% and 15% of

households still relied on these solid fuels at that time [39]. Transitioning from these polluting and inefficient energy sources toward modern bioenergy systems could play a key role in achieving cleaner energy access in regions where solar integration faces limitations.

Recent studies have demonstrated the technical feasibility of producing electricity from agro-industrial and livestock residues, such as bagasse, cow manure, and pig dung, through anaerobic bio digestion [39]. This solution can be integrated into institutional buildings, agricultural centers, or treatment plants located in areas with local availability of these inputs. Regions such as Westmoreland (Savanna-la-Mar), Clarendon, Saint Ann, Hanover, and Trelawny are notable for sugarcane



and livestock production, making them priority areas for implementing biomass-based energy solutions [39], [42]. In addition to reducing diesel use and associated emissions, this strategy supports more efficient organic waste management.

To advance the use of biogas as a modern energy source in buildings, a national strategy is required that includes:

- The implementation of demonstration pilot projects in institutional and rural buildings located in areas with high organic waste availability.
- The strengthening of technical capacity through

training programs for installers, operators, designers, and local authorities.

- The design of financial and regulatory incentives to stimulate adoption, including co-financing schemes, preferential tariffs, and support for pre-investment studies [39][42].

Finally, expanding technical education in renewable energy is essential. Installing and maintaining these systems requires specialized training for engineers, technicians, electricians, designers, and urban planners. In addition to appropriate technology, the energy transition in the building sector demands financial resources, institutional support, and the sustained development of human capacity. Long-term success will depend on building partnerships between technical institutes, universities, the private sector, and local communities [37].

2.2.2. Current Training Opportunities in Jamaica

Jamaica already has established training programs that provide a foundation for scaling renewable energy implementation:

HEART Trust/NTA Alternative Energy Solar Photovoltaic Systems Programme: The Vocational Training Development Institute (VTDI), the tertiary arm of the HEART Trust/NTA, offers a seven-week Alternative Energy-Solar Photovoltaic (PV) Systems programme at its Gordon Town and Mandeville locations. The program includes five modules covering PV orientation and site surveying, energy audit, PV system designs, solar system installations and grid tie, as well as PV system maintenance and troubleshooting. According to the HEART Trust/NTA's Labour Market Research and Intelligence Department, PV installers are in high demand across the island due to the Government's renewable energy targets and expansion of existing renewable energy plants. Students work with select schools to install solar panels as part of their practical component, ensuring competency-based education and training. (130).

Additionally, the National Tools and Engineering Institute has established a STEAM Lab focusing on training in renewable energy, with plans for additional labs offering training in instrumentation, electro-hydraulic, pneumatic, electro motor controls and Computer Numerical Control (CNC) programming. (131).



2.3. Pillar 3: Low-Carbon and Climate-Resilient Building Materials and Construction Methods

The transition to low-carbon buildings cannot be achieved through operational energy efficiency alone. A key component in progressing toward full decarbonization of the construction sector is addressing embodied carbon, emissions associated with the life cycle of building materials [43]. These emissions stem from the extraction, processing, transportation, installation, maintenance, and final disposal of materials.

In Jamaica, the extensive use of concrete and steel in construction highlights the strategic environmental and economic opportunity of rethinking supply chains, adopting alternative materials, and reducing reliance on imported, carbon-intensive inputs [44].

2.3.2. Opportunities for Jamaica: Substitution, Reuse, and Local Materials

Jamaica's heavy reliance on imported construction materials has been recognized in the Vision 2030 National Development Plan as a structural feature of the sector. This not only exposes the country to price volatility and exchange rate fluctuations but also limits opportunities for local value creation and reduces the resilience of supply chains (Vision 2030). Therefore, the use of locally available, low-impact materials can reduce life-cycle emissions while enhancing the efficiency and resilience of material supply chains [27][43].

Among the most relevant alternatives are:

- **Bamboo:** One of the most promising options, already subject to national research by the National Housing Trust (NHT) and international studies. Bamboo is a renewable, lightweight, and strong resource with the potential to support self-construction processes and generate local employment. Recent studies also highlight its role in enhancing community resilience, as it can be integrated into adaptable housing solutions that strengthen food, water, and climate security in vulnerable contexts [45][46]. However, important environmental considerations must be addressed. Certain bamboo species have demonstrated invasive characteristics in Jamaica and other Caribbean territories. Research indicates that bamboo, introduced to Jamaica in the 18th century, has naturalized along river courses, roadways, hillsides, and abandoned agricultural lands, and can colonize watersheds with potential cascading negative impacts on local ecosystems. Common bamboo (*Bambusa vulgaris*) forms extensive monospecific stands that outcompete

native vegetation and has colonized many streams and riparian areas in Jamaica, potentially affecting native stream macro-invertebrates and altering habitat resources. Therefore, any large-scale use of bamboo for construction must include careful species selection, sustainable harvesting practices, and environmental impact assessments to prevent further ecosystem degradation. (132).

- **E-Z Blocks**, is a locally manufactured alternative. These blocks are comprised primarily of cement, trapped air and fibers. Meet standards for resistance to water, fire, mold, termites, and hurricanes. They also offer thermal efficiency and a lower carbon footprint during production [47].
- **Agricultural-based materials**, such as corn fiber, sugarcane bagasse, or coconut husks are also being explored. These materials open up opportunities to develop low-carbon solutions that support circular economy models, structural resilience, and local job creation. Also, are considered technically and environmentally suitable for non-structural applications such as insulation [48].

2.3.3. Reducing Embodied Carbon

One of the most effective strategies to reduce embodied carbon emissions in buildings is the substitution of conventional materials with lower-carbon alternatives, supported by life cycle assessment (LCA) [43]. The Decarbonization Pathways for the Caribbean Construction Industry report presents a case study in Dominica, where multiple design scenarios were modeled for a 60 m² dwelling. Significant reductions in embodied carbon were achieved through three specific measures:

- **66% reduction:** Achieved through redesign and substitution of key building components, including the use of in-situ cast concrete slabs for floors and roofs, cellular concrete blocks for external walls, and gypsumboard on timber frames for internal partitions.
- **74% reduction:** Reached by sourcing cement and steel from countries with lower average embodied carbon emissions, rather than using regionally sourced materials with higher carbon intensity.
- **77% reduction:** Obtained by using green cement, defined as a type of cement that emits at least 20% less carbon than conventional Portland cement [44]

The reference to sourcing cement from countries with lower embodied carbon emissions requires careful consideration of transportation impacts. A comprehensive life cycle assessment should evaluate whether the carbon savings from lower-production emissions offset the additional transportation-related emissions. Local production of cement, particularly blended cements with lower clinker content, represents a more sustainable option when transportation impacts are considered. These products align with performance-based applications and are encouraged by Green Building Rating systems that promote supplementary cementitious materials like fly ash. In Jamaica's context, supporting local cement producers who are innovating toward lower-carbon solutions - such as Cemex's discontinuation of Ordinary Portland Cement (OPC) manufacture and their global "Future in Action" programme - provides both environmental and economic benefits including job creation, industrial resilience, and reduced foreign exchange outflows [15]. (133). Waste-to-Cement initiatives can reduce the carbon footprint of cement production while addressing

Jamaica's solid waste challenges.

These figures highlight the real potential of material selection as a tool for construction sector decarbonization. The focus should not only be on structural efficiency but also on transforming the logic behind procurement and material selection starting from the building design phase.



2.3.4. Structural Resilience to Earthquakes and Extreme Climate Events

Material selection must also comply with standards for structural resistance, durability, and safety, especially in a country like Jamaica, which is exposed to both unusual or extreme climate events and seismic risks. Areas such as Buff Bay and the Blue Mountain region present particularly high seismic risks, with hundreds of seismic events recorded annually according to the UWI Earthquake Unit [49]. Therefore, any innovation in materials or construction techniques must be evaluated for their ability to withstand adverse conditions without compromising structural safety or habitability.

In this regard, it is critical that the national building code incorporates specific requirements for hazard mitigation and climate adaptation. As a result, collaboration between the public sector, private industry, and academia will be essential to strengthen research, innovation, and technical training aimed at the development of climate-resilient materials and construction practices.

2.3.5. National Vision on Materials and Sustainability in Construction

Jamaica's national strategy for the construction sector outlines a series of key directives that support the transition toward a low-carbon and resilient model, with special emphasis on the materials used and their environmental, structural, and economic impacts [50].

Firstly, the strategy identifies high dependence on imported inputs, particularly steel, as a structural weakness. In the case of cement, it also warns of the risk of production being concentrated in a single national supplier. This situation reinforces the need to diversify sources and assess more sustainable and technically and economically viable local alternatives [50].

From an environmental standpoint, the strategy sets clear priorities aimed at improving the sector's sustainability, particularly regarding construction materials. Key priorities include:

- Promoting the reuse and recycling of construction materials.

- Increasing the use of environmentally friendly materials.
- Incorporating contractual requirements to source materials from approved suppliers.
- Encouraging the adoption of international environmental standards, such as ISO 14001, within the construction sector, which would improve impact management throughout the project and material life cycles.
- Reducing the carbon footprint of the construction sector through better life cycle planning of materials [50].

These directives support the use of lower-impact materials and promote circular economy models and supply chain traceability. Moreover, these national priorities align with the strategic directions needed to accelerate the transition toward low-carbon construction practices.

2.3.6. Climate Action Guidelines for Materials and Construction Methods

Jamaica can make significant progress in climate change mitigation by reducing emissions in the construction sector through material substitution, structural redesign, and the use of local resources. However, this transition requires support through progressive substitution policies, incentives for local production, the strengthening of technical standards, and the implementation of training programs for construction professionals.

Accordingly, three strategic fronts are identified to enable this transformation:

- Update of technical standards and enabling codes**

The current regulatory framework requires revision to incorporate sustainability criteria in material selection. It is essential that the National Construction Policy integrates embodied carbon metrics and validation mechanisms for innovative materials such as bamboo or recycled products. Although these solutions require further technical and regulatory research, they

have already been included in pilot projects and enjoy growing academic support, reinforcing their feasibility and relevance for the Jamaican context. The participation of the Bureau of Standards Jamaica and academic institutions will be key to legitimizing and operationalizing these advancements.

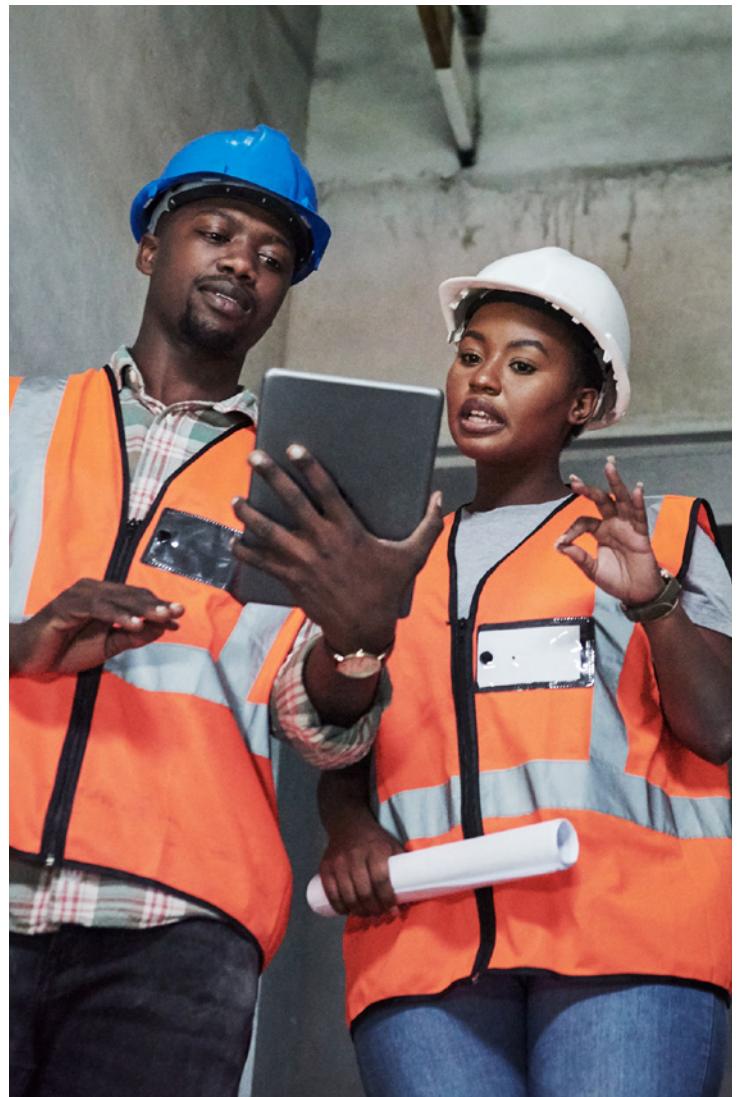
- **Promotion of circular economy in the materials supply chain**

The reuse and recycling of construction materials must evolve from sporadic practices into a structural strategy. This implies creating incentives for material recovery during demolitions and establishing infrastructure for processing. Initiatives such as E-Z Block or the use of agricultural by-products can be integrated into circular economy schemes with clear environmental and economic benefits, especially in urban and peri-urban contexts.

- **Capacity building and technical training**

For these solutions to be effective and scalable, construction professionals, including engineers, architects, technicians, and builders, must have up-to-date knowledge of sustainable materials, low-impact techniques, and environmental assessment tools. It is urgent to include these topics in technical and university-level training programs and to promote pilot projects and public-private partnerships that validate and disseminate best practices tailored to the Jamaican context.

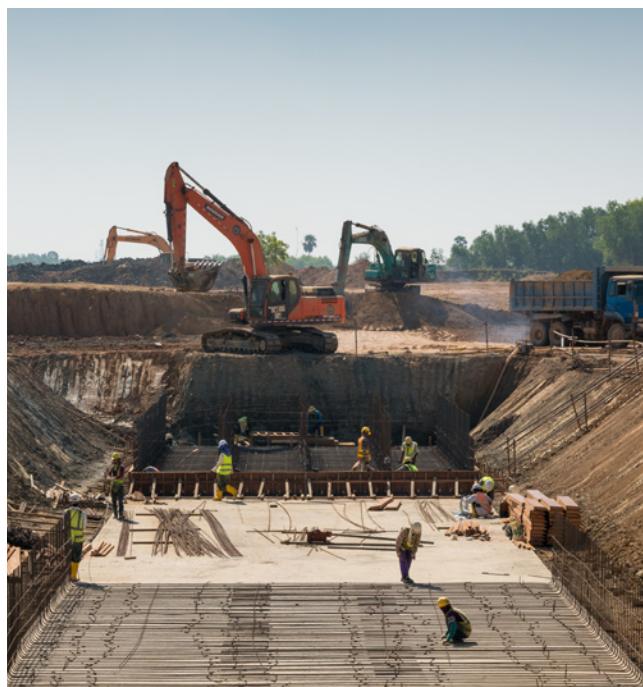
The effective implementation of these action lines will depend on strong intersectoral coordination, political will, and adequate financing. Jamaica has the resources, knowledge, and emerging initiatives which, when integrated under a clear strategy, can transform the environmental profile of the construction sector and strengthen its climate resilience.



2.4. Pillar 4. Operational Carbon Reduction

Reducing emissions directly related to a building's use phase is known as operational carbon reduction. This includes the energy used for water heating, ventilation, lighting, cooling, and appliance operation. The monitoring, optimization, and active management of energy use and emissions throughout a building's operational life cycle are the specific focus of this pillar, even though it overlaps with strategies related to electrification and energy efficiency [27].

Large-scale buildings like hotels, hospitals, shopping malls, and institutional buildings are best suited for this strategy, but residential housing and larger urban contexts, such as neighborhoods and peri-urban areas, should also use it. To make sure that buildings' energy use is effective, predictable, and in line with climate goals once they are occupied, operational carbon must be measured and reduced.



In order to facilitate continuous performance tracking for **new developments**, it is advised that projects integrate monitoring and control systems from the design stage. This includes smart meters, temperature and motion sensors, and building automation systems (BMS) that dynamically adjust equipment operation based on occupancy and weather conditions. According to a study that monitored a high-performance tropical building, BMS contribute significantly to reducing operational energy by adapting equipment use in response to external conditions and occupancy patterns [51]. To estimate and optimize future energy use, new buildings should also use predictive energy modeling during architectural design and strive for certifications that take operational carbon into account, like LEED or EDGE [44]. For example, the EDGE certification system, incorporates operational energy as a central metric and allows buildings to compare projected energy savings and carbon emissions reductions through dynamic design adjustments [52].

Besides, retro-commissioning and routine energy audits are crucial for **existing buildings**. These enable operators to pinpoint inefficiencies, adjust systems, and maximize energy consumption. For instance, older HVAC systems frequently

perform inefficiently if they are not properly maintained or if the controls are not sensitive to changes in demand. High-consumption institutional and commercial buildings should be the focus of a nationwide retro-commissioning program, with a focus on those located in crowded cities where the combined effect can be most significant. The 2024/2025 Global Status Report for Buildings and Construction highlights the importance of optimizing existing buildings to accelerate emission reductions at scale and notes that energy retrofits in high-density urban areas offer the highest potential returns [27].

For **residential communities**, digitalizing electricity consumption can help reduce operational carbon at the local level. Smart meter distribution programs would enable households to track usage in real time, pinpoint periods of peak demand, and modify behavior accordingly. Mobile applications that offer straightforward indicators of energy use and efficiency to assist users in making informed decisions, as well as public energy education campaigns that are suited to both urban and rural contexts, should complement these efforts [28]. Jamaica has made significant progress in smart meter deployment, with the Jamaica Public Service Company (JPS) reporting that over 75% of its customers (approximately 520,000 meters) can now be remotely connected using smart meters as of January 2025. This J\$14 billion investment over nine years has resulted in customers' ability to track their electricity usage

on a daily or hourly basis through the MyJPS Mobile App. Customers with smart meters can view their projected electricity bill for the month based on current usage trends, and can convert between prepaid and postpaid service without meter changes due to smart meters' dual functionality. The smart meter infrastructure also enables faster service reconnection without physical site visits, significantly improving customer experience and operational efficiency. (134).

Operational carbon emissions reduction in the larger urban context necessitates improvements to **public services and shared infrastructure**. For example, in cities, street lighting uses a lot of energy, and studies indicate that switching to LED lighting with motion sensors and remote controls can reduce electricity use by 30% to 50% compared to conventional systems. Additionally, energy optimization at the neighborhood or community level is made possible by the installation of energy management systems in public buildings, educational institutions, and medical facilities. Municipal ordinances and high-profile pilot projects that facilitate learning and replication should be used by local governments to spearhead these changes [53].

2.4.1. Key fronts of action to reduce Jamaica's Built environment Operational Carbon

Reducing operational carbon in Jamaica's buildings is essential to meeting the country's climate mitigation goals and ensuring a resilient built environment. The opportunities span from integrating smart technologies in new buildings to upgrading existing infrastructure and empowering users through education and data access. These changes require coordinated regulatory frameworks, capacity development, and innovation financing.

Three key fronts should guide action to reduce Jamaica's built environment operational carbon footprint:

2.4.1.1. Integrated energy monitoring from design

Building codes and permitting systems should mandate the inclusion of digital energy monitoring and control systems in all new public buildings, as well as in large-scale commercial developments. These requirements should be supported by technical guidelines and incentives for early adoption. Energy monitoring requirements should also extend to large-scale housing developments, particularly the increasing number of large apartment buildings in urban areas. These multi-family residential buildings have shared energy systems that present significant opportunities for operational carbon reduction through centralized monitoring and management systems. Smart building technologies can optimize shared services such as lighting in common areas, elevator operations, water heating systems, and centralized HVAC systems, leading to substantial energy savings across multiple residential units.

2.4.1.2. Nationwide retro-commissioning program

A national initiative targeting high-consumption buildings, especially in urban areas, would generate substantial energy savings and emissions reductions. The program should include audits, technical assistance, and funding mechanisms to facilitate implementation.

2.4.1.3. Local-level digitalization and behavioral change

Smart meter deployment must be paired with accessible information tools and public campaigns that enable users to understand and act upon their energy data. Partnerships with energy providers and community organizations can facilitate outreach and adaptation to local realities. This will require strengthening the role of subnational authorities by being in closer contact with the population, enabling more effective implementation of energy efficiency programs and building stronger community engagement in sustainable energy practices.

2.5. Pillar 5: Enabling regulatory frameworks and financial incentives

In order to speed up and scale up the transformation of Jamaica's built environment toward a low-carbon and climate-resilient pathway, the fifth pillar focuses on financial incentives and enabling regulatory frameworks. Although technical decisions determine the adoption of sustainable technologies and practices, the structural conditions established by the nation's financial ecosystem and policy play a major role in determining their large-scale viability [27].

From a regulatory perspective, it is advised that Jamaica amend its Building Codes to incorporate mandatory sustainability standards. This would include:

- Minimal standards for energy efficiency,
- Provisions for solar readiness before system installation,
- Use of low-carbon construction materials, and
- Standards for climate resilience, particularly in areas highly exposed to extreme weather events.

With the above, in the Vision 2030 Jamaica explicitly underscores the importance of enhancing the policy and regulatory framework, promoting adherence to environmental legislation, and embedding energy conservation and efficiency principles in the planning, design, and implementation of construction projects. These national directives align with and reinforce the recommended updates to building codes and sustainability standards [50].

2.5.1. Instruments of Finance

Increasing the variety of financial tools available for sustainable projects is essential. These instruments include: green credit lines for small and medium-sized businesses (SMEs) and households, schemes for energy leasing, revolving funds for improvements in efficiency, and the issuance of green bonds by infrastructure developers [43]

Vision 2030 also highlights the need for improved access to development financing at competitive rates, particularly for micro-, small-, and medium-sized enterprises (MSMEs), and addresses financial constraints caused by high costs of performance bonds and delayed contractor payments. In this regard, Jamaica may explore introducing a lien law as proposed in Vision 2030, to improve legal recourse and financial liquidity in the construction sector [50].

The adoption of climate finance taxonomies by commercial banks that prioritize investments in resilient and low-carbon buildings should be encouraged. To scale up green financing, it is advised that the Bank of Jamaica and the Financial Services Commission collaborate with financial institutions to establish shared standards, supported by multilateral partners such as the IDB or IFC.

The Development Bank of Jamaica has established a comprehensive climate financing mechanism through its Blue Green Facility, a blended financing structure of up to USD \$500 million over five years. This follows DBJ's accreditation to the Green Climate Fund (GCF) in 2023, making it the largest GCF accreditation in the Caribbean and granting access to over \$250 million for large-scale climate projects. The facility specifically supports green building initiatives through: (135).

- Green loans and grants for climate-related building projects.
- Equity financing for climate action initiatives
- Special emphasis on community-based projects to ensure small organizations can benefit.
- Energy loans up to \$40 million at competitive rates (11.5% interest rate).
- Support through the Gemini Programme for business plan development and application assistance.

Jamaica benefits from a US\$764 million Resilience and Sustainability Facility (RSF) arrangement approved by the International Monetary Fund's Executive Board in

March 2023. This facility supports reforms to strengthen Jamaica's physical and fiscal resilience to climate change, advance decarbonization of the economy, and manage transition risks. Several Reform Measures have already been completed by the Planning Institute of Jamaica (PIOJ), Bank of Jamaica (BOJ), and Ministry of Finance and the Public Service (MOFPS), creating a supportive policy environment for green building initiatives. (135)

International Climate Finance Access: Jamaica also has access to additional climate finance mechanisms including: (135)

- Green Climate Fund (GCF): Through DBJ's accreditation, Jamaica can access significant GCF resources for building sector climate projects
- Adaptation Fund: Available for climate adaptation projects that can include climate-resilient building design and infrastructure
- Caribbean Community Centre on Climate Change and University of Oxford partnership: Providing up to £1 million in UK funding for climate resilience investment frameworks and project pipeline development

It is also suggested to create a National Public Infrastructure Decarbonization Fund focused on institutional buildings. This fund would support high-impact interventions in hospitals, schools, and administrative facilities, mobilizing both domestic and international contributions. A results-based co-financing mechanism could be introduced to link disbursements to verified emissions reductions and energy savings, thereby accelerating low-carbon modernization of public infrastructure.

The fund could be capitalized through multiple sources like **Government Budget Allocation**: Direct allocation from Jamaica's national budget, potentially funded through green bonds or climate finance. **International Climate Finance**: Blended financing combining resources from the Green Climate Fund, World Bank, Inter-American Development Bank, and bilateral donors. **Carbon Credit Revenue**: Income from carbon offset projects and emissions trading mechanisms. **Private Sector Co-financing**: Public-private partnerships where private investors contribute to infrastructure projects with long-term returns

International Examples:

- **Costa Rica's FONAFIFO**: The National Forest Finance Fund successfully combines government resources, international climate finance, and private sector contributions for environmental projects. (136)
- **South Africa's Green Fund**: Capitalized with government and international donor resources, supporting green economy projects including energy efficiency. (137)
- **Mexico's National Housing Commission (CONAVI)**: Provides subsidies for sustainable housing with financing from government and multilateral development banks. (138)

Given Jamaica's existing institutional framework including the DBJ's climate finance capabilities, established relationships with international development partners, and existing national funds structure, a National Public Infrastructure Decarbonization Fund is feasible. The success of existing programs like the DBJ's Blue Green Facility demonstrates institutional capacity for managing large-scale climate finance initiatives.



2.5.2. Neighborhood and Urban Development

To encourage sustainable development at the urban level, local governments require enhanced financial and legal capacities. This includes the ability to issue green municipal bonds, access adaptation and mitigation financing, and create urban incentives for green-certified developments, such as increased density allowances.

It is equally important to strengthen climate-sensitive land use planning, ensuring that zoning, density, and mobility regulations support sustainable construction. Local governments must be empowered through regulations that promote sustainable materials and innovative construction methods to foster climate-resilient urban development.

2.5.3. Integration of Nature-Based Solutions:

Sustainable urban development should incorporate nature-based solutions (NbS) that provide multiple environmental and social benefits while supporting climate mitigation and adaptation goals. These include:

- **Urban Green Infrastructure:** Parks, green corridors, and urban forests that sequester carbon, provide cooling, and manage stormwater.
- **Green Roofs and Walls:** Vegetation systems that reduce building energy consumption, manage rainwater, and improve air quality.
- **Constructed Wetlands:** Natural systems for wastewater treatment that reduce energy requirements compared to conventional treatment methods.
- **Permeable Surfaces:** Reducing stormwater runoff and urban heat island effects while supporting groundwater recharge.
- **Urban Agriculture:** Community gardens and rooftop farming that reduce food transportation emissions and strengthen community resilience.

Nature-based solutions could be integrated into green certification schemes and municipal incentive

programs, with financing available through the DBJ's Blue Green Facility and other climate funds. It is equally important to strengthen climate-sensitive land use planning, ensuring that zoning, density, and mobility regulations support sustainable construction. Local governments must be empowered through regulations that promote sustainable materials and innovative construction methods to foster climate-resilient urban development.

2.5.4. Coordination of Institutions

Finally, the establishment of a national inter-institutional platform for green building promotion is recommended. This platform would convene ministries, regulatory bodies, local authorities, financial institutions, developers, and academic actors [43]. Its mission would be to coordinate multi-stakeholder efforts, monitor implementation progress, propose regulatory adjustments, and serve as a channel for climate finance and technical cooperation. Such an initiative is in direct alignment with Vision 2030's call for collaboration between the construction sector, public agencies, academia, and international partners, as well as increased investment in research and development for building technologies.

2.5.4.1. Leadership and Institutional Framework for National Platform:

Lead Agency: The Ministry of Science, Energy, Telecommunications and Transport (MSETT) would be the logical lead agency, given its mandate over energy policy, renewable energy development, and building energy standards. MSETT already leads Jamaica's renewable energy transition and climate change mitigation efforts in the building sector. The platform's establishment should be underpinned by:

- **Policy Framework:** Integration into Vision 2030 National Development Plan updates and the National Energy Policy.
- **Legislative Support:** Provisions within the Electricity Act 2015 and potential amendments to the Building Code.
- **Regulatory Authority:** Clear mandate through Cabinet decision and coordination with Office of Utilities Regulation (OUR).

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Potential Multi-Agency Structure:

- **Chair:** Ministry of Science, Energy, Telecommunications and Transport.
- **Co-chair:** Ministry of Housing, Urban Renewal, Environment and Climate Change.
- **Core Members:** Bureau of Standards Jamaica (BSJ), National Environment and Planning Agency (NEPA), Development Bank of Jamaica (DBJ), Jamaica Public Service Company (JPS), Office of Utilities Regulation (OUR).
- **Technical Partners:** University of the West Indies, private sector associations, local authorities.

The establishment of a national inter-institutional platform faces legitimate challenges requiring proactive solutions. Jamaica's agencies—including NEPA, BSJ, Ministry of Housing, Ministry of Energy, and local authorities—have historically operated independently with limited collaboration, necessitating a clear value proposition that demonstrates how collaboration enhances rather than diminishes each agency's effectiveness, defined roles and responsibilities to minimize territorial conflicts, and incentive structures linking performance metrics to collaborative outcomes.

Where mandates overlap in areas like building codes, zoning, and energy standards, territorial behaviors can be mitigated through neutral convening by MSETT with Cabinet-level mandate, voluntary pilot projects demonstrating mutual benefits, and focused technical working groups. Private sector concerns about additional bureaucracy must be addressed by streamlining processes to eliminate duplicative approvals and create "one-stop-shop" permitting for green buildings, providing clear pathways to DBJ Green Facility financing and tax incentives, and offering capacity-building programs that help developers navigate requirements efficiently. The platform's success ultimately depends on demonstrating tangible benefits from the outset, including reduced permitting timeframes, improved access to climate finance, and enhanced technical support for both public and private sector participants.





Chapter 3. Strategies for Climate Change Adaptation in Buildings in Jamaica

Jamaica faces significant challenges related to climate change, with increasing frequency of climate-related natural events positioning Jamaica among the three most exposed countries in the world to multiple natural hazards. Furthermore, it ranks as the country with the second-highest economic risk exposure to two or more threats, affecting 96.3% of the national population and 94.9% of the national territory [54][55].

Climate threats to Jamaica, in other words, the expected probability and/or intensity of adverse climatic conditions for the island, have been identified according to the most frequent natural disasters and their impacts on the population. Various studies highlight those developed by the Disaster Risk Management Knowledge Centre (DRMKC) and Climate Change Knowledge Portal, which place storms and cyclones first, followed by floods, as well as droughts and landslides [56][57][58].

3.1. Community-Based Adaptation: Localizing Climate Resilience in Jamaican Communities

As a small island developing state, Jamaica's communities face direct and escalating climate impacts that require locally-tailored adaptation strategies. The increasing intensity of hurricanes, sea-level rise with associated coastal erosion, saline intrusion into agricultural soils and freshwater aquifers, declining average precipitation, and increasingly erratic rainfall patterns pose serious threats to community livelihoods, key socio-economic sectors, and critical ecosystems. These climate stressors demand adaptation approaches that are grounded in local knowledge, community participation, and ecosystem-based solutions. (139)

Jamaica faces significant land tenure challenges that affect community-based adaptation effectiveness, particularly in informal and lower-income communities. According to UN-Habitat's Participatory Slum Upgrading Programme (PSUP), over 20% of Jamaica's population lives in informal settlements, with 82% of these communities located in urban areas. In North Gully, Montego Bay, residents experienced severe flooding in November 2017, with water levels

exceeding 3.5 meters, washing away houses. The Programme notes that “secure housing and living conditions and, above all, creating incentives and jobs for the young will help to improve the area” while emphasizing that tenure security is essential for residents to invest in long-term adaptation measures. (140)

The Portland Bight Protected Area exemplifies the critical intersection of biodiversity conservation and community resilience. This region contains some of Jamaica’s most valuable coastal ecosystems, including the best remaining examples of coastal dry forest, the longest contiguous mangrove coastline in the country, and essential fish nurseries. However, the communities of Old Harbour Bay, Hellshire, and Salt River—representing more than 20,000 residents—face high risks from hurricanes, floods, fires, and tsunamis. Climate change compounds these risks by causing ecosystem degradation, habitat loss, and the deterioration of crucial ecosystem services such as coastal protection, aquifer recharge, soil erosion control, and natural forest regeneration. (141)

Community-Based Adaptation projects address these challenges by building local capacity to manage ecosystems sustainably while adapting to changing climate conditions. Through participatory workshops and training programs, communities develop enhanced awareness of their environmental resources’ economic value and learn to implement sustainable ecosystem management practices alongside climate-adaptive alternatives. This approach ensures that adaptation strategies are not only technically sound but also culturally appropriate and economically viable for local populations. (141)



For Jamaica’s broader climate adaptation strategy, the CBA model offers valuable lessons for scaling community-level resilience across the island. By integrating traditional ecological knowledge with modern climate science, supporting community-led conservation initiatives, and strengthening local institutional capacity, Jamaica can build a more resilient foundation for climate adaptation that protects both human communities and the natural systems upon which they depend.

Considering the potential impact of natural disasters on the country, it is important to improve climate change adaptation strategies and resilience in the construction sector. The adaptation pillars have been selected considering:

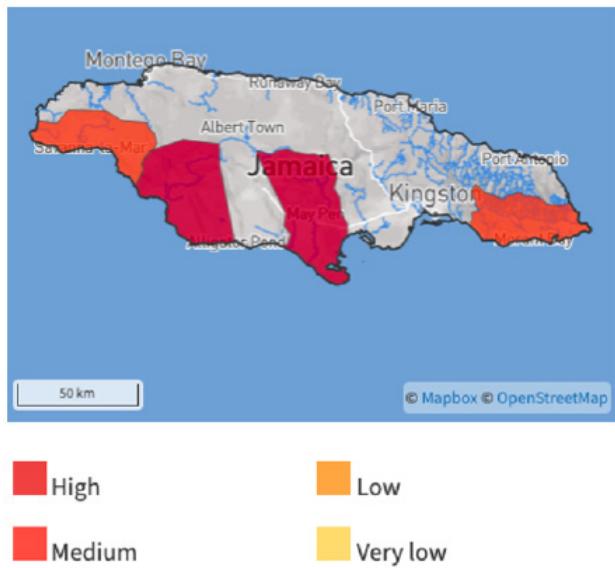
- **Climate relevance:** Direct correlation with identified threats in Jamaica.
- **Technical feasibility:** Availability of applicable technologies and knowledge.
- **Potential impact:** Capacity to significantly reduce vulnerability.
- **Systemic integration:** Synergy between different adaptation strategies.
- **Community base adaptation:** Communities awareness.
- **Scalability:** Applicability from individual buildings to territorial planning.

3.2. Pillar 1: Tropical Cyclones and Floods

Jamaica's location in the Caribbean Basin places it within the Atlantic Hurricane Season, which extends from June 1 to November 30. During this period, the country experiences tropical cyclones that are classified by intensity on the Saffir-Simpson Hurricane Wind Scale, which categorizes hurricanes from Category 1 (weakest) to Category 5 (strongest) [24]. (142) The country has also faced prolonged rainfall episodes exceeding two days, associated with 67% of severe flooding events, where 46% of these originate from hurricanes and tropical depressions. These intense rainfall events during tropical storms have increased, posing a high flood risk to both coastal and urban areas. Precipitations can exceed 200 mm in 24 hours during extreme events, while coastal areas are further threatened by storm surges that can reach 3-5 meters above normal sea level [57][59][60]. The most common impacts include direct structural damage from inundation or wave action, erosion, sedimentation and flood-borne debris, degradation of building materials during or after the event, and contamination of the building due to flood-borne substances or subsequent mold growth [61].

Consistent with these dynamics, **coastal flood hazard** in Jamaica is classified as high, this means that potentially damaging waves are expected to flood the coast at least once in the next ten years (Figure X). The areas at highest risk include Saint Elizabeth and Clarendon (highlighted in red), followed by Westmoreland and Saint Thomas (in orange).

Figure 3. Coastal flood hazard classification for Jamaica.



Source: This map illustrates the modeled classification of coastal flood hazard across Jamaica. According to ThinkHazard! (GFDRR), Saint Elizabeth and Clarendon face high hazard levels (in red), indicating a significant probability of damaging coastal floods within the next decade. Westmoreland and Saint Thomas show medium level, while eastern and north-central parishes display low to very low hazard levels. Source: ThinkHazard! – Global Facility for Disaster Reduction and Recovery (GFDRR). Available at: <https://www.thinkhazard.org/en/report/123-jamaica/CF>.

Simultaneously, **sea level rise** is a significant effect of climate change and global warming, acting as a threat multiplier, directly affecting Jamaica's coastal infrastructure and ecosystems. It results from several processes including ongoing melting ice sheets, thermal expansion of seawater, vertical land motion, and changes in terrestrial water storage. As climate change intensifies, these processes are expected to accelerate. In Jamaica, observations indicate an annual increase of 1.66 millimeters, with a projected total of sea level rise of 0.87-0.9 meters by the end of the 21st century [62].

Consequently, the impact of sea level rise and intensified storm surge is expected to be at a high level for Jamaica, with 29% of the coastal population exposed, and potential coastal GDP losses projected to exceed 27%, and the consequences depending on local conditions and driven by location specific responses from contributing processes.

Jamaica has comprehensive downscaled climate projections available through the State of the Jamaican Climate report series produced by the Climate Studies Group, Mona (CSGM) for the Planning Institute of Jamaica (PIOJ). These reports provide detailed information on observed climate variability and future climate scenarios specifically for Jamaica. The State of the Jamaican Climate Volume III (2019) provides updated climate projections showing that Jamaica's average temperature is projected to increase by 0.65-0.84°C by the 2030s, while rainfall levels will decrease by up to 9% in the 2050s. The report projects an 80% increase in Category 4 and 5 hurricanes, with sea level rise projected between 0.26-0.82 m by 2100. (143)

For the development of improvements, the infrastructure sector has been evaluated, revealing critical vulnerabilities in Jamaica [64]. Successful implementation of climate adaptation strategies requires adopting a risk-based classification system that organizes buildings into categories according to their importance and exposure to natural hazards. In accordance with the 2023 Jamaica Building Code (JBC) [65], buildings are classified into the following categories (Table X):

Table 3. Classification of Buildings by Risk Category. Based on the Jamaica Building Code (JBC) 2023, Chapter 16.

Risk Categories of Buildings

Risk Category	Description	Examples	Structural Requirement Level
I	Buildings with low hazard to human life in the event of failure	Agricultural facilities, minor storage buildings, temporary structure	Low
II	All buildings not classified under Categories I, III, or IV	Standard residential buildings, offices, small retail, hotels	Moderate
III	Buildings that pose a substantial hazard to human life in the event of failure	Schools (with >500 students), assembly buildings (>300 people), utilities (not critical), large occupancies	High
IV	Buildings essential for post-disaster recovery or containing hazardous materials	Hospitals, fire and police stations, shelters, power plants, aviation towers, critical national defense sites	Very High

Beyond the provisions of the JBC, exist adaptation strategies based on scientific evidence and international best practices that can significantly strengthen resilience against these interconnected climate hazards, as the following.

3.2.1. Multi-hazard Early Warning Systems

According to the Office of Disaster Preparedness and Emergency Management (ODPEM), the natural tsunami warning signs to look for in Jamaica are a strong earthquake, a loud ocean roar, and the ocean receding unusually far, which indicates the imminent arrival of a dangerous wave. If any of these signs are observed, individuals should move inland or to higher ground immediately, as there is no official tsunami warning system in place to alert the public to an approaching threat. (144) For fluvial (river) flooding, Jamaica has developed some early warning capacity through the Improving Climate Data and Information Management Project (ICDIMP), completed in 2022. This project, funded by the Climate Investment Funds through the World Bank, installed a network of 35 automatic weather stations for the Meteorological Service of Jamaica (MSJ) and 55 hydro-meteorological stations for the Water Resources Authority (WRA). These stations enhance Jamaica's capacity to monitor weather patterns and issue flood warnings. (145)

A 2023 assessment by the United Nations Office for Disaster Risk Reduction (UNDRR) on Multi-Hazard Early Warning Systems' Capacities in the Caribbean Region indicates that while Jamaica has made progress in developing MHEWS Multi-hazard early warning systems infrastructure, significant gaps remain in governance, disaster risk knowledge, forecasting, monitoring and detection, warning dissemination, and response capability across geological, hydrometeorological, environmental, biological, chemical, and technological hazards. (146)

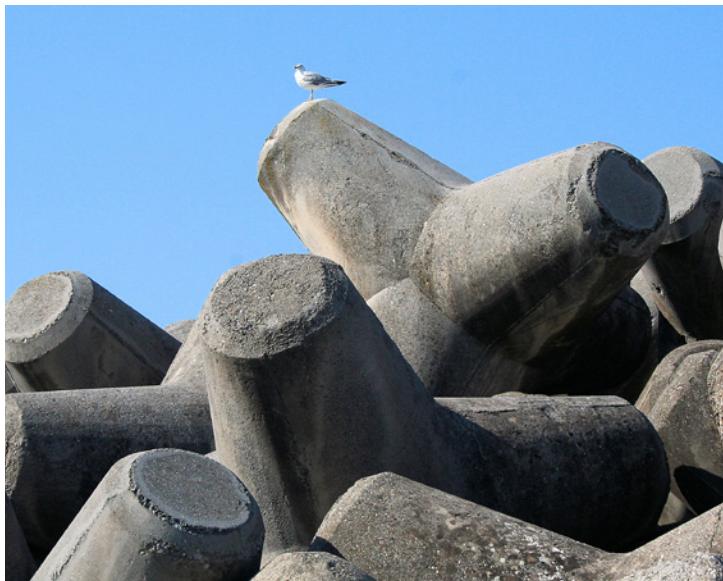
3.2.1.1. Assessment of the Four Integrated Components:

Jamaica's MHEWS (Multi-hazard early warning systems) capacity assessment across the four pillars reveals: (147)

- 1. Risk Knowledge:** Jamaica has improved climate data collection through ICDIMP, with disaster risk management plans developed for all parishes in partnership with ODPEM and municipalities. However, comprehensive risk mapping for multiple hazards at the community level remains incomplete.

- 2. Observations & Forecasting:** The meteorological and hydrological observation network has been significantly upgraded with new automated stations. However, tsunami detection capabilities are absent, and coastal inundation forecasting systems are limited.
- 3. Warning Dissemination & Communication:** Jamaica benefits from high mobile broadband penetration (95% of population can access mobile networks), providing infrastructure for warning dissemination. However, standardized communication protocols for all hazards are still under development.
- 4. Preparedness to Respond:** ODPEM coordinates disaster response at the national level, with parish-level disaster coordinators. However, community-level preparedness and response capacity varies significantly, particularly in informal settlements.

Effective systems require four integrated components that address compound climate risks: comprehensive risk knowledge that accounts for tropical cyclone tracks, rainfall patterns, and coastal flooding; robust detection and forecasting capabilities that predict storm intensity, precipitation volumes, and storm surge heights; official communication systems that provide actionable warnings for evacuation, infrastructure protection, and emergency response; and prepared community response capacity that enables coordinated action across multiple hazards [67].



3.2.2. Nature-Based Solutions for Multi-Hazard Protection

and forecasting capabilities that predict storm intensity, precipitation volumes, and storm surge heights; official communication systems that provide actionable warnings for evacuation, infrastructure protection, and emergency response; and prepared community response capacity that enables coordinated action across multiple hazards [67].

Nature-based solutions provide multi-layered protection against the full spectrum of tropical cyclone impacts while addressing long-term sea level rise adaptation. These systems offer adaptive protection that strengthens over time, unlike static infrastructure that degrades under repeated climate stress [68]. While nature-based solutions may require significant initial investment and time for establishment, they typically prove more cost-effective than conventional infrastructure over the long term, providing ongoing protection while delivering multiple co-benefits including biodiversity conservation, carbon sequestration, and ecosystem services that conventional infrastructure cannot match.

Coastal Defense Integration. Mangrove-coral reef systems provide different ecosystem services such as regulating, provisioning, cultural and supporting. As regulators coral reefs and mangroves provide different benefits (Table X).

Table 4. Ecosystem benefits according to regulatory function of Coral Reefs and Mangroves.

Coastal Defense Benefits by Coral Reefs and Mangroves	
CORAL REEFS	MANGROVES
PROTECTION OF BEACHES AND COASTLINES FROM STORM SURGES AND WAVES	PROTECTION OF BEACHES AND COASTLINES FROM STORM SURGES AND WAVES
REDUCTION OF BEACH EROSION	REDUCTION OF BEACH EROSION
FORMATION OF BEACHES AND ISLANDS	STABILIZATION OF LAND BY TRAPPING SEDIMENTS
	WATER QUALITY MAINTENANCE
	CLIMATE REGULATION

Mangroves can reduce wave energy by up to 75% when passing through 200 meters of mangrove forest, while coral reefs absorb 70-90% of wind-generated wave energy, depending on their physical and ecological characteristics. The implementation requires establishing integrated coastal management programs that include marine protected areas, restoration of degraded ecosystems by eliminating stress causes, and adaptive monitoring to improve resilience. For reefs, natural recovery can take decades (10-50 years), while mangrove restoration is relatively simpler and can involve direct planting of propagules or nursery cultivation [69][70].

Jamaica – like much of the Caribbean region – is at high risk from coastal hazards due to its exposure to tropical storms, high levels of coastal development, and vulnerable coastal communities. **Mangrove** forests in Jamaica suffer two distinct environmental problems, namely habitat loss and/or a decline in biodiversity and poor health of mangrove ecosystems. The net loss over the last five years of only 16.9 hectares or 0.1% of the 13,784 hectares of mangrove areas, as assessed by the recent Forestry Department reports, conceals the fact that the health status of many mangrove areas has been deteriorating. Between 2017 and 2021 another 19.6 ha was lost while 2.7 ha were regained through restoration initiatives. [30]. (148).

Jamaica has 1,240 km² of coral reef with approximately

64 hard coral species, 43 soft coral species, and 8 black coral species. Fringing, patch and barrier reefs surround just over 50% of Jamaica's shoreline within 50 meters from shore. (149) Recent reports indicate severe impacts from mass coral bleaching events. In 2023, almost all Caribbean corals, including those in Jamaica, experienced complete bleaching with most corals dying. In Negril, Jamaica, corals bleached and died within a week. A comprehensive search for coral survivors is underway across Jamaica, led by conservation organizations, with survivors being mapped and fragments transplanted to nurseries at sites with cleaner water quality. (150)

NEPA launched its inaugural "Coral Reef Awareness Month" in September 2025 to prevent further degradation. The initiative includes assisted fertilization through the CoralCarib Project, implemented across Jamaica, Cuba, Haiti and the Dominican Republic, focusing on collecting gametes from three threatened coral species to help replenish Jamaica's reefs (151).

Urban Flood Management. Green infrastructure systems also address the intense rainfall associated with extreme weather events while managing urban heat and air quality co-benefits. Green roofs and bioswales can reduce flood damages, with green roofs showing significantly higher effectiveness, green roofs scenarios would save 32% of the flood damages to buildings and infrastructures every year, while bioswales help

save only 0.1%. Moreover, green roofs implementation provides larger benefits in the future climate scenario demonstrating their value for climate adaptation planning [7].

Watershed-scale solutions including restored floodplains, riparian buffers, and wetlands provide flood attenuation for communities affected by extreme precipitation events, while improving water quality and supporting biodiversity recovery. Floodplain reconnection involves removing levees, or setting them back from the river, to allow for a wider natural floodplain where the river waters can go during flood events and restoring hydrological connectivity. These changes improve the distribution of river sediment and organic matter, which not only helps manage flooding but also improves the river's water quality. Conserving and restoring riparian buffers and natural lands adjacent to streams and rivers reduces flooding by providing trees and other vegetation that collect rainfall and absorb it in roots and soil, slowing the rise of floodwaters [72].

3.2.3. Integration with Building Framework

When integrating nature-based solutions with building design for flood and cyclone protection, the following structural considerations are critical [34] [35] [36]: (152) (153) (154)

- 1. Foundation Design in Coastal Zones:** Buildings located behind or near mangrove restoration areas must account for soil conditions typical of coastal wetlands. These soils often have high water content, low bearing capacity, and high salinity. Deep pile foundations or elevated structures may be required to ensure stability.
- 2. Wind Load Considerations:** While mangroves and coastal vegetation reduce wind speeds, buildings must still be designed to withstand cyclonic winds as specified in the Jamaica Building Code. Vegetation provides supplementary protection but cannot replace structural wind resistance measures.
- 3. Flood-Resistant Construction:** Buildings in areas protected by nature-based flood management systems should incorporate flood-resistant materials and design features including: elevated

first floors above projected flood levels (accounting for sea level rise projections), use of water-resistant materials for foundations and lower walls, installation of backflow valves in plumbing systems, and proper anchoring to prevent flotation during flood events.

- 4. Drainage Integration:** Building drainage systems must be designed to work synergistically with green infrastructure. This includes proper grading to direct runoff toward bioswales or rain gardens, sizing of downspouts and gutters to handle intense tropical rainfall, and connection to permeable surfaces or infiltration systems.
- 5. Green Roof Structural Loads:** Buildings designed with green roofs must account for additional dead loads from growing medium and vegetation (typically 70-150 kg/m²), saturated weight conditions during and after heavy rainfall, and live loads for maintenance access. Structural frames must be designed accordingly from the initial planning phase.

The multi-hazard early warning systems and nature-based solutions presented complement JBC specifications to create comprehensive protection that addresses tropical cyclone, flood, and sea level rise impacts through both individual building resilience and territorial adaptation approaches.

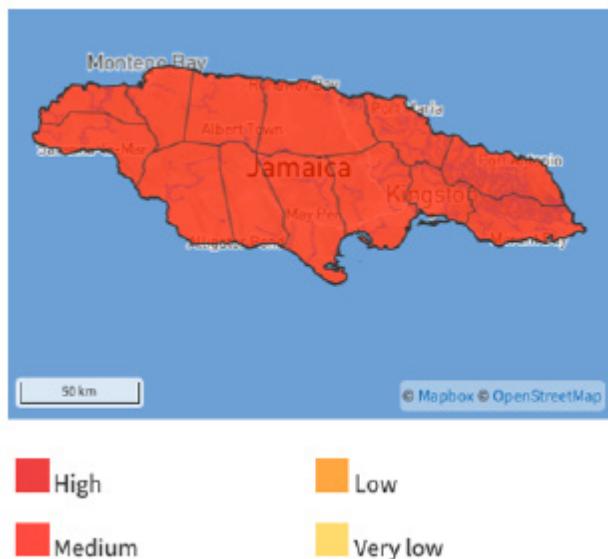


3.3. Pillar 2: Heat and Drought Resilience

Jamaica faces a growing thermal challenge due to rising average temperatures, increased frequency and intensity of heatwaves, and prolonged droughts. Projections under a business-as-usual scenario (RCP 4.5) estimate an increase in mean temperature of approximately 1.54°C by 2100 compared to the 1986–2005 baseline [62]. These climatic shifts heighten thermal stress, affect indoor comfort, and put additional pressure on water resources and cooling demand. Drought periods now extend for 6 to 8 months, reducing water availability and the cooling capacity of local ecosystems [63][74].

According to ThinkHazard! (GFDRR), Jamaica is classified as having a medium hazard level for extreme heat. This indicates that there is more than a 25% probability that all the country will experience at least one prolonged period of heat exposure leading to heat stress in the next five years. Notably, this level of risk applies throughout the island, reinforcing the urgency of designing buildings capable of maintaining thermal comfort without reliance on energy-intensive cooling systems (Figure X).

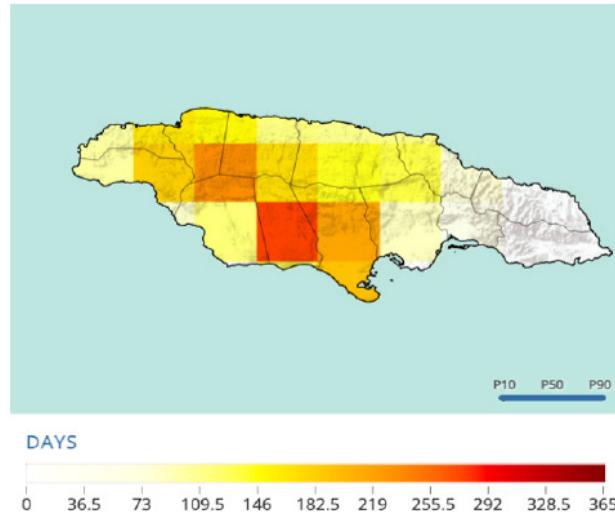
Figure 4. Extreme heat hazard classification for Jamaica



Source: Medium hazard = >25% chance of prolonged heat exposure in next 5 years. Source: ThinkHazard! – Global Facility for Disaster Reduction and Recovery (GFDRR). Available at: <https://www.thinkhazard.org/en/report/123-jamaica/EH>

Additional projections offer localized insights into Jamaica's exposure to sustained thermal conditions. Under the SSP5-8.5 high-emission scenario, the annual number of hot days ($T_{max} > 30^{\circ}\text{C}$) is projected to reach:

Figure 5. Projected number of hot days ($T_{max} > 30^{\circ}\text{C}$) per year in Jamaica under SSP5-8.5 scenario



Source: Projected number of hot days ($T_{max} > 30^{\circ}\text{C}$) per year in Jamaica under SSP5-8.5 scenario (2020–2039 period, 50th percentile).

In Jamaica's south-central region are projected to face a high frequency of extreme heat days. Specifically: Manchester (246 hot days per year), Clarendon (205 days), and Saint Elizabeth (160.0 days). Source: Climate Change Knowledge Portal, available at: <https://climateknowledgeportal.worldbank.org/country/jamaica/heat-risk>.

In light of these projections, to respond to this scenario, the building sector must adopt climate-adaptive strategies that improve thermal comfort while reducing dependence on air conditioning systems and potable water use. Given the frequency and intensity of extreme heat events, passive and low-energy design approaches become essential especially in vulnerable communities and regions already experiencing high heat exposure and limited access to reliable energy infrastructure.

3.3.1. Bioclimatic Design

Effective bioclimatic design is a foundational approach to thermal adaptation. It provides benefits from integrating local climate knowledge and natural elements, such as solar path and wind directions, into the architectural design to reduce indoor heat gains and promote natural cooling.

For this purpose, seven fundamental principles have been identified for the Caribbean region [75]:

- Strategic orientation for solar protection, particularly minimizing east and west exposure to reduce direct heat gains.

- Natural interior ventilation aligned with prevailing trade winds.
- Maximization of indirect light.
- Roofs shading and insulation.
- Low thermal mass materials in lightweight structures.
- Thermal protection by external walls.
- Transitional shaded outdoor spaces.

These principles are particularly effective in buildings

SSP5-8.5 scenario, refers to one of the Shared Socioeconomic Pathways (SSPs) used in climate modeling to explore future greenhouse gas emissions trajectories. In this case, SSP5-8.5 represents a high-emissions scenario where no new climate policies are introduced beyond current trends. It is commonly used as a "worst-case" reference to evaluate the impacts of unchecked emissions and global warming.

where mechanical systems are unaffordable or unavailable, such as low-income housing, schools, and community facilities.

3.3.2. Structural Considerations

To manage solar gains, designers can employ overhangs, verandas, vertical shading, and reflective finishes. These are effective across diverse building types and climatic zones. Airflow should be encouraged through cross ventilation and well-placed indoor partitions. Also, lightweight materials that cool quickly at night may improve thermal comfort, although in some cases, dense materials may be beneficial to buffer heat [74] [76].

Where passive measures are not sufficient, hybrid systems, such as low-energy fans or indirect evaporative cooling, can be employed, particularly in humid environments [77]. In parallel, solar photovoltaic systems can be integrated to power cooling systems while also offering shading benefits, either at building or community level [78]. These thermal design strategies contribute not only to occupant well-being but also to energy efficiency and emissions reduction. Depending on the building's features, shading and glazing solutions can reduce operational energy use by 37% to 78% [79].

However, in a hurricane-prone context like Jamaica, bioclimatic strategies must be adapted for structural safety. Extended eaves, shading devices, and lightweight materials should be engineered to resist cyclonic winds. Hip roof configurations and strong connections between roofs and walls are recommended to reduce the risk of structural uplift. Thus, bioclimatic design must balance thermal performance with disaster resilience, complying with local structural codes and climate risks.

Nature-based solutions can also effectively address heat stress in urban areas. Urban vegetation, including street trees, green roofs, and parks, provides cooling through evapotranspiration and shade. Studies show that strategic tree planting can reduce solar radiation exposure, generate significant reductions in urban temperature, and lower building cooling loads. Green corridors connecting parks and vegetated areas enhance air circulation and create cooler microclimates. At the neighborhood level, participatory approaches can generate tangible impacts on climate adaptation.

Community-managed green spaces not only provide cooling benefits but also create social cohesion and environmental stewardship [37]. (155)

For Jamaica specifically, native drought-resistant species such as lignum vitae and indigenous trees are particularly suitable for urban greening projects, as they require minimal irrigation once established and are adapted to the local climate conditions [37]. (155) Ultimately, bioclimatic architecture serves as both a thermal adaptation and climate mitigation strategy, advancing Jamaica's goals for resilience, energy reduction, and sustainable development.

3.4. Pillar 3: Water Efficiency and Water Management

Water efficiency and improved management of this resource primarily translates into reducing potable water consumption and improving water use efficiency through capture, treatment, reuse, and integrated water resource management technologies.

Although Jamaica is an island surrounded by water, it experiences growing freshwater scarcity. Precipitation patterns have shown a trend toward drier conditions, particularly since 1991. Droughts represent an increasing challenge for Jamaican agriculture, with drought events that during the 1980-2007 period could extend from two to twenty-four months, presenting an average duration of five months. Satellite data analysis indicates that severe drought events are becoming more frequent. During the most critical periods, residents may receive water supply only once per week, a situation that affects both quality of life and the country's economic development [80].

An improvement opportunity lies in implementing integrated water management systems. The combination of rainwater harvesting systems with greywater recycling systems can considerably reduce dependence on municipal water for multiple applications.

3.4.1. Rainwater Harvesting

A highlighted action to address this challenge is rainwater harvesting which, while historically used, requires integration of modern water treatment technologies to improve Jamaica's water security. Modern systems incorporate filters that purify rainwater to potable standards. Tanks can collect sufficient water during the rainy season for a four-person family to maintain water autonomy for three to four months of dry weather [81].

Jamaica has established comprehensive rainwater harvesting guidelines through the Rainwater Harvesting Planning Guideline (October 2023), developed by the Ministry of Economic Growth and Job Creation and administered by the Water Resources Authority (WRA). This guideline was developed in alignment with the National Water Sector Policy and Implementation Plan (NWSP) 2019, which recognizes rainwater harvesting as an important source of water supply. (156)

The guideline recommends rainwater harvesting for all new residential, commercial, institutional, industrial and office buildings, with minimum storage capacities as follows: (156)

- Residential Use: 700 gallons/3,150 litres.
- Commercial and Industrial Use: 1,500 gallons/6,750 litres.
- Office Use: 1,000 gallons/4,500 litres.

System Design Requirements (156):

- First flush diversion of 45.5 liters (10 gallons) of roof runoff during any rain event.
- Gutters with leaf screens (wire mesh with openings no larger than 1.27 cm or 0.5 inches).
- Roof washers containing 46 cm (18 inches) of sand, filter fabric and 15.25 cm (6 inches) of pea gravel.
- Reflux valves (backflow prevention) to prevent contamination of public water supply.
- Tanks constructed of stone, concrete, galvanized iron, or thermoplastic polyethylene with screened openings.

3.4.2. Greywater Recycling

Another promising alternative is greywater recycling, which involves treating wastewater from showers, sinks, and washing machines that constitutes 50-80% of daily domestic wastewater generation. Modern treatment technologies include biological systems, membrane filtration, and physicochemical processes that can be integrated into modular systems, producing water suitable for irrigation and toilet flushing. These systems

offer significant water savings potential: up to 30% for households and 60% for office buildings through toilet flushing alone, with additional 40% savings when including garden irrigation. However, successful implementation requires careful evaluation of energy consumption and operational costs, which vary considerably depending on the selected technology and scale of application [82].

Greywater recycling implementation will require extensive public awareness campaigns to shift cultural perceptions and improve uptake in Jamaica. Many residents may have concerns about the safety and aesthetics of using treated greywater, even for non-potable purposes like toilet flushing and irrigation.

Successful implementation strategies should include:

1. Public education campaigns highlighting water savings and environmental benefits.
2. Demonstration projects in public buildings and housing developments.
3. Clear labeling and color-coding of greywater systems to distinguish from potable water.
4. Certification programs for installers to ensure proper system design and maintenance.
5. Financial incentives or rebates for homeowners who install approved systems.
6. Integration of greywater education into school curricula to build long-term acceptance.

3.4.3. Water-Efficient Devices

The installation of water-efficient devices is one of the most cost-effective actions to reduce potable water demand in urban buildings, particularly in water-stressed contexts. This approach involves incorporating sanitary and hydraulic technologies designed to reduce water consumption, but without compromising functionality and comfort. For example, these include: low-flow toilets, sensor-activated faucets, and low-flow aerators.

Their effectiveness lies in several factors: they require relatively low upfront investment compared to more structural solutions, as they provide immediate water savings and can be easily implemented in both new construction and retrofit projects. Also, in high-occupancy buildings, such as schools, hospitals, offices or residential complexes, the cumulative impact of these devices can save thousands of cubic meters of water [83].

From an adaptation perspective, these technologies help to reduce pressure on water supply systems during droughts or service restrictions, an increasingly common scenario in Jamaica. While they do not structurally address issues like water source availability in public networks, they enhance domestic and institutional resilience by lowering non-essential potable water demand.

3.4.4. Landscaping

Drought-resistant landscaping is a water-efficient design strategy that incorporates native and climate-adapted plant species to reduce irrigation needs, making it relevant in water-stressed environments. Species such as vetiver grass, lignum vitae, and tropical ornamental shrubs like hibiscus and ixora are naturally suited to Jamaica's warm climate, and they typically require minimal watering once established. These plants also offer additional benefits including reduced maintenance requirements and enhanced support for local wildlife and biodiversity [84].

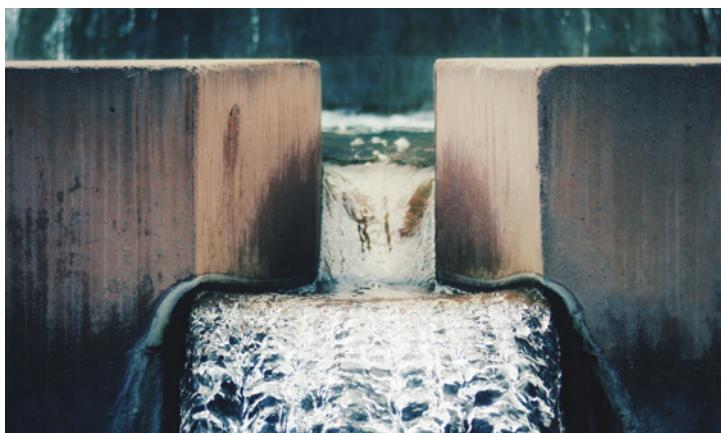
To complement these practices, rainwater harvesting systems can be implemented to capture and store roof runoff for landscape irrigation, reducing reliance on traditional water sources and offering a cost-effective solution for green space maintenance. Furthermore, permeable surfaces, like permeable pavers, gravel beds or planted strips, allow rainwater to infiltrate the ground instead of generating surface runoff. This practice helps recharge aquifers, reduces pressure on stormwater infrastructure during extreme rainfall, and contributes to cooling urban spaces by decreasing heat absorption [85].

3.4.5. Integrated Systems and Decentralized Treatment

Integrated water systems, combining rainwater harvesting with greywater recycling, offer a resilient and efficient strategy to reduce water demand, especially in urban settings. These hybrid approaches address the limitations of standalone systems. While rainwater harvesting alone typically supplies around 15% of non-potable demand, integrated approaches can achieve up to 48% reductions in municipal water consumption, with payback periods as short as six years. This is possible because the integrated system alternates between water sources, which helps compensate for seasonal variability.

In addition to water savings, the integration of digital monitoring technologies enhances system performance. For example, continuous monitoring (minute-by-minute) can detect leaks, 15-minute intervals can support tracking, and hourly data can optimize overall water distribution networks. These monitoring tools allow for early anomaly detection, informed decision-making, and improved maintenance, boosting the system's resilience to climate variability and occupancy fluctuations [86][87].

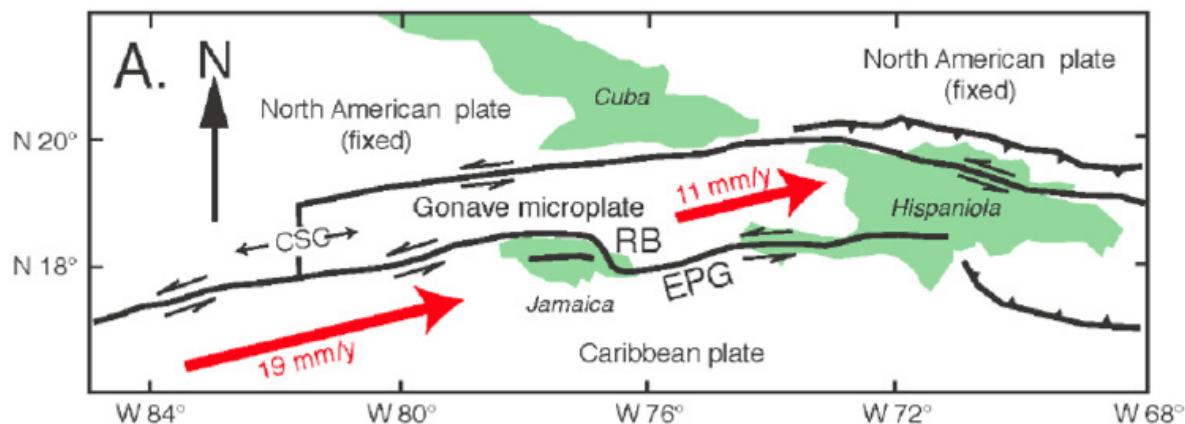
Effective implementation, however, also requires trained professionals capable of designing, installing, and operating these systems. Jamaican educational institutions can play a key role by developing certification programs. Overall, these integrated systems align with Jamaica's adaptation goals by reducing reliance on centralized infrastructure, enhancing resilience at the building level, and improving flood management during heavy rainfall events.



3.5. Pillar 4: Structural Resilience to Extreme Events

It is fundamental to increase structural resistance against extreme events such as earthquakes and hurricanes. This involves improving building codes, using resistant materials, and implementing earthquake-resistant engineering techniques. This is because Jamaica is located in one of the most seismically active zones of the Caribbean, where the intersection between the Caribbean Plate and the Gonâve Microplate generates high seismic hazard conditions that have been historically underestimated. The island is crossed by the Enriquillo-Plantain Garden Fault Zone (EPG), a left-lateral strike-slip fault system extending from Hispaniola to Jamaica (Figure X), located less than 5 kilometers from Kingston, the capital city where two-thirds of the national population lives. Historical records show that this fault zone has generated at least one large earthquake ($>Mw 6$) per century during the last five centuries, including the devastating events of 1692 and 1907, which destroyed Port Royal and Kingston, respectively [88].

Figure 6. Plate tectonic setting of Jamaica. The vectors show the motions of the Caribbean Plate and Gonave microplate relative to the North American Plate



Source: EPG = Enriquillo – Plantain Garden fault, RB = restraining bend, CSC = Cayman spreading center. Source: Abbott, Richard & Bandy, Betsy & Rajkumar, Adrianna. (2013). Cenozoic burial metamorphism in eastern Jamaica. Caribbean Journal of Earth Science. 46. 13-30. Available at: https://www.researchgate.net/publication/279449247_Cenozoic_burial_metamorphism_in_eastern_Jamaica/citation/download.

3.5.1. Regional Seismic Framework

Successful implementation of seismic structural resilience in Jamaica requires immediate regulatory framework update to incorporate the most recent seismic design standards. Jamaica's Building Code 2023 must be complemented with specific seismic provisions based on model codes developed by the Association of Caribbean States and adapted to specific local conditions.

Although the Caribbean has developed specific regulatory frameworks for regional seismic conditions, their implementation has been uneven. The Caribbean Uniform Building Code (CUBiC), introduced in 1985,

continues to be used in Belize, Jamaica, Barbados, and Trinidad and Tobago, with country-specific additions [89]. However, the Association of Caribbean States recognizes the urgent need to update these codes, these revisions should be considered at time intervals in the range of 5 years with a maximum of 10 years [90].

Additionally, seismic zoning must be based on comprehensive updated scientific studies, using internationally accepted, transparent, and repeatable methods. It is recommended to develop a "model seismic zoning map" and a "model wind velocity map" for the Greater Caribbean region that avoids inconsistencies at borders between different states.

3.5.2. Earthquake-Resistant Structural Systems

Modern seismic design philosophy is based on the understanding that it is economically unfeasible to design buildings for complete elastic response during large earthquakes. As a result, a certain level of structural damage is considered acceptable, as long as collapse is prevented. This requires critical regions of the structure to be adequately designed for ductility and energy dissipation [91]. The capacity design approach embodies this principle by selecting and ensuring a controlled plastic deformation mechanism that can develop and be sustained throughout the seismic event.

Seismic Risk Categorization. Modern codes use Seismic Design Categories (SDC) that replace traditional seismic zones, providing a more precise approach based on site-specific hazard and structure importance. For Jamaica, which presents medium to high seismic hazard conditions, structures must be classified from SDC B to SDC D, where each category imposes specific design and detailing requirements [92].

SDC C and higher structures that include columns, pilasters, and beams as part of the seismic force-resisting system require a minimum transverse reinforcement ratio of 0.0015, with maximum spacing of one-quarter of the smaller nominal dimension for columns and pilasters, and half the nominal depth for beams. For SDC D and higher structures, additional modifications are required as indirect measures to increase flexural ductility of elements forming part of the seismic force-resisting system [92].

Special Reinforced Masonry. Special reinforced masonry represents a particularly appropriate solution for Jamaica, where materials such as concrete blocks are widely available and labor has experience in their construction. However, successful implementation requires following strict reinforcement and detailing protocols that differ significantly from traditional unreinforced masonry practices. Special reinforced masonry shear walls must be designed considering shear capacity [91][92].

Reinforced Concrete Frames, designed for ductility, require specific detailing that guarantees controlled inelastic behavior during intense seismic events. Special moment-resisting frames must comply with geometric and reinforcement requirements that include

limitations on element dimensions, minimum and maximum reinforcement ratios, and specific anchorage and splice details [91].

Seismic Base Isolation. Base isolation, also known as seismic isolation, represents a state-of-the-art method that constitutes one of the most effective means of protecting structures against earthquake forces. This technology uses structural components called isolators to substantially decouple the superstructure from the foundation that rests on shaking ground, thus protecting building integrity and providing climate resilience against seismic events. It works by installing specialized devices called isolators between a building's foundation and superstructure, effectively allowing the ground to move during an earthquake while keeping the building relatively stable. This approach achieves very large decreases in seismic demand compared to conventional construction, with significantly reduced accelerations and lateral deformations that protect both the structure and its contents [93].

Reinforced Masonry and Reinforced Concrete Frames is well-founded and aligns with broader evidence from the IDB report. The report confirms that improving the resiliency of outer walls and roofs using reinforced concrete and properly engineered masonry systems can significantly reduce the Caribbean region's vulnerability to hurricanes and other climate impacts (157).

The economic analysis in the IDB report supports the recommendation for fiber-reinforced concrete and reinforced structural systems, demonstrating that despite potentially higher initial costs, these materials provide substantial savings over the building lifecycle by reducing damage from repeated climate events (157).

This technology is particularly valuable for Jamaica's climate adaptation strategy because it addresses earthquake vulnerability while minimizing construction disruption. Unlike traditional strengthening methods that require extensive work throughout a building, isolation systems are installed at a single level, allowing buildings to remain operational during retrofit. This makes it especially suitable for critical infrastructure like hospitals, schools, and government buildings that must maintain services during climate-related emergencies. Also, for Jamaica's context, seismic isolation offers dual climate benefits: protecting buildings from earthquake damage that often accompanies or follows major hurricanes, while ensuring rapid post-disaster recovery

since damage is concentrated only at the isolator level rather than throughout the entire structure.

3.5.3. Specialized Professional Training

Capacity development should include intensive training programs for structural engineers, architects in seismic design principles, as well as contractors and construction workers including quality control. Jamaica should establish a modern seismic instrumentation network to monitor tectonic activity and record ground motions during seismic events. This network should include strong motion stations strategically located in urban areas and near critical infrastructure to capture data that allows validation and refinement of seismic design codes.

3.5.4. Post-Event Evaluation

A systematic protocol for post-earthquake evaluation should be established that documents performance of buildings constructed under different codes and standards. This information is crucial for validating effectiveness of seismic design measures and identifying improvement opportunities in future codes.

3.6. Pilar 5: Green-Blue Infrastructure for Urban Adaptation

In land use planning, integration of climate change adaptation through urban policies and territorial management of cities is increasingly important, incorporating nature-based solutions to address climate risks. Among the detected tools is **green infrastructure**, which is defined by the European Commission as “a strategically planned network of natural and semi-natural areas with other environmental features, designed and managed to deliver a wide range of ecosystem services while protecting biodiversity.” These services include, for example, water purification and air quality improvement. This network of green (land) and blue (water) spaces improves environmental quality and protects biodiversity in both rural and urban settlements, and improves nature’s capacity to facilitate ecosystem goods and services, establishing a network of connections between natural and urban spaces that were previously isolated and fragmented [94].

For their part, **blue infrastructures** constitute elements intrinsically related to green infrastructures, through components or processes related to water supply, efficiency, and management. Therefore, it contributes to preventing floods, establishing buffer spaces for main rivers and streams, as well as regulating watershed runoff through rainwater infiltration. Additionally, it allows slowing soil erosion through vegetation presence. Consequently, balanced urban development is promoted, reversing territorial degradation, optimizing land uses [95][96].

3.6.1. Integrated Green Technologies

Jamaica’s Building Code 2023 already establishes standards for constructing resilient structures, providing the necessary regulatory framework to improve these strategies. Main strategies include creating green roofs that can reduce surface temperature and allow runoff reductions and increasing urban green coverage and managing stormwater through green infrastructure supported by retention capacities [97].

At the neighborhood level, it is beneficial to promote ecological connectivity through creating green corridors and community water management systems. A study demonstrates that participatory approaches can generate tangible impacts on climate adaptation [98]. Similarly, strategic tree planting can reduce solar radiation, generating significant reductions in urban temperature [99].

Regarding infrastructure level, coastal protection is favored through mangrove restoration. Studies at University of California, Santa Cruz demonstrate that mangrove and reef restoration can be cost-effective for coastal flood reduction in more than 20 Caribbean countries, using rigorous valuation methods that show positive investment returns [100].

Although hundreds of hectares of mangroves have been lost in Jamaica, more than 70% could be restorable. Here

community support is relevant according to evaluations conducted at Bogue Lagoon, Salt Marsh, and Portland Cottage, where most residents have expressed interest in restoration.





Chapter 4. Net Zero Buildings and Smart Cities

Jamaica stands at a pivotal moment in its development trajectory. As the island nation struggles with rising energy costs, climate change impacts, and rapid urbanization, the built environment emerges as both a significant challenge and an unprecedented opportunity. Buildings in Jamaica consume as much as 55% of the total electrical energy generated (164), with the majority of this energy derived from imported fossil fuels that burdens the national budget and contribute to greenhouse gas emissions.

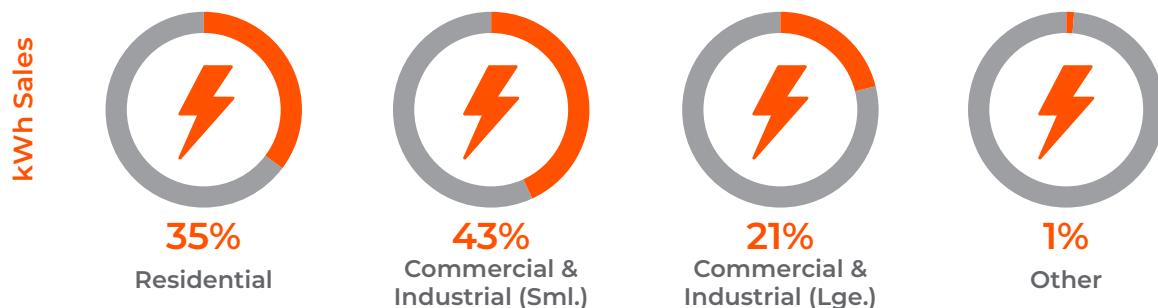
4.1. Defining Zero Buildings in the Caribbean contexts

A zero net energy building (ZNEB), also referred to as a net zero building, is engineered to generate the same amount of energy it uses over the course of a year. This balance is accomplished by implementing energy conservation strategies alongside renewable energy systems installed on the property, typically including solar panel installations. The objective is to reduce or completely eliminate dependence on external power grids and energy suppliers. (165)

The Caribbean definition also emphasizes climate resilience, recognizing that net zero buildings must maintain functionality during extreme weather events, including hurricanes and extended drought periods. This resilience requirement influences design strategies, material selection, and energy storage solutions. To determine the viability for sectors in Jamaica to address and embrace the concept of a Net Zero building, it is important to understand its current energy building profile and consumption patterns.

4.2. Jamaica's Current Energy Profile and Consumption Patterns – Jamaica energy conservation code.

Figure 7. Jamaica's electricity consumption patterns



Source: Annual Report 2024, Jamaica Public Services (JPS).

Based on Jamaica's electricity consumption patterns shown above (graphic 1), the distribution reveals critical opportunities for targeted renewable energy implementation across all sectors. Commercial and industrial operations represent the largest energy consumers, with small commercial and industrial facilities accounting for 43% of total consumption and large commercial and industrial operations consuming 21%, collectively representing nearly two-thirds of Jamaica's electricity demand. This concentration makes these sectors prime candidates for renewable energy adoption, as implementing solar panels, wind systems, or hybrid renewable solutions could significantly reduce the nation's overall carbon footprint and energy costs while providing businesses with long-term economic benefits through reduced utility expenses. The residential sector, consuming 35% of electricity, presents an equally important opportunity for distributed renewable energy systems such as rooftop solar installations, which could enhance energy security at the household level while reducing strain on the national grid during peak demand and outage periods. Even the "Other" category at 1%, likely representing public infrastructure and services, should prioritize renewable sources to demonstrate government leadership in sustainable energy transition. Given Jamaica's abundant solar resources and consistent trade winds, each sector's transition to renewable energy is not only environmentally imperative but also economically strategic, offering protection against volatile fossil fuel prices while supporting the country's energy independence and climate resilience goals.

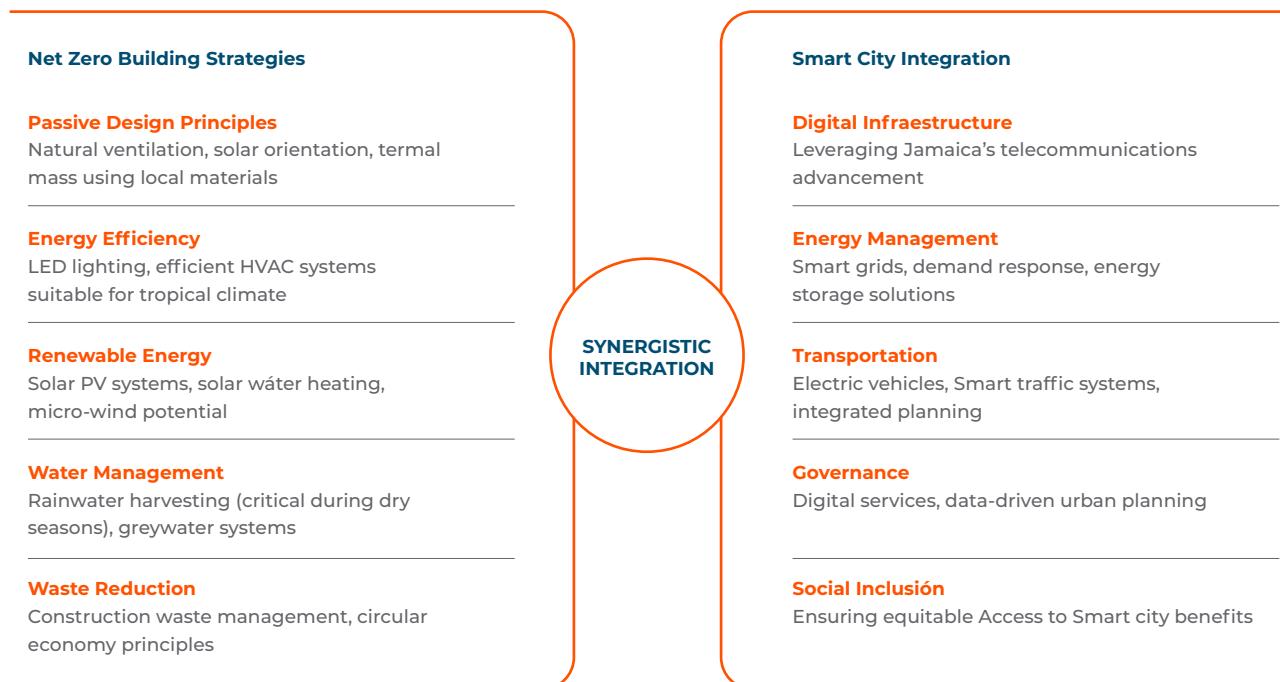
4.3. Effective strategies to leverage Net Zero transition and Smart Cities

As discussed in the previous chapters, which identified comprehensive strategies for both climate adaptation and mitigation, it becomes evident that an integrated approach combining all these strategies is imperative if Jamaica aims to achieve net zero energy buildings that serve as the foundation for developing smart cities. The interconnected nature of building performance, urban systems, and community resilience requires coordinated implementation rather than isolated interventions.

Numerous developing nations, including Jamaica, have recognized the critical necessity of achieving carbon neutrality by 2050, yet the immediate implementation of concrete, measurable actions remain essential to meet this ambitious target. Intelligent urban technologies and integrated building systems offer significant potential to facilitate and accelerate the transition to carbon neutrality through multiple complementary mechanisms. These include dramatically reducing overall energy consumption through efficient building design and smart systems, promoting the rapid transition from fossil fuel dependency to locally-generated clean energy sources, enhancing the efficient utilization of natural resources such as water and materials, minimizing transportation energy requirements through integrated urban planning, and fostering the adoption of sustainable lifestyle practices among citizens through accessible technology and community engagement.

For Jamaica specifically, this integrated approach recognizes that net zero buildings cannot achieve their full potential in isolation but must be designed and operated as components of broader smart city ecosystems that address the island's unique challenges of energy security, climate resilience, and sustainable economic development.

Figure 8. Jamaica's Integrated Approach, Net Zero Buildings + Smart City Infrastructure = Sustainable Future.



Although intelligent urban technologies offer significant opportunities to achieve carbon neutrality goals, their implementation is often limited by inadequate digital networks, limited financial resources, lack of uniform standards and connected systems, conflicting stakeholder priorities, and weak local government capabilities. However, these challenges are being systematically addressed across the Caribbean region, with Jamaica playing a pivotal role in developing and accelerating solutions through regional collaboration and innovation.

This coordinated regional response is exemplified by the launch of the Caribbean Climate-Smart Accelerator, which directly tackles these implementation barriers through unprecedented collaboration between 26 Caribbean countries and over 40 international partners.

4.4. Caribbean Climate Smart Accelerator: Regional Framework for Jamaica's Green Building and Net Zero Energy Development.

The Caribbean Climate-Smart Accelerator represents a transformative regional initiative that provides crucial context and support for Jamaica's net zero building aspirations. Launched in August 2018 in Kingston, Jamaica, this groundbreaking partnership brings together an unprecedented coalition of 26 Caribbean countries and over 40 private and public sector partners, including Prime Minister of Jamaica Andrew Holness, the Inter-American Development Bank, Virgin Group Founder Sir Richard Branson, and the World Bank. The Accelerator's ambitious vision is to make the Caribbean the world's first climate-smart zone, covering a region of 1 million square miles and over 40 million people. (166)

The initiative's comprehensive approach to climate resilience directly aligns with Jamaica's net zero building objectives through its focus on enhanced energy security via promotion of energy efficiency, renewable energy, and low-carbon sources. The Accelerator defines a climate-smart zone as one characterized by reduced vulnerability to climate-related hazards through resilient infrastructure, reduced greenhouse gas emissions from transportation and other pollutants, healthy ecosystems both marine and terrestrial, and the incorporation of Sustainable Development Goals in all major projects. This framework provides Jamaica's building sector with a clear pathway to contribute to broader regional climate goals while accessing substantial financial and technical support. (166)

4.4.1. The Caribbean Climate-Smart Accelerator Pillars

Through strategic partnerships, this climate-smart zone demonstrates how small island developing states can lead international climate action while fostering economic prosperity, creating a beacon of hope that inspires worldwide transformation. This comprehensive vision is operationalized through the Caribbean Climate-Smart Accelerator's foundational pillars, which provide the strategic framework for Jamaica's net zero building initiatives and broader sustainable development goals: (167)

- **Climate Smart Map:** A map detailing the key milestones with costs, implications and timelines for moving at pace to our desired state.
- **90% Renewable Energy for all:** A path to generate 90% of electricity from renewable resources and electrify the transport sector by 2035
- **Protecting 30% of Ocean and Land:** A strong governing framework and secure required investment to protect 30% of Caribbean land and water by 2030.
- **1.5% Green Jobs:** Strengthen the region's economic resilience against exogenous shocks by

building climate action as an economic industry.

While the 90% renewable energy target by 2035 represents the Accelerator's aspirational goal, Jamaica's current trajectory suggests a more gradual transition. Recent government reports indicate accelerated progress toward renewable energy targets. As of May 2025, Jamaica has achieved 12.5% renewable energy in its electricity generation mix, with an additional 100 MW scheduled to come online during 2025/2026, representing 4.5% additional capacity and bringing the total to 17%. A further 220 MW will be procured in 2025 for commissioning in 2027/2028, adding approximately 10% and bringing the total renewable electricity generation to 27% by 2028. (128) Interim milestones of 30% by 2030 and progressive increases through 2040 may provide more realistic pathways while maintaining momentum toward the long-term 90% goal.

4.4.2. Financial Commitments, innovation and entrepreneurship

Since its launch in 2018, financial commitments were made to the Accelerator to create significant opportunities for Jamaica's green building development. The Inter-American Development Bank has pledged \$1 billion specifically for climate-smart investments across the Caribbean region, building on an existing portfolio of over \$200 million for low-carbon energy, sustainable infrastructure, and energy efficiency projects. The World Bank Group has committed \$1 million annually for three years in in-kind services while supporting Caribbean countries with an almost \$2 billion portfolio focused on strengthening resilience and financial protection against disasters. These funding mechanisms, including blended finance and contingent credit facilities, provide Jamaica with access to resources that can accelerate net zero building implementation while reducing financial barriers for both public and private sector projects. (166)

The Accelerator's emphasis on innovation and entrepreneurship creates a supportive ecosystem for Jamaica's green building sector development. Through initiatives like the annual \$50,000 Speed Awards recognizing leading countries, businesses, and individuals working toward climate-smart goals, the platform encourages breakthrough solutions and best practice sharing across the region. (166)

4.5. Jamaica's First Net Zero Energy Building: A regional Milestone

Jamaica achieved a significant breakthrough in sustainable construction with the official opening of the Caribbean's first net zero energy building in October 25, 2017 at the University of the West Indies Mona Campus. This 2,300-square-foot prototype structure, located along Gibraltar Way, represents a transformative moment for regional building practices and serves as a comprehensive demonstration of how tropical architecture can achieve energy independence while maintaining comfort and functionality. (168), This was made possible with a US\$2,361,000 grant and in-kind contributions from the Global Environmental Facility (GEF), with the technical assistance from the United Nations Environment Programme (UNEP), which totalled US\$7,461,000 in support (169),

The building operates on the principle that total annual energy consumption equals the renewable energy generated on-site, creating a balanced energy equation that eliminates dependence on grid electricity. Designed to house the Centre for Advanced Research in Renewable Energy (CARRE), the Caribbean's first dedicated renewable energy research facility, the structure integrates photovoltaic solar systems, wind energy components, and biomass energy research capabilities. This combination demonstrates how multiple renewable energy sources can be effectively integrated into building design to achieve net zero performance in tropical climates. (168)

Table 5. Strategies applied in the design and construction of Jamaica's First Net Zero Energy Building

Strategic Orientation:

Building positioned to minimize heat gain from sun and maximize natural breeze.



Shading Systems:

South-side shading helps keep building cool.



Natural Lighting:

Designed to let in light rather than heat, reducing artificial lighting needs.



Table 5. Strategies applied in the design and construction of Jamaica's First Net Zero Energy Building**Solar PV Panels:**

Generate on-site renewable energy to meet building needs.

**Grid Integration:**

Excess energy can be fed back to the electrical grid.

Energy Independence:

Building generates surplus energy for its requirements and maintains power during grid outages from tropical storms and hurricanes.

Rainwater Harvesting:

Collects and stores rainwater for building use.

**Water-Efficient Fixtures:**

Toilets use 50% less water than conventional systems.

Multi-Purpose Systems:

Stored rainwater serves toilets, urinals, and emergency fire suppression.

**Flood Protection:**

Raised flooring keeps building above flood water levels.

Structural Integrity:

Robust engineering provides earthquake and storm resistance.

Adaptive Design:

Building resilient to changing climate conditions including storms, floods, and seismic activity.

Images Source: Project Documentary - LGGE - "Promoting EE and RE in Buildings in Jamaica" – Built better Jamaica

4.6. The New Kingston Smart City

The New Kingston Smart City Demonstration Project was first announced in 2016 as Jamaica's pilot program to transform the premier business district into a smart city. After years of planning and development, the project received substantial momentum in October 2020 when the United States Trade and Development Agency (USTDA) awarded a US\$500,000 grant to Jamaica Public Service Company (JPS) to advance the initiative. This funding was intended to help identify and deploy smart technologies and develop a roadmap for broader implementation of smart cities throughout Jamaica. (158)

4.6.1. Project Implementation and Key Features

Following the 2020 grant award and subsequent planning, the New Kingston Smart City Demonstration Project entered its active implementation phase, with a comprehensive roadmap presented at the Jamaica Smart City Forum held at The Jamaica Pegasus hotel in September 2023. The project aims to evaluate potential smart city solutions in five crucial domains: (159)

1. Smart Digital Services
2. Energy Management (Smart Grid)
3. Transportation and Mobility (Intelligent Transportation)
4. Environmental Monitoring and Public Health
5. Safety and Security

The New Kingston project also includes public access to Wi-Fi throughout the business district, smart city mobile applications for residents and visitors, digital signage providing real-time information, and integration with various municipal services and agencies. For transportation, the project integrates with Jamaica Intelligent Transportation System (JITS) and Urban Traffic Management System (UTMS), incorporating smart traffic management using real-time data and advanced public transportation systems with GPS tracking. (160)

Figure 9. The New Kignston Smart City

Smart Urban Design Transforms the Physical Environment to Realize the Smart City Vision

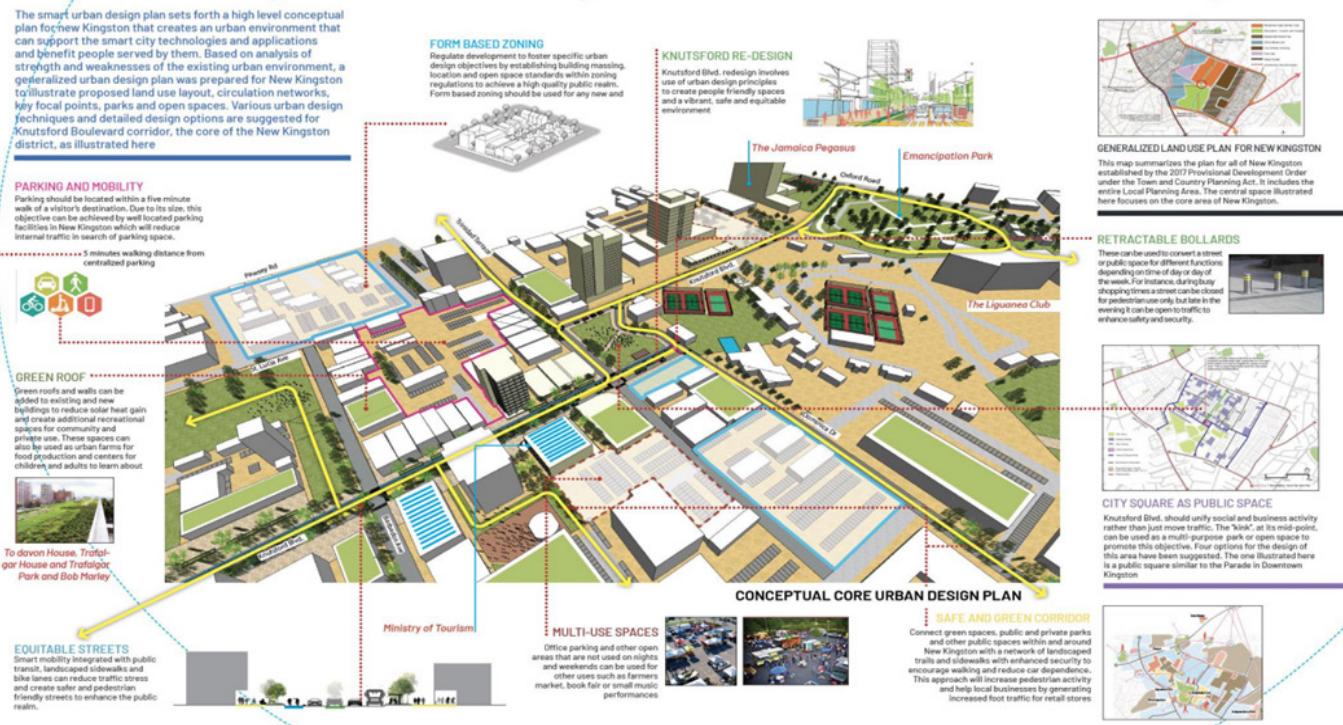
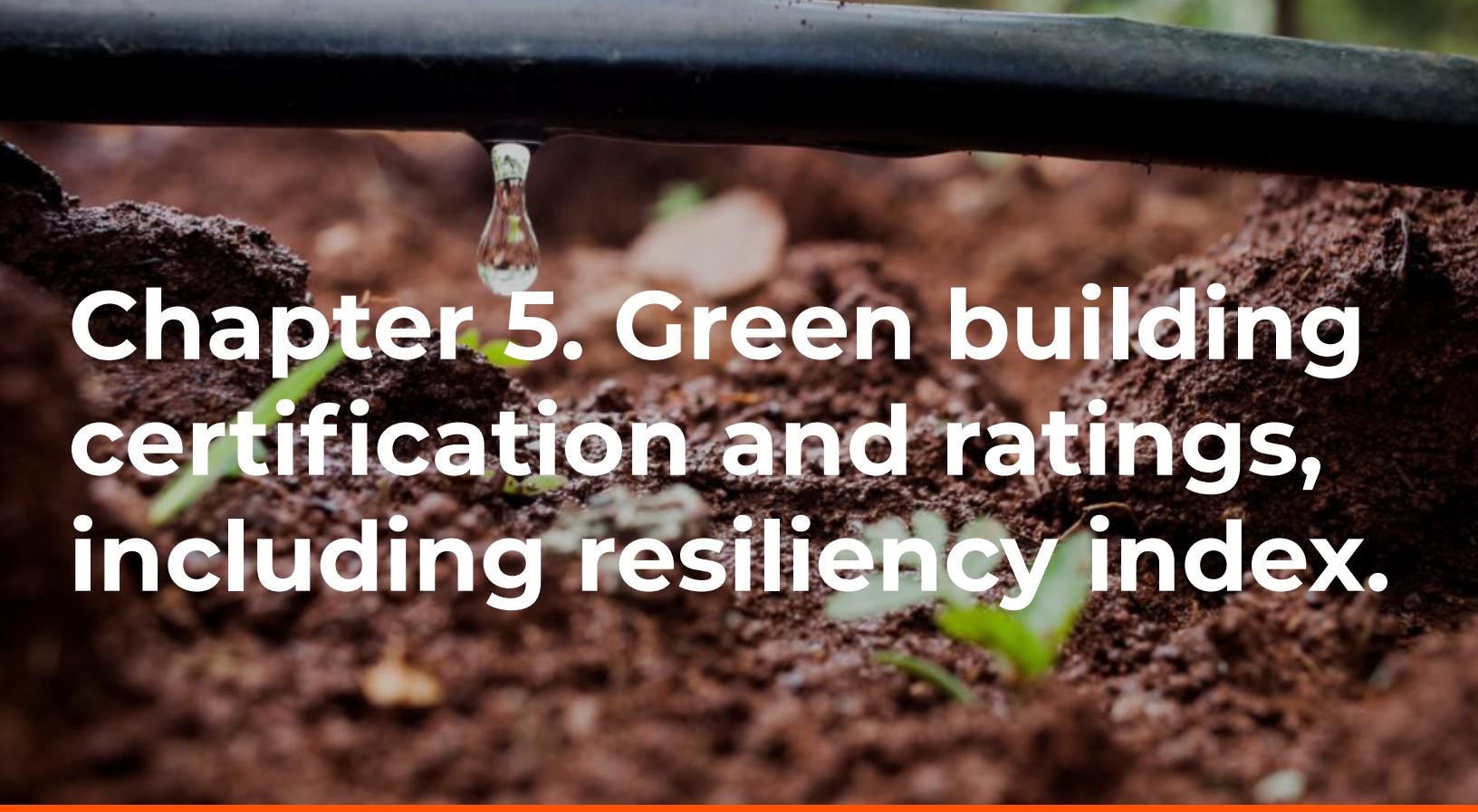


Image source: <http://jpsco.com/wp-content/uploads/2023/09/New-Kingston-Smart-City-Roadmap-Sector-Overview.cleaned.pdf> - An initiative led by JPS in partnership with Tuatara Group.



Chapter 5. Green building certification and ratings, including resiliency index.

The overall condition of the construction necessitated a comparative framework to establish key objectives aimed at developing sustainable and resilient infrastructure capable of meeting the basic needs of both humans and other species. Various public and private sector initiatives have established different rating systems to evaluate and compare new and existing buildings. However, it is important to recognize that climate change demands an integrated response—one that extends beyond individual buildings to include resilient infrastructure capable of providing essential services and ensuring interoperability with other buildings and public or private systems. This is crucial to maintaining a balance between environmental preservation and human activity [101].

Although certification systems have focused their efforts on reducing operational emissions—based on a design approach centered on resource optimization and the analysis and use of site conditions—the assessment of embodied energy has been largely overlooked in these certification systems, even though buildings are among the largest sources of greenhouse gas emissions. [102]. Reference [103] presents an analysis of more than 650 life cycle assessment (LCA) case studies, which shows a clear reduction in the operational energy of buildings. However, it also reveals an increase in emissions associated with manufacturing processes.

The integration of certification systems as design tools for infrastructure and buildings represents an opportunity to comprehensively address the need to mitigate and respond to climate change by enhancing the ability of buildings to cope with acute or chronic risk factors, such as sea level rise, droughts, heatwaves, health epidemics, tornadoes, among other [104].

Sustainable building certification systems, in addition to serving as verification mechanisms, aim to function as design tools and operational guides, supporting project development in alignment with the decarbonization and climate resilience goals outlined in the Paris Agreement. These efforts seek to limit global warming to 1.5 °C above pre-industrial temperature levels [105]. Although efforts have been made since the Paris Agreement came into force to reduce greenhouse gas emissions, these have proven insufficient to meet the agreement's targets. Achieving these goals will require increased investment in sustainable technologies and projects, as well as stronger commitments from high-emission countries—such as the United States and China—to implement effective greenhouse gas reduction policies [106] [107].

5.1. Sustainable construction certifications

Sustainable building certification systems have developed various programs focused on multi-attribute project evaluation. In other words, they do not assess sustainable categories in isolation, but rather aim to evaluate projects holistically across multiple areas. Depending on the type of certification, these systems emphasize aspects such as well-being, energy efficiency, water use, materials, resilience, climate change, location, and more.

With recent updates to certification systems such as Envision, LEED, BREEAM, EDGE, and others, the evaluation methodology has been revised to more explicitly incorporate factors related to risk assessment, mitigation, and resilience in the context of climate change. Although these aspects were addressed in previous versions, the growing urgency to accelerate climate action has led to modifications in the metrics, giving greater weight to strategies that reduce greenhouse gas emissions in construction projects.

5.1.1. Types of system of certification

Sustainable building certification systems are highly diverse. Many originate from private initiatives or public entities that, depending on their development goals and the current state of sustainable construction, implement various metrics and methods to assess sustainability strategies in alignment with local construction practices. While some certification systems have a global scope, many adapt to the regulations and contextual realities of each country. Below is a presentation of the most internationally recognized certification systems that evaluate sustainability projects using a multi-attribute methodology as well as the Role of Green Building Councils in Developing Country-Specific Certifications.

1. LEED

LEED (Leadership in Energy and Environmental Design) is a certification system developed by the U.S. Green Building Council. It evaluates projects across nine areas: sustainable sites, water efficiency, energy and atmosphere, materials and resources, indoor environmental quality, location, education, innovation, and regional priority. The assessment of each area is designed to address impact categories that aim to develop strategies to mitigate climate change, improve indoor environmental quality, reduce resource depletion, promote human health, and protect water sources [108].

The certification system establishes a set of minimum compliance requirements across the previously described areas. In addition, projects must implement sustainability strategies that enable them to achieve a minimum number of points to be certified. Based on the total points earned, different certification levels are

awarded, with the highest-level being Platinum, which requires achieving at least 72% of the possible points granted by the certification system.

Figure 10. Levels of LEED Certification



Source: U.S. Green Building Council, «LEED rating system,» [On line]. Available: <https://www.usgbc.org/leed>.

2. EDGE

Excellence in Design for Greater Efficiencies (EDGE) is a green building certification system developed and promoted by the International Finance Corporation (IFC), a member of the World Bank Group. Its goal is to evaluate buildings in three main categories: energy efficiency, water efficiency, and embodied carbon in materials. In addition to providing a sustainability verification standard, EDGE also offers a free-access software tool for assessing sustainability measures across different building typologies.

To achieve the sustainability goals defined by the EDGE certification system, projects must attain at least a 20%

reduction in operational energy use, water consumption, and embodied carbon in materials. Project evaluation is based on a baseline defined by the EDGE software, which takes into account the site context and building typology, weighting sustainability strategies according to the project's location.

The certification system also recognizes exemplary energy performance: projects that achieve over 40% savings in operational energy receive the EDGE Advanced Certification. Furthermore, projects that demonstrate zero operational emissions are awarded the EDGE Zero Carbon Certification [110].

3. WELL

WELL is a certification system developed by the International WELL Building Institute (IWBI), focused on promoting the health and well-being of occupants in the built environment. It is evaluated through ten categories, or concepts: air, water, nourishment, light, movement, thermal comfort, sound, materials, mind, and community. WELL is grounded in the principles of being equitable, global, evidence-based, technically robust, customer-focused, and resilient.

In its version 2, the system includes a total of 126 features, of which 19% are preconditions, meaning they are mandatory. The remaining optional features award points that contribute to achieving different certification levels — with a minimum of 40 points required for the Core level, and Platinum status awarded for projects exceeding 80 points [111].

4. BREEAM

BREEAM (Building Research Establishment's Environmental Assessment Method) is a certification system developed by the Building Research Establishment (BRE), focused on assessing sustainability in the built environment and infrastructure. It is one of the most widely used certification systems in the world, particularly in Europe, with a framework based on whole-life performance, health and social impact, circularity and resilience, biodiversity, and disclosures and reporting.

Like most certification systems, BREEAM is structured around a set of mandatory and optional requirements. These requirements contribute to an overall percentage score, which determines the certification level. A project

must achieve at least 30% overall performance to be eligible for certification, with five possible rating levels available [112].

applicability and relevance of each strategy, allowing projects to be certified according to their local context and benefiting from the flexibility offered by Envision's design-based methodology for infrastructure development [104].

To achieve Envision certification, a project can qualify for different levels depending on the sustainability strategies it implements. The certification levels are as follows.

- Verified 20%
- Silver 30%
- Gold 40%
- Platinum 50%

5.1.2. Country-Specific Green Building Certifications and the Role of National Green Building Councils

Green Building Councils serve as critical intermediaries in developing certification systems that bridge global sustainability standards with local building contexts and needs. These organizations recognize that while international certifications like LEED and BREEAM provide valuable frameworks, they often require significant adaptation to address specific climatic conditions, material availability, economic constraints, and cultural practices unique to different regions.

Country-specific certifications such as CASA Colombia, Green Star Australia, and CASBEE Japan exemplify how national Green Building Councils have successfully created indigenous rating systems that incorporate local building traditions, available materials, and climate-responsive design strategies while maintaining rigorous sustainability standards.

For instance, CASA Colombia was developed by the Colombian Council for Sustainable Construction (CCCS) and its members, under the guidelines of the World Green Building Council in 2017, and its technical development continues under the CCCS. The tool includes a framework for new housing, which is classified as VIS and non-VIS housing, and a reference framework for existing housing. (161)

CASA is a multi-attribute system, based on performance, with quantitative indicators and that has a third-party verification. It is based on a points system distributed across seven key categories of comprehensive sustainability [43]: (161)

- Sustainability in the environment
- Sustainability in construction
- Water efficiency
- Energy efficiency
- Material efficiency
- Wellness
- Social responsibility

These locally-developed certifications typically achieve higher adoption rates because they offer more realistic and cost-effective pathways to sustainability that align with local construction practices, regulatory frameworks, and economic conditions.

Furthermore, Green Building Councils play essential roles in capacity building by training local professionals, establishing regional expertise, and creating educational programs that ensure the construction industry can effectively implement and maintain certified green building practices. This localization approach not only makes sustainable construction more accessible and economically viable but also helps preserve and enhance traditional building knowledge while advancing modern environmental performance standards.

Figure 11. Sustainable Certifications for Buildings

Building rating or certification system	Single or multi attribute	Type of standard	Managing Organization	Issues / Areas of focus
LEED (Leadership in Energy and Environmental Design)	Multi – Attribute	<ul style="list-style-type: none"> • New Construction (NC) • Existing Buildings, Operation and Maintenance (EB O&M) • Commercial Interiors (CI) • Homes • Neighborhood Development (ND) • Cities and Communities • Core and Shell (CS) • Retail • Healthcare (HC) 	U.S Green Building Council	<ul style="list-style-type: none"> • Sustainable Sites • Water Efficiency • Energy and Atmosphere • Materials and Resources • Indoor Environmental Quality • Location and Transportation • Awareness and Education • and Regional Priority <p>all through a set of prerequisites and credits.</p>
EDGE	Multi – Attribute	A universal standard and a certification system for residential and commercial structures.	International Finance Corporation (IFC), a member of the World Bank Group.	<p>Assessment areas include:</p> <ul style="list-style-type: none"> • Energy • Water • Materials
BREEAM	Multi – Attribute	<p>Certification system is a multi-tiered process with pre-assessment, third-party consultant guidance through an assessment organization for:</p> <ul style="list-style-type: none"> • New Construction • Communities • In Use Buildings • Eco homes 	Bre Global	<p>Assessment uses recognized measures of performance, which are set against established benchmarks in:</p> <ul style="list-style-type: none"> • Energy and Water use • Internal environment (health and wellbeing) • Pollution • Transport

Figure 11. Sustainable Certifications for Buildings

Building rating or certification system	Single or multi attribute	Type of standard	Managing Organization	Issues / Areas of focus
				<ul style="list-style-type: none"> Materials Waste Ecology Management processes
Envision	Multi – Attribute	Rating system for development projects located on sites with or without buildings.	Institute for Sustainable Infrastructure	<p>Performance criteria in the areas of:</p> <ul style="list-style-type: none"> Quality of Life Leadership Resource allocation Natural World Climate and resilience
WELL Building Standard	Multi – Attribute	<p>Performance based standard and certification program for:</p> <ul style="list-style-type: none"> New and Existing Buildings New and Existing Interiors Core and Shell Retail Education Facilities Restaurant Commercial Kitchen Multifamily Residential 	Administered by the International WELL Building Institute TM (IWBI)	<p>Measures attributes of buildings that impact occupant health by looking at seven factors:</p> <ul style="list-style-type: none"> Air Water Nourishment Light Fitness Comfort Mind

Source: S. Vierra, «Green building standards and certification systems,» National Institute of Building Sciences, Washington, 2016.

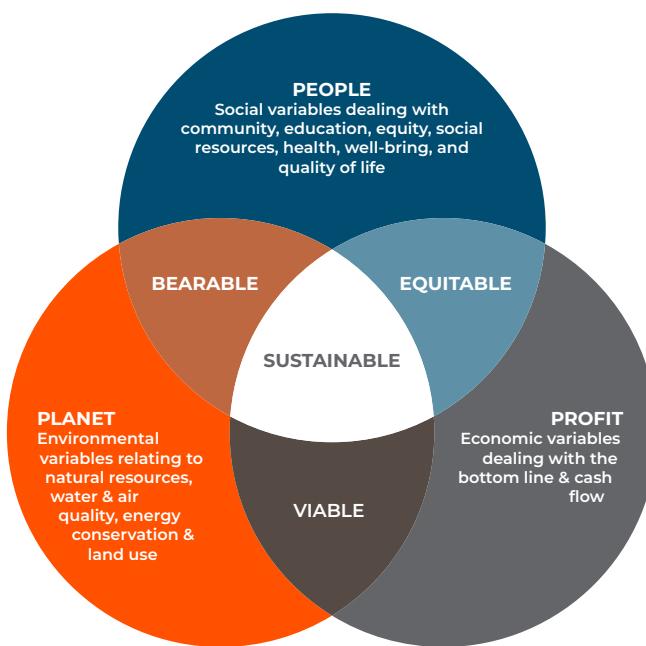
5.2. Influence of rating certification system in resilience and climate change

Resilience is an implicit concept in the implementation of strategies to address climate change. Buildings must be capable of adapting to chronic or acute risks caused by human activity or natural phenomena. This cross-cutting approach enables certification systems to effectively address actions that promote both climate change adaptation and risk mitigation.

In general, certification systems follow the Triple Bottom Line methodology (People, Profit, and Planet). This approach aims to create a balance between economic development, human needs, and environmental protection. To achieve this balance, a structure based on the principles of reduce, reuse, and recycle (RRR) is established. The foundation of this approach is that, to remain in harmony with the environment, it is essential first to reduce the use of natural resources, raw materials, and electricity; second, to reuse systems and equipment that have already been built—such as building envelopes and water management systems; and finally, to recycle waste within the production chain as raw materials. This reduces the need to extract virgin materials from mines, forests, or other sources, thereby decreasing the environmental impact of production processes.

Different certification systems have been adapting their evaluation metrics, giving greater importance to strategies that directly impact climate change mitigation. The U.S. Green Building Council (USGBC) is the organization responsible for managing certification systems such as LEED and SITES, among others. From its perspective, each certification specifically addresses climate resilience through the framework of prevent, prepare, and restore.

Figure 12. The interconnection of the elements of the Triple Bottom Line concept



Source: A. Dalibozhko y I. Krakovetskaya, «Youth entrepreneurial projects for the sustainable development of global community: evidence from Enactus program,» SHS Web of Conferences, vol. 57, 2018.

From the perspective of **LEED v4.0** certification, there is no specific approach to resilience and climate change. However, measures such as water management, minimum energy performance, advanced refrigerant management, reduction of the heat island effect, and life cycle assessment are strategies that directly impact climate change mitigation and the reduction of greenhouse gas emissions.

A similar case applies to the **SITES** certification, which also lacks a dedicated resilience and climate change approach. Instead, it integrates these considerations through mandatory and optional measures, including strategies such as wildfire risk reduction, on-site stormwater management, aquatic ecosystem conservation, and restoration of water resources.

In contrast, the **LEED for Cities & Communities** certification does feature a specific focus on resilience by including the Resilience Planning strategy, which promotes the development of communities prepared to address climate, natural, and human-induced risks [114].

The **LEED v5** guide has identified a gap in the assessment of climate change-related risks and the integration of mitigation strategies. To address this, the new version includes three prerequisites related to climate resilience assessment, human impact, and carbon emissions.

In addition, the certification system has introduced new credits aimed at reducing the use of fossil fuels for building energy generation. This includes the introduction of an electrification credit designed to reduce reliance on fossil fuels for heating and other industrial processes, as well as the incorporation of decarbonization plans and operational carbon projections.

This new version of the certification places climate risk mitigation and greenhouse gas reduction at its core, making it a valuable reference framework for the design of both new and existing buildings in alignment with the goals of the Paris Agreement [115].

BREEAM, as a certification system focused on buildings, incorporates various measures into its evaluation framework aimed at reducing the impact of climate change on the built environment. To this end, it places a specific focus on structural resilience and building durability, aiming to reduce the frequency of structural component replacement due to natural wear or unexpected events such as hurricanes, earthquakes, or fires.

Additionally, the certification includes strategies to support climate change adaptation, such as reducing energy use and carbon emissions, enhancing thermal comfort, managing hazards, promoting low-carbon design, efficient water consumption, and surface water runoff management. All of these are approached from a holistic perspective, recognizing that effective climate change mitigation depends on a set of integrated actions [112].

Although this certification system primarily focuses on validating measures for infrastructure projects, the conceptual framework used to define sustainability strategies can be applied to any type of building. This is based on the understanding that it should serve as a transversal and integrative design tool involving institutions, governments, contractors, designers, and communities—fostering two-way communication for the establishment of sustainability policies during the design, validation, and implementation phases. The goal is to ensure that these strategies not only endure throughout the building's life cycle, but can also be adapted to evolving environmental conditions.

5.3. Cost associated with the implementation of certification system

A comprehensive analysis was conducted on sustainable projects in Latin America, focusing on understanding the costs associated with implementing sustainable construction strategies. The study was developed by the Colombian Green Building Council [116].

Investment

- Sustainable buildings required an average additional investment of 1.39%.
- Only 25% of projects reported an additional investment between 1% and 3%.
- 63% of projects had an additional investment of less than 1%.

Return on Investment

- 81% of projects reported a return on investment in less than one year.
- No project reported a return on investment exceeding five years.

Areas of Additional Investment

- Photovoltaic systems
- Rainwater treatment systems
- High-efficiency equipment
- Sustainable building consultancy

However, a 2016 study [117] shows that there is no conclusive evidence to assert that sustainable construction can compete in cost with its traditional counterpart, as results vary between -0.4% and 21%. Additionally, various studies indicate that the costs associated with sustainable construction vary significantly depending on the regional conditions of each project. Therefore, it is not possible to provide a generalized cost estimate for sustainable construction. Nonetheless, all studies agree that sustainable buildings achieve significant reductions in operational costs compared to conventional constructions, which represents a competitive investment advantage for these types of projects.



5.4. Success cases in the Caribbean and islands and Latin-American

Insight into certification cases in the Caribbean, highlighting their impact on construction, wellness, and climate change response

5.4.1. Kingston Courtyard by Marriott Hotel

The Marriott Hotel, located in Kingston, Jamaica, is a project certified under the LEED v3 BD+C: New Construction system, with certification granted on June 7, 2017, and a total area of 8,652 m². The project achieved Silver level certification, becoming the first LEED-certified project in Jamaica.

The project implemented significant sustainability strategies that allowed it to reach a high certification level, with particular emphasis on location and accessibility strategies. Additional measures included the reduction of the heat island effect and the minimization of both exterior and interior water consumption, earning 100% of the available points in the Water Efficiency category. In the energy category, the project stands out for its outstanding energy performance and enhanced refrigerant management.

Citibank is a new construction project located in Port-

Figure 13. Kingston Courtyard by Marriott Hotel



Source: Marriott Hotel, [En línea]. Available: <https://www.marriott.com/en-us/hotels/kincy-courtyard-kingston-jamaica/photos/>.
Citibank na Haiti

au-Prince, Haiti, certified under the LEED v3 BD+C: New Construction system on September 19, 2013, with a total

area of 1,368 m². The project achieved LEED Certified level, becoming the first non-residential LEED-certified project in Haiti.

The project implemented various sustainability strategies, with a strong focus on optimized energy performance. In addition to meeting the minimum energy efficiency requirement, it earned 7 additional points out of a possible 19 in this credit, which significantly improves the building's operational performance and contributes to the reduction of greenhouse gas emissions through decreased energy consumption. Additionally, the project excelled in water resource management, achieving 80% of the available points in the Water Efficiency category, for both indoor and outdoor use.

5.4.2. Four Points Georgetown – Guyana

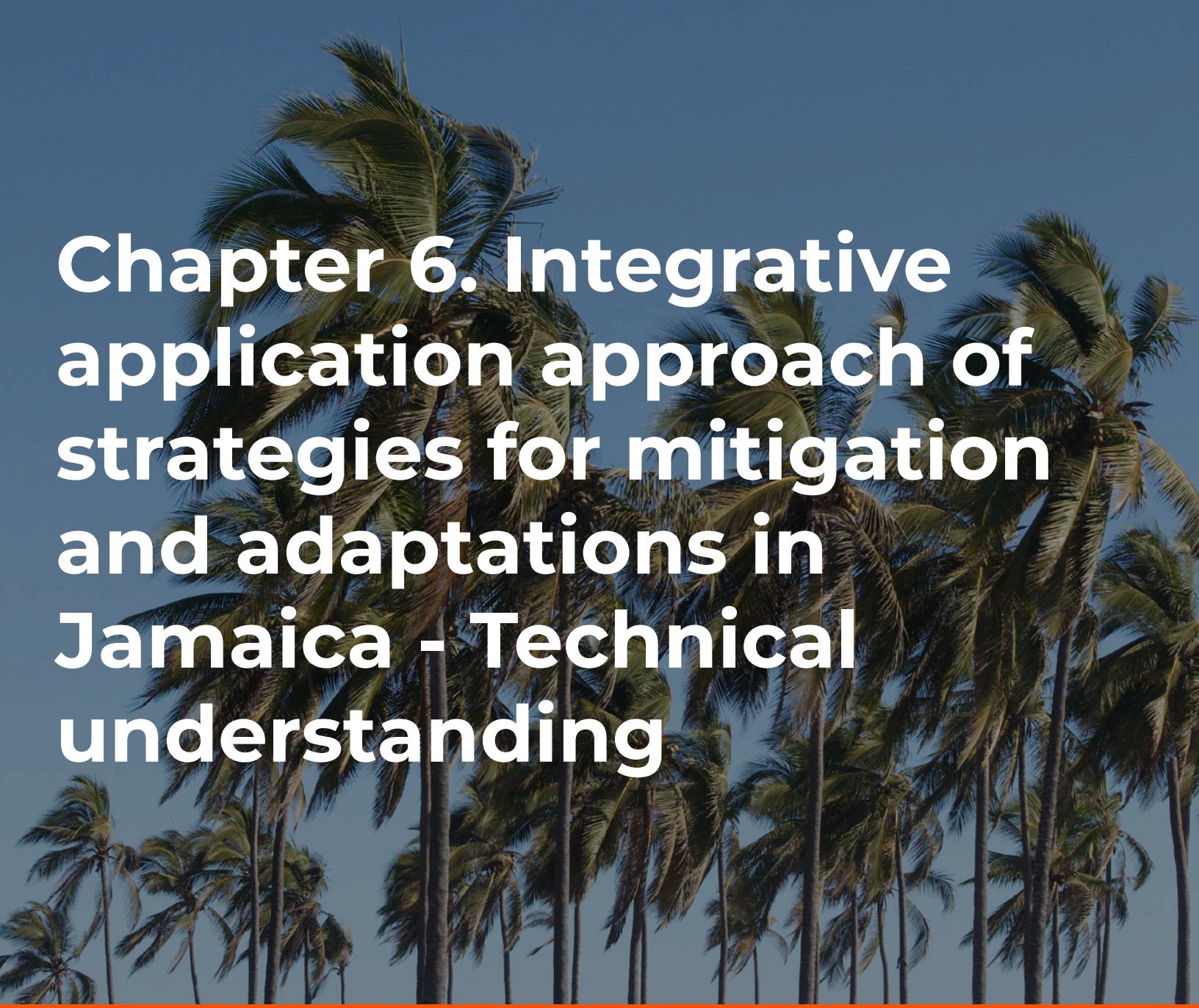
Four Points represents an upper-midscale brand within the Marriott International umbrella and earned an EDGE Advance Certification on 2023 highlighting many sustainability features including 43% of savings in Energy Consumption, 36% in water saving and 41% in Less embodied Carbon Materials. (162)

Figure 14. Four Points Georgetown



Source: <https://www.marriott.com/en-us/hotels/geofp-four-points-georgetown/overview/>

Four Points Georgetown ("the Project) is the development, construction and operation of a 172 room Four Points by Sheraton hotel in Georgetown, Guyana. The Project feature a restaurant, two bars, an outdoor pool, as well as 16,000-square feet of meeting space and 25,000-square feet of retail area.



Chapter 6. Integrative application approach of strategies for mitigation and adaptations in Jamaica - Technical understanding

6.1. Why passive design matters

In Jamaica, the built environment is predominantly composed of service-oriented and residential infrastructure, making this sector a key contributor to environmental impacts. As previously highlighted, buildings are responsible for over 30% of total greenhouse gas emissions, encompassing their full life cycle from construction through operational phases. Given this significant contribution, it is imperative to develop a comprehensive, data-driven framework to guide sustainable and resilient building design and construction in Jamaica.

6.1.1. Focusing on Residential Buildings

A study analysis of the Jamaican ideal building conditions shown below focuses on residential buildings because homes represent the largest sector of Jamaica's construction industry. More importantly, they directly shape the quality of life for Jamaican families.

How well does a building maintain comfortable temperatures naturally? Using ASHRAE Standard 55 as a benchmark, the analysis examines how smart design choices, proper insulation, and climate-responsive strategies can reduce cooling needs while keeping occupants comfortable. Based on ASHRAE Standard 62.1 guidelines, the study (see Figure 1). evaluates how natural ventilation can refresh indoor air, remove heat, and minimize dependence on mechanical cooling systems.

Getting these fundamentals right creates homes that consume less energy, stand up better to Jamaica's climate, and provide healthier, more comfortable living spaces for residents.

Figure 15. First and second floor of Passive House

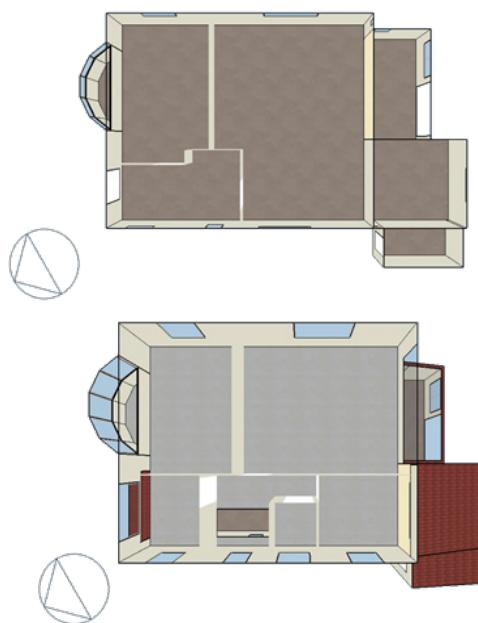
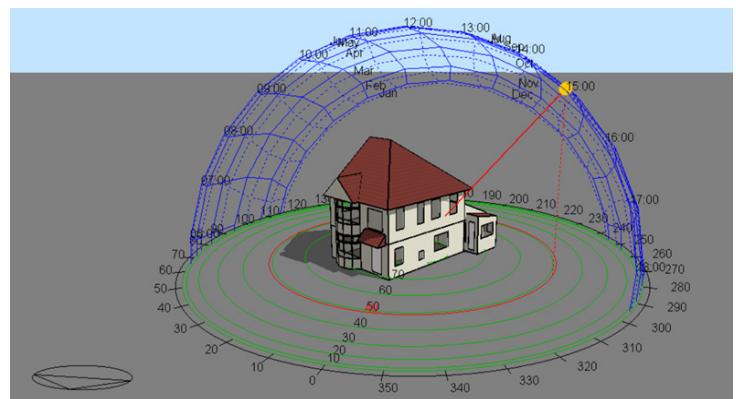


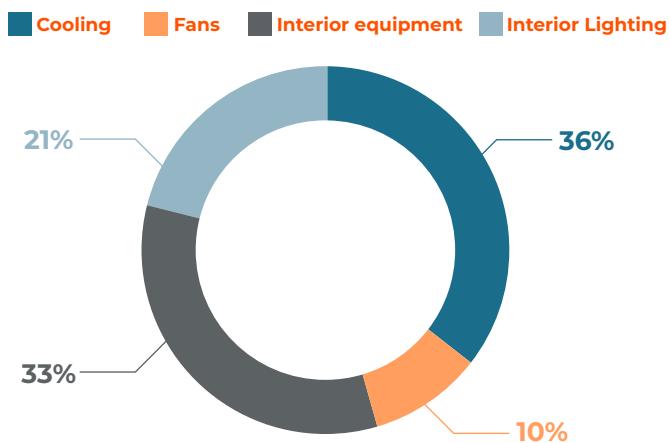
Figure 16. Passive House



6.1.2. Where Energy Goes in Jamaican Homes

In warm coastal climates like Jamaica's, cooling systems dominate household energy use, accounting for over 40% of total consumption (see Figure 3). This makes HVAC the single largest energy expense for most families.

Smart design can dramatically reduce this burden. By focusing on three key areas—passive cooling strategies, well-insulated building envelopes, and efficient mechanical systems—homes can stay comfortable while using far less energy. This approach not only lowers utility bills but also reduces strain on natural resources and cuts greenhouse gas emissions, building a more sustainable future for Jamaica.

Figure 17. Energy Consumption House ASHRAE Climate Zone 1A

6.1.3. Understanding Passive design

Passive House is a proven building approach that works with nature rather than against it. It carefully considers building shape, orientation, materials, and natural elements—like sun, wind, and shade—to keep spaces comfortable using minimal energy. Think of it as precision engineering applied to bioclimatic design, ensuring consistent comfort in any climate through smart planning rather than energy-hungry systems.

In Jamaica's warm climate, these passive design strategies work together to keep buildings cool naturally:

Building Orientation – Positioning the building based on the sun's path throughout the year helps determine the best placement for windows, walls, and shading to minimize heat gain.

High-Performance Glazing – Specially coated glass that blocks heat while allowing light in, reducing glare and keeping interiors cooler.

Insulated Building Envelope – Well-insulated walls, roofs, and floors act as a thermal barrier, preventing outdoor heat from penetrating indoor spaces.

Reflective Surfaces – Light-colored exterior finishes that bounce solar radiation away instead of absorbing it, naturally reducing cooling needs and combating urban heat.

Natural Ventilation – Strategic window and opening

placement that captures breezes, allowing fresh air to flow through and carry heat out without mechanical systems.

Window-to-Wall Ratio – The balance between glass and solid wall area. In warm climates, less glazing means less heat gain, since solid walls provide better insulation and thermal mass than windows.

Testing What Works - To identify the most effective combinations, 1,120 different building configurations were analyzed. Each was evaluated using ASHRAE Standard 55 criteria for thermal comfort, ensuring the results meet international standards for healthy, comfortable indoor environments.

The aim of this study is to establish overarching recommendations derived from the extensive range of potential design configurations for residential buildings. This does not suggest that only the design alternatives assessed herein are appropriate for Jamaica's construction context. Each building development should be evaluated individually, considering the unique contextual, climatic, and technological factors specific to the island. The variables presented in Table 6 illustrate construction strategies that are not only contextually relevant but also practical and straightforward to implement.

Table 6. Optimization Matrix for Passive House Envelope

Envelope optimisation			
Window to Wall Ratio	External Walls	Glass	Roof
20% - 60% with incremental intervals 5%	Wall, Mass, R-10.0 (1.76), U-0.088 (0.50)	Vidrio U=5.8 W/m2.K SHGC=0.8	Cast Concrete + Granite
	Concrete block 12 cm k=0.51 W/mK	Vidrio U=5.8 W/m2.K SHGC=0.5	Cast Concrete with SR 0.5
	Brick 12 cm k=0.72 W/mK	Vidrio U=2.8 W/m2.K SHGC=0.8	Cast Concrete with SR 0.6
	Cast Concrete 12 cm k=1.13 W/mK	Vidrio U=2.8 W/m2.K SHGC=0.5	Lightweight Cast Concrete with SR 0.7
	Wall Mass R-0.712		Roof insulating entirely above deck R-20
			Roof Metal building R-0
			Roof Metal building R-10

U-value: Thermal transmittance

SHGC: Solar Heat Gain Coefficient

R: Insulation Coefficient

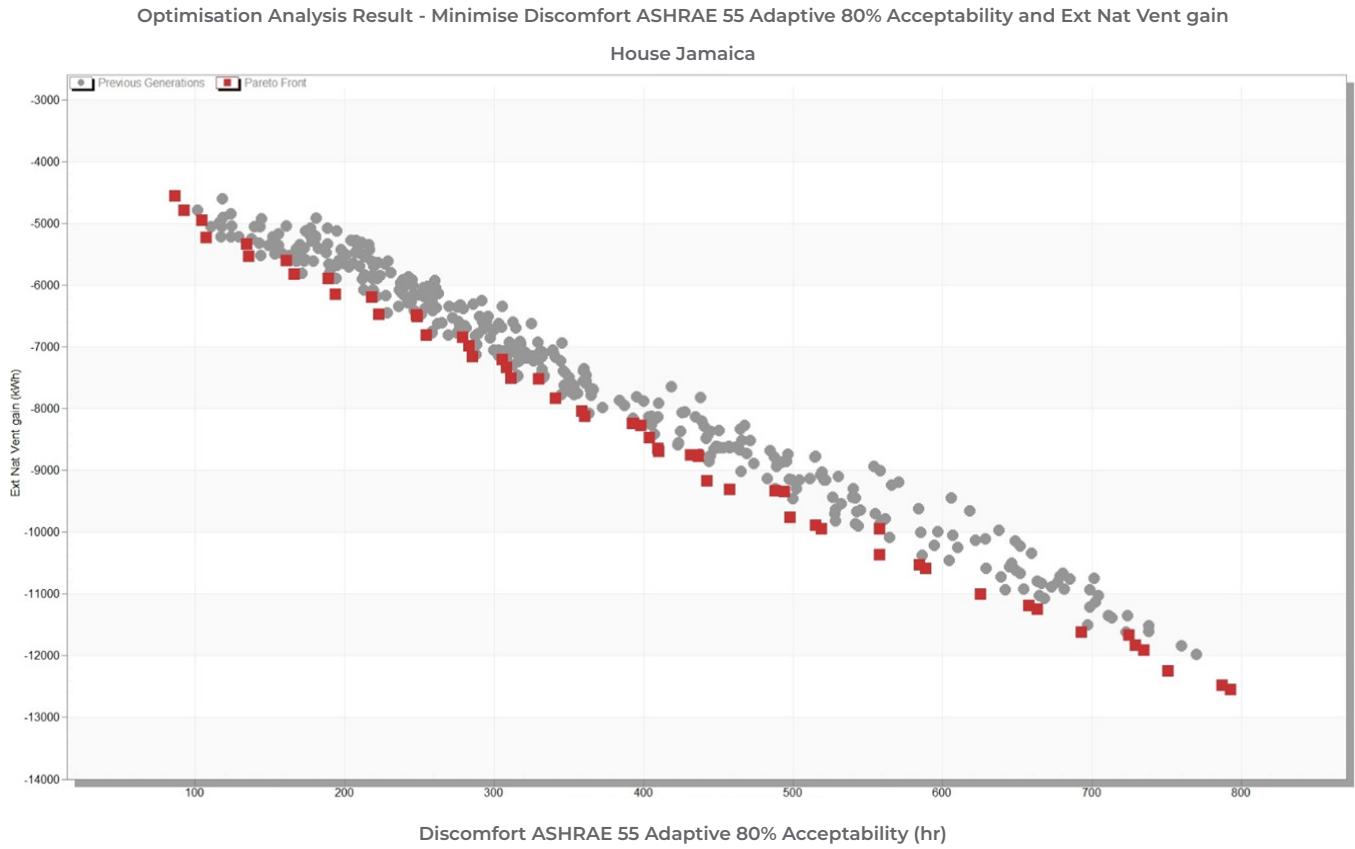
Presents the results that maximize both thermal performance and natural ventilation in the residential prototype, contributing to the creation of indoor environments that are not only thermally comfortable but also promote occupant health and well-being. The implementation of natural ventilation facilitates continuous air renewal, which induces controlled thermal losses that help maintain indoor temperatures within the acceptable limits defined by established thermal comfort standards, thereby enhancing the overall habitability and resilience of the dwelling.

Table 7. Optimal results for Passive House

Discomfort ASHRAE 55 Adaptive 80% Acceptability (hr)	External Natural Ventilation Gain (kWh)	Window to Wall %	Glazing type	External wall construction	Pitched roof construction (unocc)
87	-4557	25	U=5.8 W/m2.K SHGC=0.5	_Wall, Mass, R-10.0 (1.76), U-0.088 (0.50)	Lightweight Cast Concrete with SR 0.7
93	-4798	20	U=5.8 W/m2.K SHGC=0.5	_Wall, Mass, R-10.0 (1.76), U-0.088 (0.50)	CZ1 Residential, Roof, Ins Entirely above Deck, R-19.9c.i. (3.5c.i.), U-0.048 (.273)
104	-4960	25	U=2.8 W/m2.K SHGC=0.5	_Wall, Mass, R-10.0 (1.76), U-0.088 (0.50)	Cast Concrete with SR 0.6
108	-5234	20	U=2.8 W/m2.K SHGC=0.5	_Wall, Mass, R-10.0 (1.76), U-0.088 (0.50)	CZ1 Residential, Roof, Ins Entirely above Deck, R-19.9c.i. (3.5c.i.), U-0.048 (.273)
134	-5336	25	U=2.8 W/m2.K SHGC=0.5	_Wall, Mass, R-10.0 (1.76), U-0.088 (0.50)	Cast Concrete with SR 0.5

U-value: Thermal transmittance**SHGC:** Solar Heat Gain Coefficient**R:** Insulation Coefficient

Figure 4 illustrates the findings of the thermal optimization analysis conducted for the project, revealing a predominantly linear trend driven by the window-to-wall ratio (WWR). The analysis indicates that the highest levels of thermal discomfort occur at WWR values exceeding 50%, particularly when clear glazing with a Solar Heat Gain Coefficient (SHGC) of 0.8 is employed. Conversely, optimal thermal comfort conditions are observed at WWR values below 30%, in combination with the use of solar-control glazing. These results highlight the critical role of façade design variables, particularly glazing type and aperture ratio, in enhancing thermal performance within residential buildings.

Figure 18. Results of the Optimization Process for Passive House Strategies

In summary, for residential buildings in Jamaica, the implementation of strategies aimed at mitigating internal heat gains resulting from solar radiation and elevated outdoor temperatures is essential to achieving optimal indoor air quality and thermal comfort. As evidenced in Table 2, the adoption of high-reflectance roofing systems, reduced window-to-wall ratios (WWR), and solar-control glazing demonstrates the highest effectiveness in improving building thermal performance. Furthermore, the integration of thermally insulated exterior wall assemblies with high surface reflectance significantly enhances energy efficiency and occupant comfort. Across all evaluated configurations, insulated exterior walls consistently emerge as a critical design element for optimizing residential building performance in warm climates.

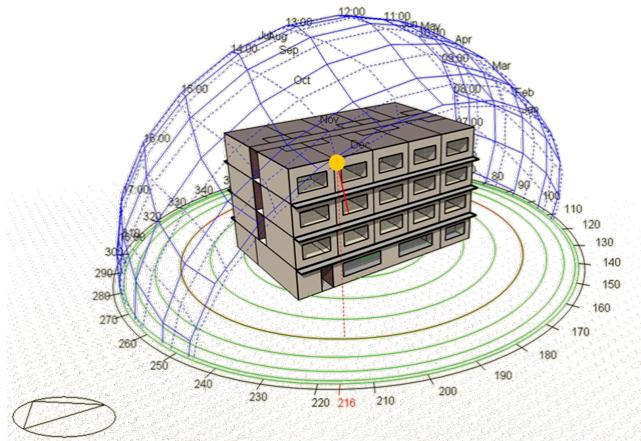
6.1.4. Passive design in non-residential projects

The reduction of greenhouse gas emissions and the optimization of a project's environmental performance can be achieved by leveraging the site's climatic conditions through the implementation of various strategies aimed at enhancing thermal comfort, natural ventilation, and daylight utilization. However, in non-residential projects, passive design strategies alone are often insufficient to meet the required comfort and operational performance standards. Therefore, these strategies should be complemented by high-efficiency active systems, such as luminaires with high luminous efficacy and HVAC systems with coefficients of performance (COP) greater than 4.5, among other energy-efficient technologies.

For the present analysis, it is important to note that in Jamaica, the main economic sector is services—particularly tourism, which contributes significantly to the country's gross domestic product (GDP). Consequently, a representative building providing hospitality services was selected for this study, as illustrated in Figure 19.

Figure 20 illustrates the typical energy consumption distribution for a hotel building located in a Type 1A

Figure 19. Model Hotel project



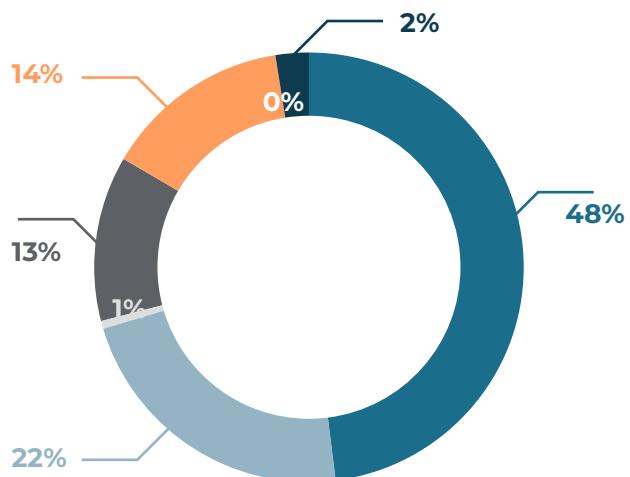
climate, such as that of Jamaica. The data show that the HVAC system represents the largest share of total energy consumption, accounting for approximately 62%, followed by lighting, which contributes around

22%. Consequently, passive architectural design strategies play a critical role in reducing greenhouse gas emissions. They also encourage design approaches that integrate natural lighting as a key component to reduce daytime lighting demand without causing a significant increase in solar heat gains that could, in turn, elevate HVAC energy use.

Figure 20. Distribution of Consumption

Energy Consumption Hotel ASHRE Climate Zone 1A

█ Cooling █ Interior Lighting █ Exterior Lighting █ Fans
█ Interior Equipment █ Pumps █ Services water heating



A total of 330 simulations were carried out to assess the hotel's thermal performance using the adaptive comfort method described in ASHRAE Standard 55-2023, as well as its relationship with indoor air quality. The analysis was based on the optimization matrix presented in Table 8, which includes the passive design strategies described in Section 7.1.3.

The results show a clear correlation between high-performance building envelopes and reduced solar heat gains. Walls with high thermal inertia also contribute positively by absorbing heat during the day and releasing it at night, helping to maintain more stable indoor conditions.

The key strategies identified to support good thermal performance and indoor air quality include:

- Insulated roofing with high reflectivity
- Solar control glazing with a Solar Heat Gain Coefficient (SHGC) below 0.5
- A high window opening ratio to enhance natural ventilation
- North–south orientation for the main façades
- A high window-to-wall ratio (WWR) to optimize daylight provided that high reflectivity is maintained in the opaque envelope

Figure 21. Optimization Results

Optimisation Analysis Result - Minimise Discomfort ASHRAE 55 Adaptive 80% Acceptability and Ext Nat Vent gain

Hotel OSH

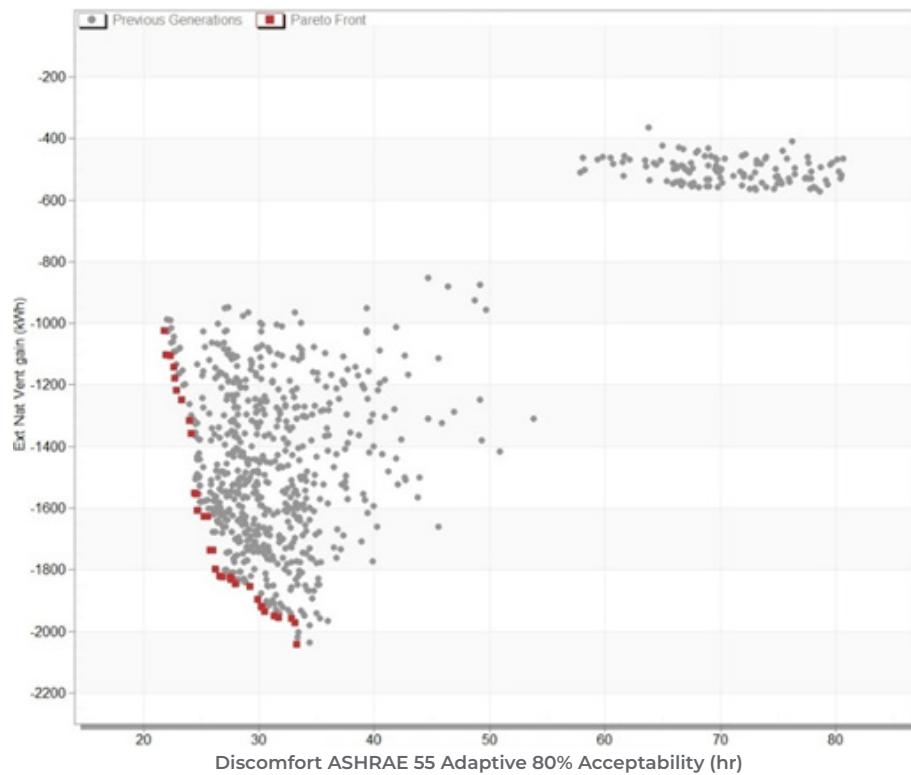


Table 8. Optimization Matrix**Envelope optimisation**

Window to Wall Ratio	External Walls	Glass	Roof	Site Orientation	Window Free aperture
20% - 60% with incremental intervals 5%	Wall, Mass, R-10.0 (1.76), U-0.088 (0.50)	Vidrio U=5.8 W/m2.K SHGC=0.8	Cast Concrete + Granite	0°	0%
	Concrete block 12 cm k=0.51 W/mK	Vidrio U=5.8 W/m2.K SHGC=0.5	Cast Concrete with SR 0.5	45°	25%
	Brick 12 cm k=0.72 W/mK	Vidrio U=2.8 W/m2.K SHGC=0.8	Cast Concrete with SR 0.6	90°	
	Wall Brick U value 0.251 R 3.979 SR 0.3	Vidrio U=2.8 W/m2.K SHGC=0.5	Lightweight Cast Concrete with SR 0.7	135°	50°
	Walls adobe (U value: 3,05 R value:0,33 SRI:80)		Flat roof concrete (U value:2,22 R value:0,45 SRI:80)		
			Sandwich Panel Roof	180°	75°

As shown in Table 9, there are various design options based on the orientation and architectural configuration of hotel projects that can achieve favorable thermal and ventilation performance under local design conditions. These strategies help reduce the energy consumption of active systems such as HVAC and artificial lighting, which, as illustrated in Figure 20, represent the largest share of total energy use.

A clear trend can be observed toward maintaining high window opening ratios, even in buildings with a low window-to-wall ratio (WWR). This approach takes advantage of the natural wind resource, promoting heat dissipation within interior spaces. Conversely, when window openings are completely closed, thermal comfort decreases significantly—as shown in the right-hand group of Figure 21—where, despite using different envelope configurations, the thermal comfort levels remain outside the desired range.

When high WWR values are applied to the longer façades, the envelope must incorporate high-reflectivity strategies. This requires the use of roofs and wall finishes with a solar reflectance greater than 0.8, typically achieved with polar white coatings. These should be combined with high-performance solar control glazing characterized by a low Solar Heat Gain Coefficient (SHGC) and a high Visible Light Transmittance (VLT). In this regard, Low-E glass technologies available in the market are particularly suitable, as conventional solar control glass tends to darken interior spaces, leading to higher lighting energy consumption.

Although these strategies do not aim to eliminate the need for HVAC systems—which remain essential for this type of building—they do enable a significant reduction in electricity consumption. This reduction directly contributes to lowering greenhouse gas emissions, a particularly relevant goal in Jamaica, where the energy matrix still relies heavily on fossil fuels.

Table 9. Results Summaries

Discomfort ASHRAE 55 Adaptive 80% Acceptability (hr)	Ext Nat Vent gain (kWh)	WWR %	Flat roof construction	Glazing type	External wall	Free Aperture	Site orientation (°)
24.5	-1553.0	60	Sandwich Panel Roof	Glass 8mm SHGC 0,3 U: 4,7	Walls adobe (U value:3,05 R value:0,33 SRI:80)	AP75	0
25.8	-1736.9	60	Cast Concrete + Granite 110 mm	Glass U=5.8 W/m2.K SHGC=0.5	Walls adobe (U value:3,05 R value:0,33 SRI:80)	AP75	0
31.7	-1956.6	60	Concrete roof 12 cm SR 0.5	Glass U=2.8 W/m2.K SHGC=0.8	Wall, Mass, R-10.0 (1.76), U-0.088 (0.50)	AP75	135
22.4	-1106.3	25	Flat roof concrete (U value:2,22 R value:0,45 SRI:80)	Glass U=2.8 W/m2.K SHGC=0.8	Wall Brick U value 0.251 R 3.979 SR 0.3	AP75	0
26.0	-1737.0	60	Cast Concrete + Granite 110 mm	Glass U=2.8 W/m2.K SHGC=0.8	Walls adobe (U value:3,05 R value:0,33 SRI:80)	AP75	180

6.2. Storm resilience

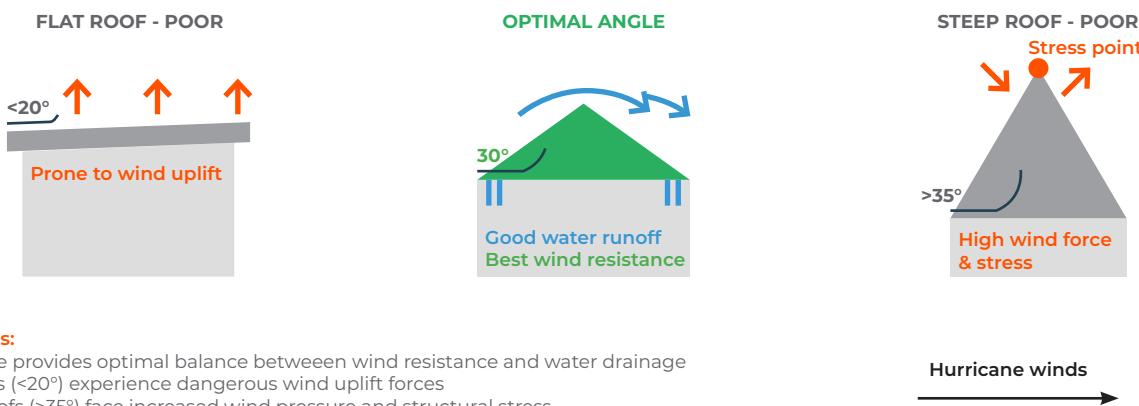
When it comes to protecting homes from **hurricanes in Jamaica**, the roof is one of the most critical components. The **design, materials, and construction** methods used for roofing play a vital role in determining its ability to withstand strong winds and flying debris. Below is an overview of what makes roofing more hurricane-resistant in Jamaica:

- Design considerations** - Proper roof geometry, slope angles, and structural integration with the building frame help distribute wind loads effectively and reduce uplift forces.
- Material selection** - Durable materials such as metal roofing, reinforced concrete tiles, or properly installed asphalt shingles with high wind ratings provide better resistance to hurricane-force winds.
- Construction methods** - Secure fastening systems, proper installation techniques, and adequate structural connections between the roof and walls are essential for maintaining roof integrity during extreme weather events.

6.2.1. Building resilient roofs

- Optimal Roof Angle**

Figure 22. Optimal Roof Angles for Hurricane Resistance in Jamaica



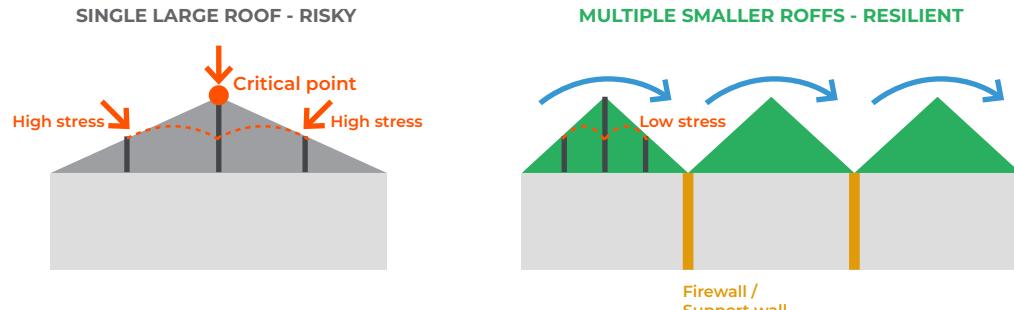
Adapted from: The Gleaner Jamaica, Stormproof your roofs - July 22,2024; tips by Richard Picart – Director of strategic project development at the Urban Development Corporation.

The diagram uses arrows to show wind patterns and includes visual indicators for water runoff and stress points and illustrates the three roof angle scenarios (170):

- Flat roofs (less than 20°) - Shown in red as problematic because they experience dangerous wind uplift forces that can literally lift the roof off the building.
- Optimal angle (30°) - Shown in green as the ideal choice because it deflects wind effectively while allowing good water drainage.
- Steep roofs (over 35°) - Shown in red as problematic because they present a large surface area to hurricane winds, creating excessive structural stress.

- **Roof spans**

Figure 23. Hurricane-Resistant Roof Design: Multiple Spans vs Single Span



Problems:

- Long unsupported spans
- Single point of failure
- High material stress
- Total roof loss if failure occurs

Benefits:

- Shorter spans = less stress
- Redundancy if one section fails
- Independent structural support
- Easier repair and maintenance

Adapted from: The Gleaner Jamaica, Stormproof your roofs - July 22,2024; tips by Richard Picart – Director of strategic project development at the Urban Development Corporation.

This diagram illustrates the key concept of using multiple smaller roof spans instead of one large roof for better hurricane resistance. Here's what it shows (170):

Left side (Single Large Roof - Risky):

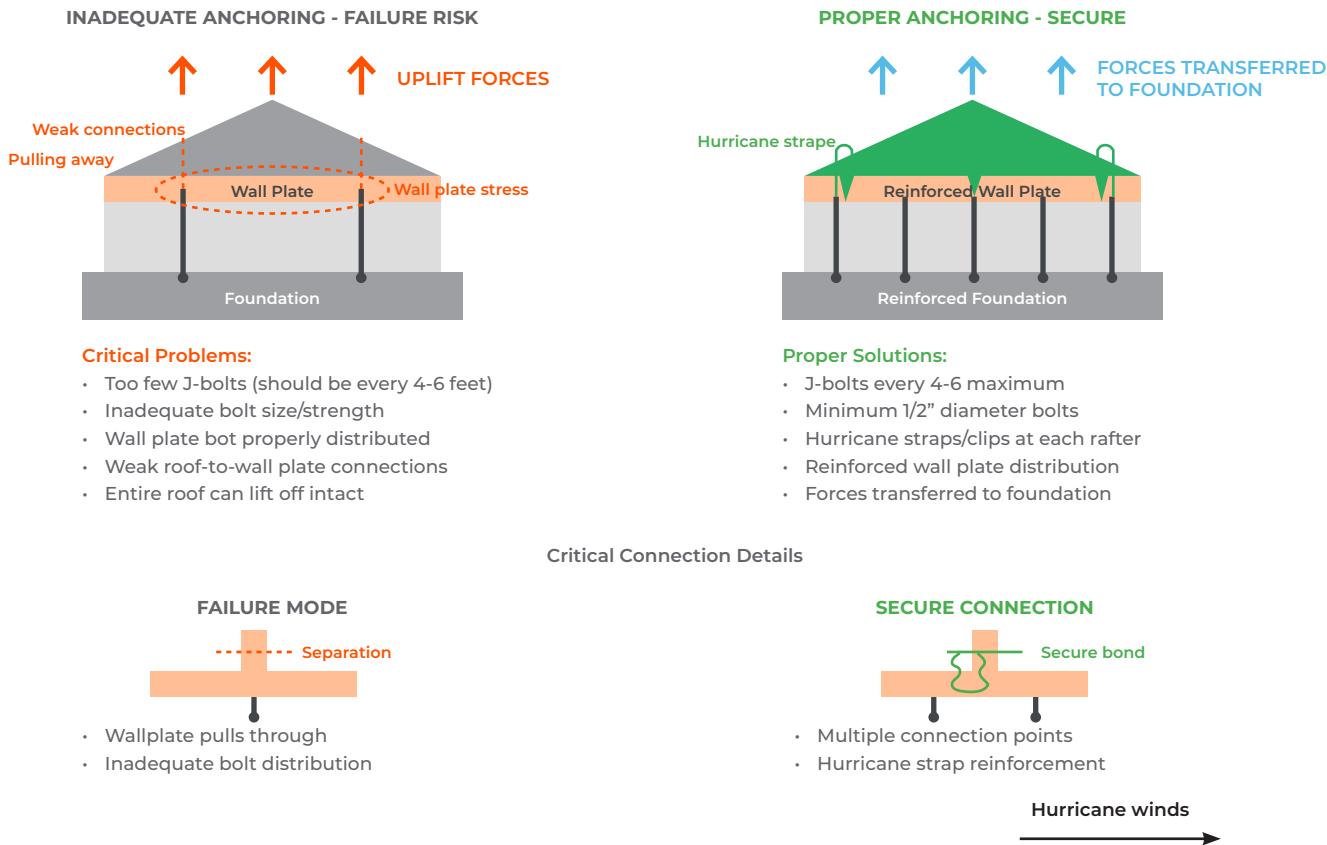
- One continuous roof structure with long unsupported spans.
- High stress points along the roof beams
- Single point of failure that could result in total roof loss
- Maximum wind pressure concentrated on the entire surface

Right side (Multiple Smaller Roofs - Resilient):

- Three separate roof sections with shorter spans
- Independent structural support for each section
- Compartmentalized design with firewalls/support walls between sections
- Lower stress distribution across each smaller span

- **Roof lifting and wall plate failure**

Figure 24. Roof Anchoring: Critical Connection Points



Adapted from: The Gleaner Jamaica, Stormproof your roofs - July 22, 2024; tips by Richard Picart – Director of strategic project development at the Urban Development Corporation.

This diagram illustrates the key concept of using multiple smaller roof spans instead of one large roof for better hurricane resistance. Here's what it shows (170):

Left Side - Inadequate Anchoring (Dangerous):

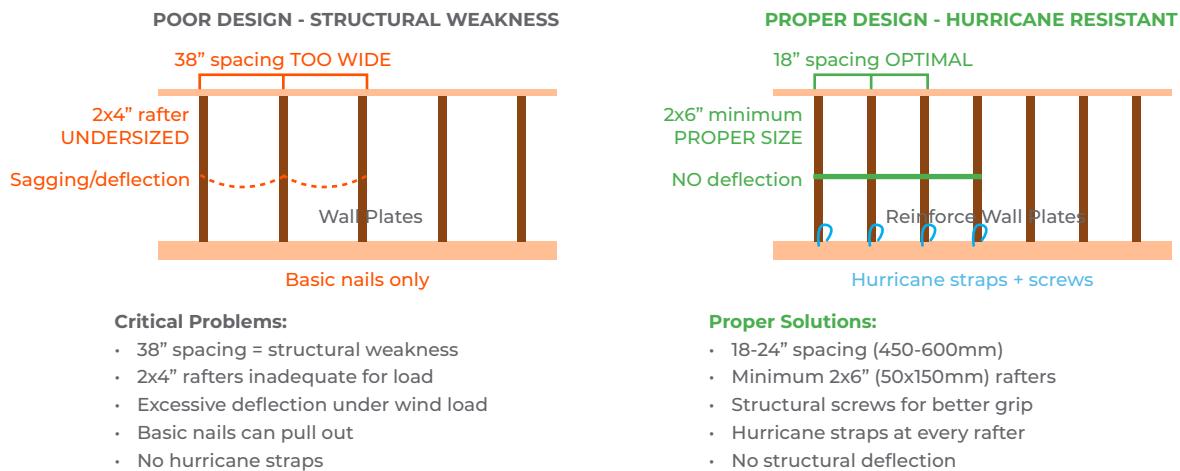
- Too few J-bolts with poor spacing
- Weak connections between roof and wall plate
- Wall plate stress concentration at few points
- Risk of entire roof lifting off intact due to inadequate anchoring
- Shows how uplift forces can overcome weak connection points

Right Side - Proper Anchoring (Secure):

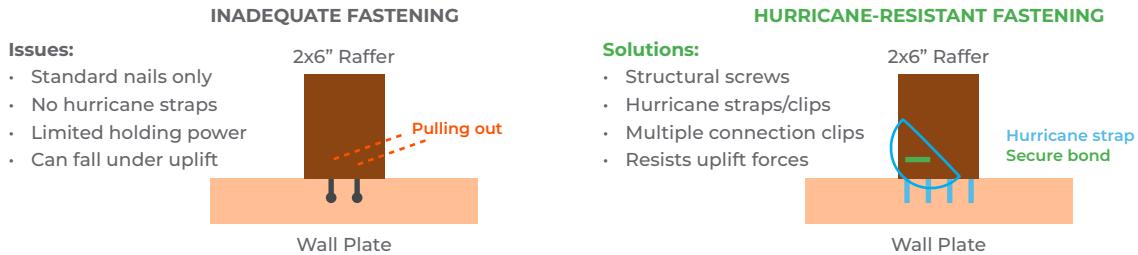
- J-bolts spaced every 4-6 feet maximum
- Hurricane straps/clips connecting each rafter to the wall plate
- Reinforced wall plate for better load distribution
- Multiple secure connection points
- Forces properly transferred down to the foundation

- **Rafter and batten spacing**

Figure 25. Hurricane Resistant Rafter Design: Spacing, Sizing, and Fastening



Critical Fastening Methods Comparison

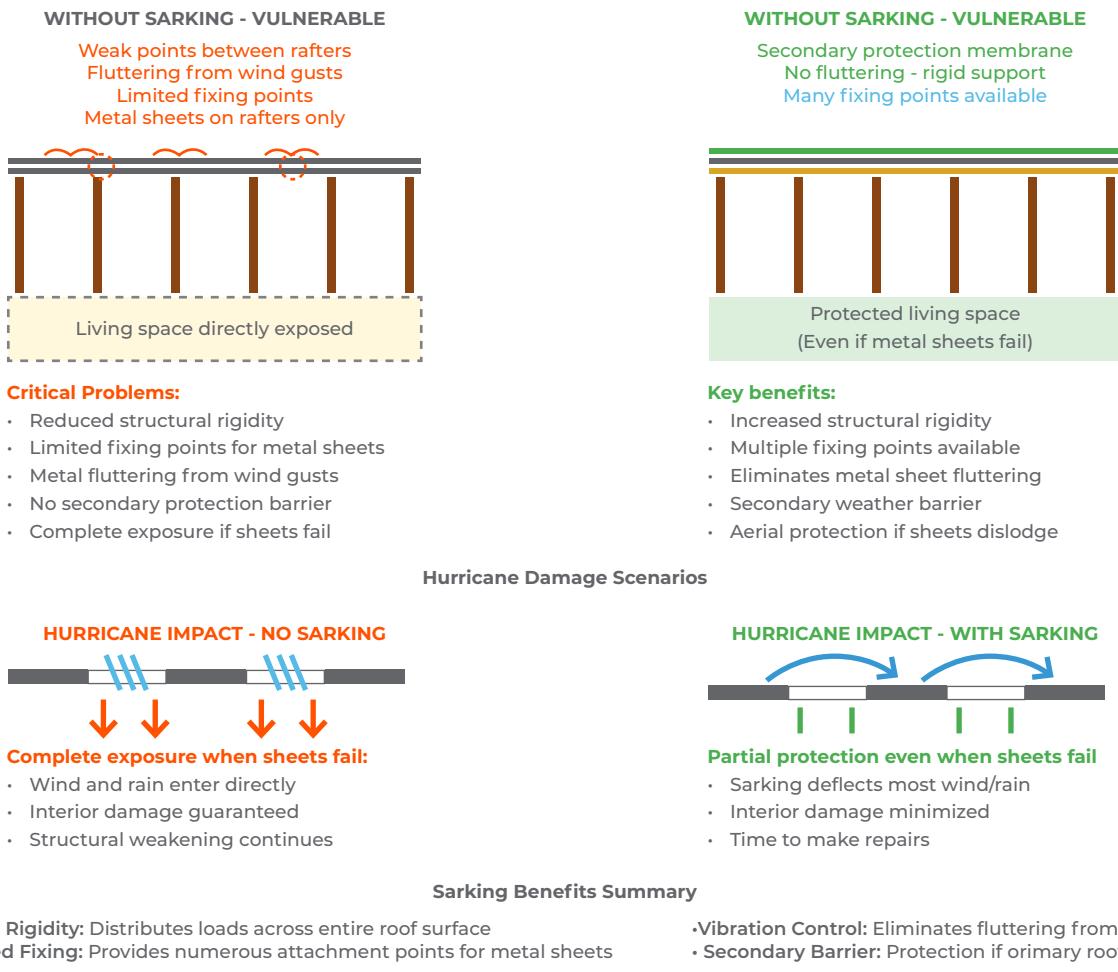


Adapted from: The Gleaner Jamaica, Stormproof your roofs - July 22,2024; tips by Richard Picart – Director of strategic project development at the Urban Development Corporation.

To ensure hurricane resistance, roofing systems must avoid the combination of excessive rafter spacing and undersized structural members, as this significantly compromises the roof's ability to withstand wind loads. Optimal rafter spacing should range between 18-24 inches (450-600mm) depending on the specific design requirements, with no rafter smaller than 2x6 inches (50x150mm) to provide adequate load-bearing capacity. Equally critical is the fastening methodology - basic nailing alone is insufficient for hurricane conditions. Instead, structural screws combined with hurricane straps at every rafter connection point dramatically increase the roof's resistance to wind loading and uplift forces. This comprehensive approach to spacing, sizing, and fastening creates a robust structural system capable of surviving Jamaica's most severe hurricane conditions while preventing catastrophic roof failure (170):

- **Ridge and end caps**

Figure 26. Sarking and Under support: Critical Hurricane Protection



Adapted from: The Gleaner Jamaica, Stormproof your roofs - July 22,2024; tips by Richard Picart – Director of strategic project development at the Urban Development Corporation.

This comprehensive diagram illustrates the critical importance of sarking (plywood or tongue-and-groove boards) for hurricane resistance (170):

Left Side - Without Sarking (Vulnerable):

- Metal sheets attached directly to rafters only
- Limited fixing points (only at rafter locations)
- Metal sheets flutter and vibrate from wind gusts
- Weak points between rafters create vulnerabilities
- Complete exposure to elements if sheets fail
- No secondary protection barrier

Right Side - With Sarking (Protected):

- Continuous plywood/tongue-and-groove layer under metal sheets
- Multiple fixing points available across entire surface
- Rigid support eliminates fluttering and vibrations
- Enhanced structural rigidity distributes loads
- Secondary weather barrier provides protection
- Living space remains partially protected even if metal sheets fail

- Overhangs and design functionality

Figure 27. Sarking and Under support: Critical Hurricane Protection



High Risk Factors:

- Long overhang = high uplift force
- Exposed rafters create wind friction
- Turbulent airflow increases loads
- Higher structural stress
- Greater chance of failure

Benefits:

- Shorter overhang = reduced uplift
- Boxed eaves eliminates friction
- Smooth airflow reduces loads
- Low structural stress
- Enhanced hurricane survival

Eave Design Comparison: Exposed vs Boxed



WIND HITS EACH RAFTER INDIVIDUALLY:

- Creates turbulence and friction
- Increases structural loads
- Higher chance of rafter failure

WIND FLOWS SMOOTHLY OVER SURFACE:

- No turbulence or friction
- Reduced structural loads
- Better hurricane resistance

Adapted from: The Gleaner Jamaica, Stormproof your roofs - July 22,2024; tips by Richard Picart – Director of strategic project development at the Urban Development Corporation.

Top Left - Long Overhang with Exposed Eaves (High Risk) (171):

- Long overhang (24"+ / 600mm+) creates high uplift forces
- Exposed rafters create wind friction and turbulence
- Each rafter acts as an individual obstruction to wind flow
- Higher structural stress and greater chance of failure

Top Right - Short Overhang with Boxed Eaves (Low Risk) (171):

- Short overhang (12-18" / 300-450mm) reduces uplift forces
- Boxed eaves with soffit create smooth, continuous surface
- Wind flows smoothly over the structure without friction
- Significantly reduced structural load

6.2.2. Solar PV Integration with Hurricane-Resistant Roofs

Most solar panels are constructed to withstand wind loads of approximately 2,400 pascals (Pa), equivalent to winds of about 140 mph (172) (173). This rating aligns with Category 4 hurricane wind speeds based on the Saffir-Simpson Hurricane Wind Scale (173). However, for Jamaica and the Caribbean, which are susceptible to Category 4 and 5 storms with wind speeds exceeding 210 km/h (130 mph), panels rated at 5,400 Pa or higher are strongly recommended (174).

- **Testing Requirements**

Solar panels undergo dynamic mechanical load (DML) testing, which simulates cyclic push-pull forces from hurricane winds through 1,000 cycles at frequencies of 3-7 cycles per minute (175).. The minimum IEC 61215 standard requires panels to withstand 2,400 Pa loading, but for hurricane-prone regions, modules certified to withstand 5,400 Pa provide an adequate safety margin (175)..

- **Regional Considerations**

Florida, for example, requires most PV arrays to withstand 160 mph winds and 3,300 pascals of pressure [4]. Jamaica should consider similar enhanced standards, as the standard international certification translates to wind speeds of approximately 100 mph, which Category 3 hurricanes already exceed (174)..

- **Critical Installation Practices**

During a hurricane, solar panels face three primary destructive forces: positive pressure (direct wind pushing down), negative pressure or uplift (air moving rapidly over the surface creating lift), and oscillating loads (rapid shifts between positive and negative pressure causing flexing and vibration) (174)..

- **Installation Best Practices**

Based on analysis from Caribbean hurricane impacts (176):

Table 10. Installation Best Practices

Category	Practice	Specifications/Details
1. MODULE ATTACHMENT		
Module Attachment	Bolting Method	Use through-bolting instead of top-down clamps where possible
	Clamp Type (if required)	Use clamps that hold modules individually or independently
	Hardware Security	Implement vibration-resistant hardware or independently
2. RACKING SYSTEMS		
Racking Systems	Load Rating	Specify high-load racking system rated for uplift forces up to 5,400 Pa
	Structural Support	Ensure adequate lateral racking support and proper bolt torque specifications
	Ballast Restriction	Avoid ballasted-only systems on pitched roofs
3. DESIGN CONSIDERATIONS		
Design Considerations	Panel Placement	Avoid overhanging panels on pitched roofs
	Edge Protection	Increase attachment spacing near roof edges where wind uplift risks are highest
	Manufacturer Verification	Confirm with racking manufacturers that site conditions comply with their wind tunnel testing assumptions

6.2.3. Impact Resistant Windows

Impact-resistant windows and doors are critical for Jamaica's hurricane-prone environment, serving as the primary defense against extreme winds, flying debris, and storm surge. These specialized systems can withstand winds exceeding 200 mph, providing protection well beyond Category 5 hurricane thresholds (177).

Advanced Technology and Performance

High-performance impact systems utilize laminated glass with multiple layers bonded by specialized interlayers, particularly Structural Glazing Polyurethane (SGP), which can double the system's pressure resistance. Heat-strengthened glass combined with reinforced aluminum frames creates a composite barrier that maintains integrity under severe impact loading. This technology ensures the glass remains intact even when shattered, preventing catastrophic failure that could compromise the building envelope (177).

Multi-Functional Benefits

Beyond storm protection, these systems provide year-round advantages including superior sound reduction (up to 40% noise attenuation), UV protection (blocking 99% of harmful radiation), and enhanced energy efficiency through improved thermal performance. The robust construction also creates a significant security barrier against forced entry, with the laminated glass remaining intact even when damaged. (177).

Economic and Insurance Advantages

Impact-resistant windows and doors often qualify homeowners for substantial insurance premium reductions, with discounts ranging from 10-45% on wind coverage. The enhanced security profile and proven hurricane protection capabilities provide long-term value through reduced insurance costs, energy savings, and eliminated need for temporary storm protection measures like shutters or plywood (177).

Installation and Operational Benefits

Professional installation ensures optimal performance and integration with the building's structural systems. Unlike traditional hurricane shutters requiring pre-storm deployment, impact-resistant systems provide continuous protection without homeowner action, eliminating preparation stress while ensuring constant readiness. For Jamaica homeowners, these systems

represent a comprehensive investment in property protection, safety, and home value enhancement that addresses the unique challenges of Caribbean hurricane exposure (174).

6.2.4. Wind-Resistant Structural Design

Buildings in hurricane-prone Caribbean regions, including Jamaica, should be designed to withstand wind speeds of up to 150 miles per hour (mph) [9] (178). The Caribbean Uniform Building Code (CUBiC) provides building standards for the Caribbean region to reduce structural vulnerability to natural hazards, though CUBiC remains largely a guideline rather than legally enforceable code in many territories [10] (179). A properly engineered concrete structure built to these enhanced standards would be designed to resist Category 4 hurricane winds, which range from 130 to 156 mph, providing significant protection against major hurricane impacts.

Table 11. Building Materials for homes and buildings in Jamaica**CONCRETE:**

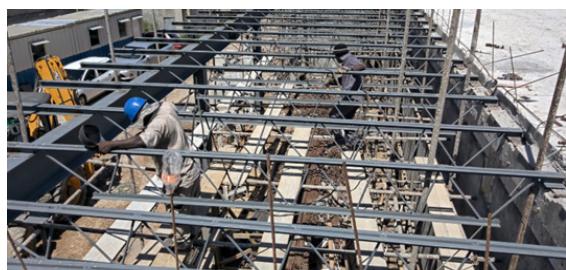
- Concrete structures excel at resisting hurricane-force winds, critical during storm season. They're also naturally resistant to termites, rot, and moisture damage common in tropical climates.
- Used for foundations, walls, and floors. Modern Jamaican homes typically use reinforced concrete blocks for walls, strengthened with steel for added wind resistance.
- Concrete's thermal mass absorbs heat during the day and releases it at night, naturally regulating indoor temperatures and reducing air conditioning costs.

**TIMBER:**

- Commonly used for roof framing, flooring, window and door frames, and exterior cladding. Many Jamaican homes combine timber with concrete construction for optimal performance.
- Regular upkeep is essential for timber longevity. Apply quality wood sealants periodically to protect against moisture and pests.

**STEEL:**

- Primarily used for structural framing, roof systems, and concrete reinforcement. Also effective for exterior elements like gates, fences, and storm-resistant features.
- When properly insulated, steel-framed homes provide excellent thermal performance and energy efficiency, helping maintain comfortable indoor temperatures year-round.

**METAL ROOF:**

- Metal roofs withstand winds up to 160 mph compared to asphalt shingles' 60 mph rating, using interlocking panels and concealed fasteners for superior wind resistance.
- They achieve Class 4 Impact Resistance—the highest rating—continuing to protect even when dented by flying debris.
- Metal roofing maintains structural integrity throughout its extended service life without adhesive breakdown.
- Professional installation is essential to achieve full performance capabilities.

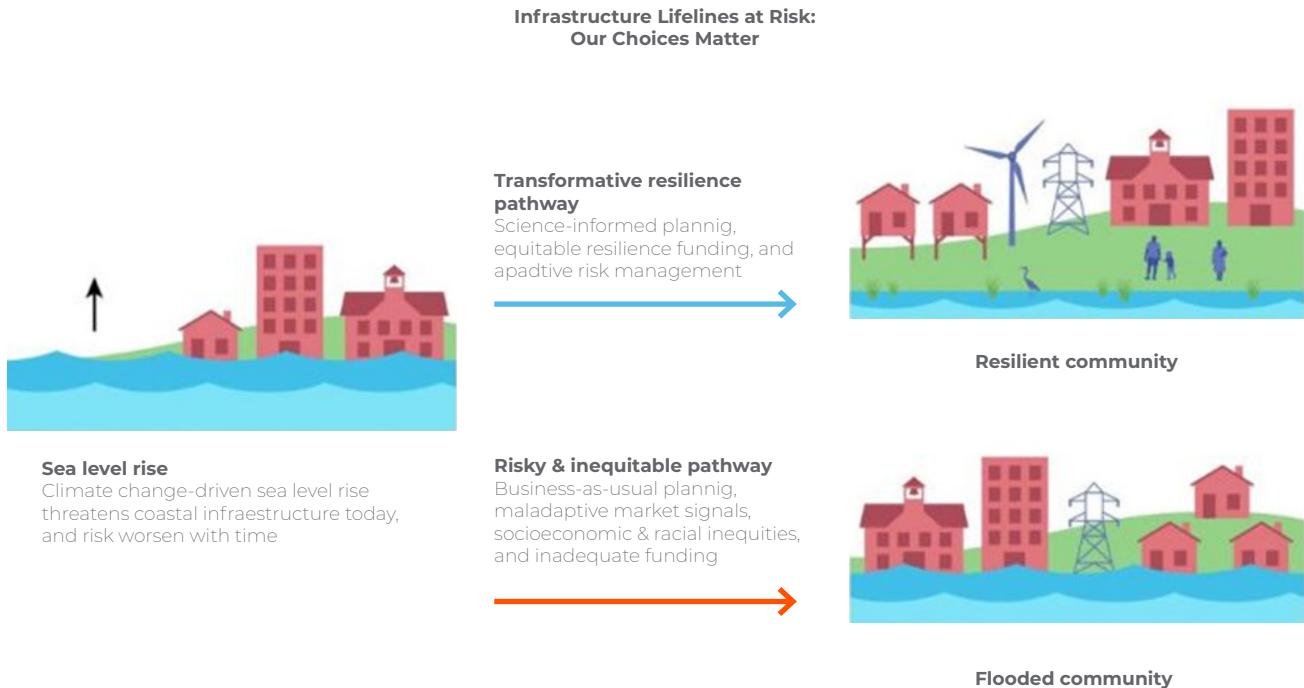


6.3. Flood Resilience

6.3.1. Plan for near- and long-term risk.

Communities must collaboratively evaluate their physical exposure and vulnerability to sea level rise hazards while developing comprehensive adaptation strategies. All infrastructure planning, design, construction, and maintenance activities should integrate scientific sea level rise projections and coastal flood modelling to ensure long-term resilience and sustainable development.

Figure 28. Looming Deadlines for Coastal Resilience



Source: <https://www.ucs.org/resources/looming-deadlines-coastal-resilience#read-online-content>

6.3.2. Proper Site Elevation:

Foundation Elevation and Design Requirements

The cornerstone of flood-resilient design lies in proper foundation elevation above anticipated flood levels. Base Flood Elevation (BFE) represents the elevation at which floodwaters are expected to rise during a base flood event, while Design Flood Elevation (DFE) is the actual design elevation [11] (180). The elevation process begins with consulting flood zone maps or historical flooding records to determine the site's flood classification and corresponding Base Flood Elevation (BFE). In Jamaica, this assessment is essential due to the island's vulnerability to river overflow, coastal storm surge, and urban drainage failures. The following table identifies Jamaica's primary flood-prone areas and their real estate implications.

Table 12. Flood Causes and Implication in Jamaican Homes

Region	Parish	Flood-prone Areas	Primary Flood Causes	Real Estate Implications
Interior	Clarendon	May Pen	Rio Minho river overflow	Higher insurance premiums, flood modifications required
	St. Catherine	Portmore, Spanish Town	Coastal plains, low elevation, river proximity	Enhanced drainage systems needed
	Kingston & St. Andrew	New Haven, Mona, Hope River areas	Poor drainage, river overflow	Flood-resistant construction essential
Eastern/ Southern	St. Thomas	Yallahs, Morant Bay	River systems, coastal storm surge	Dual flood/surge protection required
	St. Elizabeth	Black River wetlands	Prolonged rainfall, wetland overflow	Wetland development restrictions
Western Coastal	Hanover	Lucea	Hurricane storm surge	Storm-resistant construction
	Westmoreland	Negril	Coastal flooding, storm surge	Elevated construction recommended
	St. James	Parts of Montego Bay	Hurricane storm surge	Comprehensive flood insurance needed

Adapted from: [Jamaica-homes.com](https://jamaica-homes.com); Flood Zone, October 2024

Site preparation requires a comprehensive topographic survey conducted by licensed land surveyors to establish precise elevation relationships. If the DFE is 13 feet and the land elevation is 7 feet, the house needs to be built 6 feet above ground (180). This calculation demonstrates the critical relationship between site conditions and required elevation heights for flood protection.

Open Foundation Systems for Flood Resistance

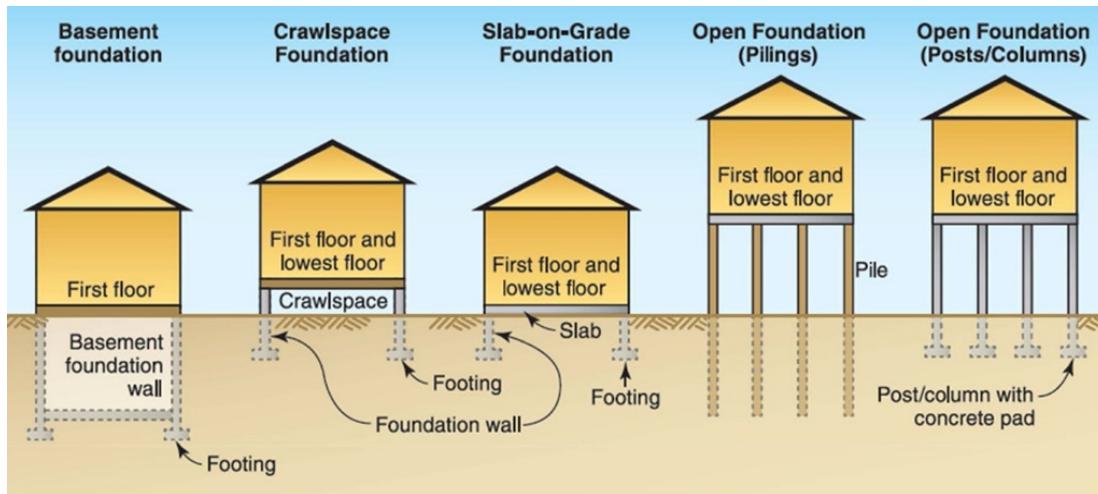
An open foundation allows water to pass through the foundation of an elevated building, reducing the lateral flood loads the foundation must resist (181). This fundamental principle makes open foundations significantly more effective than closed systems in flood-prone areas. Examples of open foundations are pile, pier, and column foundations designed to minimize the amount of vertical surface area that is exposed to damaging flood forces. Open foundations have the added benefit of being less susceptible than closed foundations to damage from flood-borne debris because debris is less likely to be trapped (181).

The regulatory framework clearly defines foundation requirements based on flood zone classification. A closed foundation does not allow water to pass easily through the foundation elements below an elevated building; thus, these types of foundations obstruct floodwater flows and present a large surface area upon which waves and flood forces act (181).

Pile Foundation Design and Installation

Pile foundations are widely used in coastal environments and offer several benefits. Deep foundations are much more resistant to the effects of localized scour and generalized erosion than shallow foundations (181). The design process requires careful consideration of multiple load factors including compression capacity, tension capacity for uplift resistance, and lateral load capacity.

Figure 29. A New Framework for Sustainable Resilient Houses on the Coastal Areas



Source: Taki, A.; Doan, V.H.X. A New Framework for Sustainable Resilient Houses on the Coastal Areas of Khanh Hoa, Vietnam. *Sustainability* 2022, 14, 7630. <https://doi.org/10.3390/su14137630>

Material Selection for Pile Construction

Treated timber piles are readily available and because they are wood, they can be cut, sawn, and drilled with standard construction tools used for wood framing. However, timber piles have specific limitations including being subject to eventual decay when in soil or intermittently submerged in water and vulnerability to damage from driving (splitting). Additionally, they have comparatively low compressive load capacity and relatively low allowable bending stress (181).

Pre-cast (and typically pre-stressed) concrete piles are not readily available in some areas but offer several benefits over treated timber piles. Generally, they can be fabricated in longer lengths than timber piles. For the same cross section, they are stronger than timber piles and are not vulnerable to rot or wood-destroying insects. The strength of concrete piles can allow them to be used without grade beams, which reduces vulnerability to scour damage as foundations without grade beams are less vulnerable to scour than foundations that rely on grade beams (181).

Steel piles are generally not used in residential construction but are common in commercial construction. Steel piles have high resistance to bending, are easy to splice, and are available in many lengths, sections, and sizes. However, steel piles are vulnerable to corrosion, may be permanently deformed if struck by heavy object, have high initial cost, and present some difficulty with attaching wood framing (181).

Installation Methods and Capacity Implications

The installation method significantly affects pile performance and load capacity. Driving involves hitting the top of the pile with a pile driver or hammer until the pile reaches the desired depth or it is driven to refusal. Ultimate load resistance is achieved by a combination of end bearing of the pile and frictional resistance between the pile and the soil. A record of the blow counts from the pile driver can be used with a number of empirical equations to determine capacity (181).

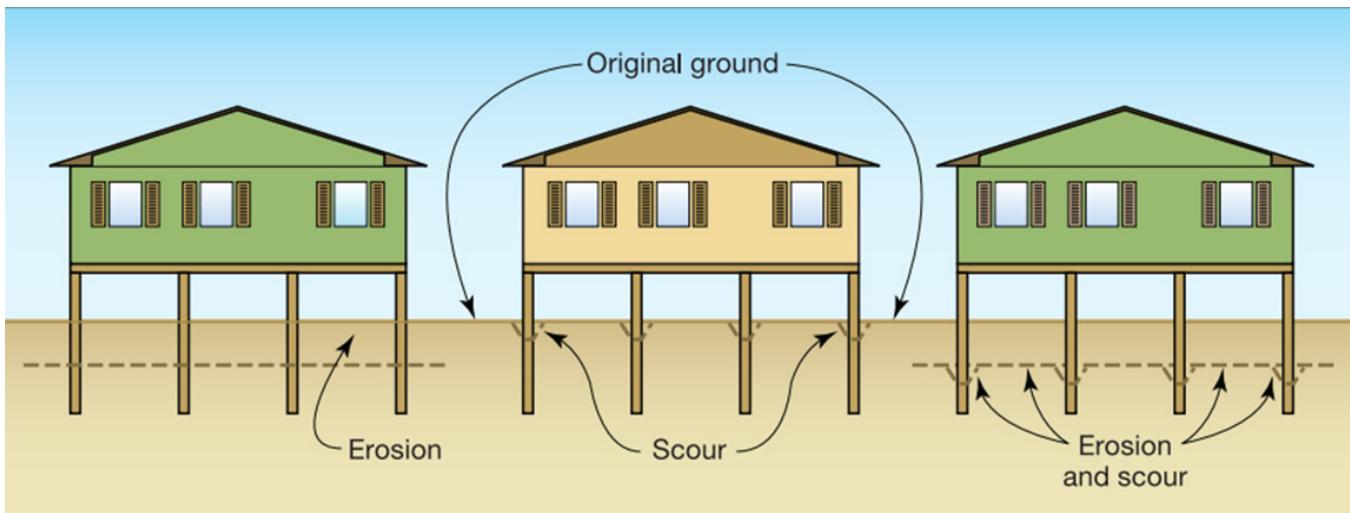
Both augering and jetting remove natural, undisturbed soil along the side of the pile. Load resistance for both of these methods is achieved by a combination of end bearing and frictional resistance, although the frictional resistance is much less than that provided by driven piles. This disturbance of soil adjacent to pile reduces

earth pressure coefficients KHC and KHT to 40 percent of that driven for piles (181).

Scour and Erosion Design Considerations

Coastal homes are often exposed to scour and erosion, and because moving floodwaters cause both scour and erosion, it is rare for an event to produce one and not the other. Scour washes away soils around the piling, reducing pile embedment, and increases stresses within the pile when the pile is loaded. Erosion is even more damaging. In addition to reducing pile embedment depths and increasing stresses on piles, erosion increases the flood forces the foundation must resist by increasing the Stillwater depth at the foundation that the flood produces (181).

Figure 30. Scour and erosion effects on piling embedment, Coastal Construction: Designing the Foundation



Source: Scour and erosion effects on piling embedment, Coastal Construction: Designing the Foundation by Gilber Gedeon, P.E.

Flood-Resistant Interior Materials

Concrete is highly durable and resistant to water damage. It doesn't rot, warp, or lose its structural integrity when exposed to water. Additionally, concrete can be sealed to further enhance its water resistance, providing an added layer of protection (182).

Brick is another strong and durable material that withstands flooding well. It resists water absorption better than many other materials, reducing the risk of mold and mildew growth. When combined with proper mortar and sealing techniques, brick walls can offer excellent protection against floodwaters (182).

PVC panels are an excellent alternative to drywall for flood-prone areas. The panels are non-porous, antimicrobial, 100% waterproof, install with a watertight seal, can withstand long-term exposure to flood water filled with bacteria and chemicals, and will never grow mold or mildew (182).

6.3.3. Site Design and Water Management

Landscaping for Flood Control

Proper landscaping plays a crucial role in mitigating flood damage by managing water flow and absorption around your property. Proper grading ensures that your yard slopes away from your home, directing water to flow away from the foundation. This simple but effective technique prevents water from accumulating near the house, reducing the risk of basement foundation flooding and damage. (182).

Incorporating plants that have high water absorption capacities can help manage excess water. Native plants, grasses, and shrubs with deep root systems improve soil structure and increase permeability, allowing more water to be absorbed rather than running off. Traditional concrete and asphalt surfaces are impermeable and can contribute to water runoff. Permeable paving materials, such as porous concrete, permeable pavers, or gravel, allow water to pass through and be absorbed by the ground below. This reduces surface runoff and helps manage stormwater effectively (182).

Figure 31. Design of bioretention planters for stormwater flow-control



Source: Master thesis 2015, Challenge Lab / <https://challengelab.chalmers.se/2018/03/14/design-of-bioretention-planters-for-stormwater-flow-control-and-removal-of-toxic-metals-and-organic-contaminants/>

Advanced Drainage Solutions

Rain gardens are shallow, planted depressions designed to collect and absorb runoff from roofs, driveways, and other surfaces. They are typically filled with native plants and grasses that tolerate both wet and dry conditions. Rain gardens slow down the flow of water, increase infiltration, and filter pollutants, making them an effective and eco-friendly solution for managing stormwater (182).

Retaining walls can be used to control the flow of water on sloped properties. They help prevent soil erosion and manage runoff by directing water to specific areas where it can be safely absorbed or diverted ². Retaining walls also create terraces that can be planted with water-absorbent vegetation, further enhancing flood resistance (182).

Waterproofing and Protective Systems

Active Water Management Systems

Install a sump pump in your basement or crawl space to actively remove water that accumulates. Sump pumps automatically activate when water levels rise, pumping water out and away from your home. Ensure you have a battery backup system to keep the pump running during power outages (182). Active systems provide critical protection during extended flood events when power infrastructure may be compromised.

Use backflow valves on your home's sewer lines to prevent sewage from backing up into your basement during heavy rains or flooding. These valves allow water to flow out but prevent it from coming back in, protecting your home from contaminated floodwater (182). This protection against contaminated backflow represents a critical public health consideration in flood-resistant design.

Passive Waterproofing Strategies

Apply waterproofing membranes to the exterior walls of your basement or crawl space. These membranes create a durable barrier that prevents water from penetrating the walls. Interior waterproofing paints and sealants can also be used to add an extra layer of protection. Sealing cracks and gaps in your home's exterior is critical in preventing water intrusion. Even small openings can allow water to seep in during heavy rains or floods, leading to significant damage over time (182).



Chapter 7. Overview of potential cost saving and opportunities from investing in low – carbon resilient buildings.

The perception that sustainable buildings require significant additional investment has long been a barrier to green construction adoption. However, comprehensive studies across Latin America reveal a different reality where green building certification can be achieved with minimal additional costs while delivering substantial operational savings and enhanced asset value. The evidence from recent analyses of both LEED and CASA Colombia certified projects demonstrates that the business case for sustainable construction is not only compelling but increasingly necessary in today's competitive market.

7.1. True Cost of Green Building Strategies and Certifications

A comprehensive analysis of LEED-certified projects across Latin America reveals remarkably modest additional investment requirements that challenge conventional assumptions about green building costs. The study found that the average additional investment for LEED certification amounts to only 1.39% of total project costs. This finding is particularly striking when examining the distribution of costs across projects: 63% of surveyed projects indicated having an additional investment that was imperceptible or less than 1% of total project costs, while 25% of projects reported additional investments between 1% and 3% (183).

The timing of certification decisions plays a crucial role in determining cost implications. More than 80% of interviewed projects opted to pursue LEED certification from the early planning phase, while the remaining 18% made this decision during early design or preliminary project phases (Document 1, page 1). This early integration of sustainability considerations enables project teams to optimize designs and identify synergies that minimize additional costs. Notably, projects that did not initially contemplate ventilation systems before pursuing certification experienced higher additional investments, typically ranging between 5% and 8% of total project costs. (183).

Specific country certifications like CASA Colombia certification study presents even more encouraging cost data, demonstrating that sustainable residential construction can be achieved with exceptionally low-cost premiums. The research found that the average additional investment for projects to achieve CASA Colombia certification is only 0.42% of total costs. This translates to an average additional cost of approximately \$7,471 COP per square meter, or roughly \$1.8 USD based on exchange rates at the time of the study. (184).

The distribution of additional costs across CASA Colombia projects shows remarkable consistency in affordability. 89% of projects indicated having additional investments below 1%, while 11% reported costs between 1% and 1.2%. Significantly, no project reported additional investments exceeding 1.2%, and no VIS (social housing) project reported additional investments above 1% (184). This data demonstrates that sustainable practices are economically viable across all market segments, including affordable housing where cost sensitivity is highest.

7.2. Understanding Investment allocation

7.2.1. Direct construction cost in Sustainable Building

The allocation of additional investments in LEED projects focuses primarily on building performance systems and efficiency measures. Direct costs typically encompass the specification of efficient building envelopes with insulation, dual plumbing systems for water treatment, water treatment systems themselves, solar panel implementation, efficient equipment, and systems for interior air renewal [14](183). These investments directly contribute to the building's operational performance and long-term efficiency.

For CASA Colombia projects, direct cost investments show a different pattern focused on fixtures and systems that directly impact occupant behavior and resource consumption. 37% of projects identified additional investments in the implementation of water-saving fixtures and aerators, with this figure rising to 80% among VIS projects. Twenty-six percent of projects reported additional costs for integrating bathroom exhaust fans, with 40% of VIS projects including this feature. LED lighting delivery in apartments represented an additional cost for 21% of projects overall, but 60% of VIS

projects [15] (184).. These investments demonstrate how sustainable features can be systematically integrated into residential projects with modest cost implications.

7.2.2. Indirect Cost and Professional Services

Indirect costs represent a significant portion of additional investments in sustainable building projects, particularly those related to professional expertise and certification processes. For LEED projects, indirect costs include consulting services for LEED certification, bioclimatic analysis, energy modeling, commissioning, and administrative certification fees paid to the Green Business Certification Inc. (GBCI) (183).

CASA Colombia projects show a similar pattern, with 68% of projects reporting additional investments primarily associated with certification costs, consulting contracts, and complementary studies such as energy modeling, bioclimatic analysis, and landscape intervention consulting (184).. This allocation suggests that much of the additional investment goes toward ensuring proper design and documentation rather than expensive materials or systems, making the certification process more accessible than commonly perceived.

7.3. Operational Performance and Savings

7.3.1. Energy and Water Conservation Results

The operational performance of LEED-certified buildings demonstrates substantial resource conservation that translates directly into cost savings for building owners and occupants. On average, LEED projects achieve energy savings of 31% and water savings of 53% compared to conventional buildings (183). These savings represent significant operational cost reductions that accumulate over the building's lifetime, providing ongoing returns on the initial sustainability investment.

Performance varies by building type and certification approach, with new construction projects (LEED BD+C: NC) showing the highest performance levels. These projects achieve average energy savings of 33% and water savings of 58% (183). The superior performance of new construction projects stems largely from the fact that property owners or developers who create the project are often the same entities that operate it, giving them complete control over interior finishes and systems optimization.

Platinum-certified projects demonstrate exceptional performance levels, achieving energy savings of 46% and water savings of 78% (183). This enhanced performance illustrates how higher certification levels, while not requiring proportionally higher investments, can deliver substantially greater operational benefits through more comprehensive sustainability strategies and optimized building systems.

7.3.2. Environmental Impact Quantification

Beyond cost savings, LEED projects deliver measurable environmental benefits that contribute to broader sustainability goals. Based on energy savings alone, projects average a reduction of 56 tons of operational CO₂ equivalent emissions per year, per square meter [14](183). This carbon footprint reduction represents a significant contribution to climate change mitigation while simultaneously reducing operational costs for building owners.

7.4. Financial Returns and Investment Recovery

7.4.1. Rapid Payback Periods

The financial returns from sustainable building investments occur remarkably quickly, challenging assumptions about long-term payback requirements. Among LEED projects surveyed, 81% indicated payback periods of less than one year for their sustainability investments (183). This rapid return on investment reflects the substantial operational savings achieved through energy and water conservation, as well as reduced maintenance costs associated with efficient systems.

The study found that no LEED project reported a payback period exceeding five years, with the distribution heavily weighted toward immediate returns. Within projects reporting payback periods under one year, some achieved actual savings below their initial budgets through design strategies selected to obtain certification, resulting in final costs below original project budgets (183). This phenomenon demonstrates how integrated sustainable design can identify efficiencies that reduce overall project costs while improving performance.

accessed green construction credit lines with interest rate benefits, while 63% facilitated their clients' access to green mortgage credit (184). Overall, 95% of projects accessed some form of financial benefit, demonstrating the widespread availability of incentives that improve project economics (184).

7.4.2. Enhanced Financial Performance Indicators

CASA Colombia projects demonstrate improved financial metrics beyond simple payback calculations. 63% of projects identified improvements in financial indicators such as ROI (Return on Investment), NPV (Net Present Value), or IRR (Internal Rate of Return) attributed to having a certified project (184). These improvements stem primarily from access to green construction credit lines, but also result from comprehensive project analysis, synergies identification, and cost optimization that generate value without incurring additional costs.

The availability of green financing plays a crucial role in project economics. 89% of CASA Colombia projects

7.5. Perceived Benefits Beyond Direct Financial Returns and Strategic Implementation

7.5.1. Health, Comfort, and Operational Advantages

The benefits of sustainable building certification extend well beyond energy and water savings to encompass occupant wellbeing and operational efficiency. Among LEED projects, 93% identified improved health and wellbeing for occupants as the primary benefit, reflected in good indoor air quality, user comfort, and generally higher satisfaction with the space and its environment (183). This benefit has gained increased relevance since the publication of the original 2021 LEED Business Case for Latin America, suggesting growing awareness of the connection between building performance and occupant health.

Operational benefits represent another significant value proposition, with 86% of LEED projects reporting that certification provides lower building operating costs, reflected in utility bills and reduced maintenance costs associated with building systems. Additionally, 71% of projects indicate that certified buildings are easier to operate and provide access to system manuals, contributing to more efficient building management and reduced operational complexity (183).

7.5.2. Asset Valuation and Market Performance

Sustainable building certification contributes to enhanced asset value and market performance in multiple ways. 79% of LEED projects report that certification provided greater asset valuation, while 71% confirm easier operation and access to system documentation (183). These benefits contribute to improved investment returns and reduced ownership risks over the building's lifecycle.

For projects with sale or rental business models, certification provides additional market advantages. 35% of such projects recognize that LEED certification attracts special and environmentally conscious clients, particularly in office projects. However, the study notes that in commercial projects, LEED certification is not yet familiar to many clients, and benefits are more closely associated with improved operation and administration rather than client recognition. Twelve percent of

projects achieved premium pricing per area compared to similar projects in the same zone, though this benefit was observed only in projects intended for sale (183).

7.5.3. Timing and Integration Strategies

The success of sustainable building projects depends heavily on the timing of sustainability decisions and their integration into the overall project development process. The data clearly demonstrates that early commitment to sustainable designing strategies and/or certification enables more effective cost management and performance optimization. Projects that incorporate sustainability considerations from the initial planning phases can identify synergies, avoid redundant systems, and optimize designs to achieve certification requirements without significant cost premiums.

One exemplary case study from the CASA Colombia research illustrates this integrated approach through the Los Ocobos project, developed by Caja de Compensación Familiar Compensar and Arquitectura y Concreto, which achieved CASA Colombia Gold certification in 2023 (184). The project demonstrated how comprehensive analysis can consolidate a sustainable business model through strategic system integration. For example, the team's analysis of solar panel installation for common area lighting initially contemplated traditional light posts requiring extensive copper wiring, individual connections, and corresponding protections. When copper costs made this approach expensive, they conducted a comparative study with solar generation, analyzing actual lighting demand, required panel quantities for efficient coverage, and optimal luminaire placement. The reconfiguration concentrated solar panels on building rooftops to power facade and common area lighting, resulting in costs that were economically equivalent or slightly more favorable than the original proposal while providing the additional benefit of maintaining illuminated common areas during power outages (184).

7.5.4. Organizational Culture and Market Approach

Successful sustainable building projects align sustainability strategies with organizational culture and market positioning. The Los Ocobos case study demonstrates how sustainability and social responsibility can be deeply embedded in internal company processes and partner collaboration, where these elements are not perceived as additional expenses but as intrinsic components that add value to projects and companies (184). This cultural integration enables more effective implementation and reduces resistance to sustainable practices throughout the development process.

Volume negotiations with suppliers represent another strategic approach that can minimize additional costs while maintaining quality standards. Projects that coordinate purchases of efficient fixtures, materials, and systems can achieve better pricing on sustainable alternatives, making green building more economically viable (184). This approach requires early planning and commitment to sustainability goals but can result in cost-neutral or even cost-positive outcomes.

7.6. Policy Support and Financial Incentives

7.6.1. Tax Incentives and Regulatory Benefits

Government support for sustainable building through tax incentives and regulatory benefits plays an increasingly important role in project economics. Among CASA Colombia projects, 63% applied for sustainability-related tax incentives, with 92% seeking VAT exemptions and 8% pursuing both VAT exemptions and income tax deductions [15][184]. The success rate for these applications is encouraging: 50% of submitted applications achieved the benefit, 45% remain in process, and only 5% were denied (184).

The elements for which projects most commonly seek tax incentives include elevators (45% of applications), environmental consulting and studies (14%), CASA certification processes (14%), solar control windows (14%), and insulated roofing (5%) (184). This distribution reflects both the significant cost impact of certain sustainable technologies and the government's recognition of their environmental benefits through fiscal incentives.

7.6.2. Green Financing Ecosystem Development

The development of green financing options has created a supportive ecosystem for sustainable building projects. The widespread availability of green construction credit lines, evidenced by 89% of CASA Colombia projects accessing such financing, demonstrates financial sector recognition of sustainable building as a viable and desirable investment category (184). This financing infrastructure reduces capital costs for developers while enabling more projects to achieve sustainability certification.

Access to green mortgage products for end users further supports market development by making sustainable homes more affordable for buyers. The fact that 63% of projects facilitated client access to green mortgage credit indicates systematic market support that extends beyond the development phase to include long-term ownership (184). This comprehensive financing ecosystem helps create sustainable demand for green building while supporting both developers and end users.

The comprehensive evidence from LEED and CASA Colombia certified projects across Latin America establishes a compelling business case for sustainable building that transcends traditional cost-benefit analyses. The data demonstrates that green building certification and sustainable design strategies can be achieved with minimal additional investment—averaging 1.39% for LEED projects and just 0.42% for CASA Colombia projects—while delivering substantial operational savings, enhanced asset value, and improved occupant satisfaction.

The rapid payback periods observed, with 81% of LEED projects recovering their sustainability investments in less than one year, illustrate how operational savings quickly offset initial costs. Combined with average energy savings of 31% and water savings of 53%, these projects deliver ongoing financial benefits that compound over the building's operational lifetime. The environmental benefits, including an average reduction of 56 tons of CO₂ equivalent per year per square meter, provide additional value that will become increasingly important as carbon pricing and environmental regulations evolve.

The success of these projects depends critically on early integration of sustainability considerations into project planning and design processes. Projects that embrace sustainable strategies from inception can identify synergies, optimize systems, and achieve certification requirements without significant cost premiums. The availability of green financing options, tax incentives, and regulatory support creates an increasingly favorable environment for sustainable building development.

For property developers, investors, and construction professionals, the evidence clearly indicates that sustainable building represents not just an environmental imperative but a sound business strategy. The minimal additional costs, rapid returns, substantial operational savings, and enhanced market positioning demonstrate that the question is not whether the industry can afford to build sustainably, but whether it can afford not to embrace these proven strategies for superior building performance and financial returns.

Annex



8. Stakeholders Analysis

Jamaica's built environment faces increasing climate-related risks including flooding, extreme rainfall, heat stress, and coastal erosion. This stakeholder analysis supports the Green Buildings Toolkit for Jamaica, an IDB Invest initiative promoting sustainable and resilient construction practices.

Based on semi-structured interviews conducted in February 2025 with representatives from six sectors, this analysis maps key stakeholders, assesses institutional dynamics, and identifies strategic entry points for climate-aligned action. Using a Power/Interest Matrix, the report identifies three critical engagement strategies: empowering high-capacity actors; incentivizing under-engaged sectors; and supporting high-interest, lower-power stakeholders.

Kingston exemplifies Jamaica's climate vulnerability, being exposed to both coastal and inland flooding. Urban vulnerability is exacerbated by aging infrastructure, lack of enforceable construction standards, and limited integration of climate resilience into urban planning. The construction sector serves as both a major greenhouse gas emissions source and one of the most at-risk sectors for climate-related hazards.

8.1. Methodology

This analysis uses a qualitative approach based on semi-structured interviews with key actors from Jamaica's construction, sustainability, and urban development ecosystem. Stakeholders represented public institutions, private developers, financial entities, civil society organizations, environmental consultants, technical cooperation agencies, and academic institutions. Responses were thematically analyzed and synthesized into sectoral categories using a standardized analytical structure covering context, key findings, opportunities, barriers, and suggested actions.

8.2. Cross-Sector Analysis

The following table summarizes the role, opportunities, barriers, and strategic actions for each stakeholder sector in advancing green building practices in Jamaica:

Table 13. Cross Sector Analysis

Sector	Context & Role	Key Opportunities	Main Barriers	Suggested Actions
Public Sector (MHURECC, NEPA, NWA, ODPEM, Municipal authorities)	Establishes regulatory, policy, and investment frameworks. Central to managing climate risks and urban development through licensing, development control, and public service delivery.	<ul style="list-style-type: none"> Strengthen regulatory frameworks with resilience requirements. Integrate adaptation into national policies. Leverage public procurement. Enhance climate risk mapping. Utilize policy reform momentum. 	<ul style="list-style-type: none"> Fragmented institutional mandates. Limited technical/financial capacity. Slow policy-to-practice translation. Bureaucratic inertia. Weak local government integration. 	<ul style="list-style-type: none"> Integrate resilience into licensing. Expand interagency coordination. Invest in capacity development. Use procurement for transformation Create actionable local resources.
Private Sector (Large developers, contractors, suppliers, engineering firms)	Drives economic growth and infrastructure renewal (~18% of GDP). Navigates regulatory pressures, consumer sustainability expectations, and growing climate risks.	<ul style="list-style-type: none"> Private investment for innovation. Design and materials innovation. Public-financial partnerships. Market differentiation via sustainability. Supply chain influence. 	<ul style="list-style-type: none"> Perceived high upfront costs. Uncertain ROI. Regulatory complexity. Limited finance/technical access. Short-term delivery emphasis. 	<ul style="list-style-type: none"> Foster cross-sector dialogue. Expand green financing products. Build confidence via case studies. Preferential conditions for sustainable companies.
Financial Sector (Banks, credit unions, insurers, development finance institutions)	Shapes sustainable transitions through capital flows, risk management, and investment products. Determines project viability and terms.	<ul style="list-style-type: none"> ESG market leadership. Specialized financial products. Technical partnerships for de-risking. Climate risk disclosure response. Blended finance innovation. 	<ul style="list-style-type: none"> No national taxonomy. Limited bankable projects. Weak verification mechanisms. Administrative complexity. Scarce local performance data. 	<ul style="list-style-type: none"> Develop green building taxonomy. Collaborate on eligibility criteria. Introduce targeted products. Establish project preparation facilities. Integrate climate risk metrics.
Civil Society & NGOs	Bridge gaps in government capacity. Connect communities, state, and private actors through community-based adaptation, advocacy, and participatory governance.	<ul style="list-style-type: none"> Community resilience building. Public education campaigns. Monitoring and accountability. Citizen engagement facilitation. Affordable solutions innovation. 	<ul style="list-style-type: none"> Limited decision-making access. Short-term project funding. Capacity constraints. Technical framework disconnect. Geographic support inequities. 	<ul style="list-style-type: none"> Formalize CSO roles in planning. Strengthen through reliable funding. Promote local government collaboration. Document community innovations. Implement equity-focused education.
Academic & Professional (Universities, JIE, World GBC)	Enable long-term transformation through curriculum development, applied research, technical accreditation, and policy engagement. Influence workforce expertise and industry standards.	<ul style="list-style-type: none"> Climate-integrated curricula. Updated accreditation frameworks. Applied research and innovation. Policy and code development participation. Regional/international collaboration. 	<ul style="list-style-type: none"> Curricular gaps in climate content. Limited policy integration. Education-practice disconnect. Resource constraints. Underdeveloped regional cooperation. 	<ul style="list-style-type: none"> Update curricula for climate realities. Build knowledge-policy channels. Develop continuing education. Prioritize applied research. Lead national education strategy.
Consulting & Technical Cooperation	Translate policy into actionable plans and compliance strategies. Provide environmental assessments, design optimization, performance verification, and capacity development.	<ul style="list-style-type: none"> Policy-to-criteria translation. Independent verification. Pilot new solutions. Capacity-building delivery. Multilateral partnership facilitation. 	<ul style="list-style-type: none"> Short-term contracting limits. Restricted upstream involvement. Resource constraints (smaller firms). Lack of standardized tools. Regulatory uncertainty delays. 	<ul style="list-style-type: none"> Engage in policy formulation. Develop standardized guidance. Build long-term partnerships. Facilitate knowledge networks.

8.3. The Critical Role of Small and Medium Enterprises (SMEs)

Small and Medium Enterprises represent the backbone of Jamaica's construction ecosystem, accounting for the majority of firms and employment in the sector. SMEs are uniquely positioned to drive green building adoption at scale due to their:

- Market penetration: SMEs reach communities and market segments that large corporations often overlook.
- Agility and adaptability: Smaller organizational structures enable faster adoption of new practices and technologies.
- Local knowledge: Deep understanding of community needs, local materials, and climate-specific challenges.
- Employment generation: Critical for skills development and workforce transformation toward sustainable practices.
- However, SMEs face distinct challenges that require targeted support:

Table 14. The Critical Role of Small and Medium Enterprises (SMEs)

Sector	SME-Specific Barriers	Strategic Actions for SME Engagement
Private Sector SMEs (Small contractors, design firms, material suppliers)	<ul style="list-style-type: none"> Limited access to capital and green financing. High cost of certifications and training. Lack of technical knowledge on green practices. Difficulty meeting procurement requirements. Limited bargaining power with suppliers. Vulnerability to market fluctuations. 	<ul style="list-style-type: none"> Create SME-specific green loan programs with lower collateral requirements. Subsidize green building certifications and training. Establish mentorship programs pairing SMEs with experienced firms. Simplify procurement processes with SME set-asides. Facilitate bulk purchasing cooperatives for green materials. Provide business development support and market access.
Financial Sector SMEs (Credit unions, community banks, microfinance)	<ul style="list-style-type: none"> Limited capacity to assess green project viability. Higher perceived risk in SME lending. Lack of specialized ESG expertise. Small loan sizes make due diligence expensive. Limited access to green finance guarantee schemes. 	<ul style="list-style-type: none"> Develop simplified green assessment tools for SME loans. Establish partial guarantee programs specifically for SME green lending. Provide technical assistance and ESG training for SME lenders. Create standardized green loan products with pre-approved criteria. Enable portfolio-level green lending approaches.
Consulting SMEs (Small environmental firms, engineering consultants)	<ul style="list-style-type: none"> High cost of specialized software and tools. Difficulty competing for large contracts. Limited access to international best practices. Challenges in maintaining certified staff. Cash flow constraints from delayed payments. 	<ul style="list-style-type: none"> Provide subsidized access to modeling software and tools. Reserve portions of public contracts for SME consultants. Facilitate knowledge exchange through professional networks. Offer continuing education scholarships. Implement prompt payment policies for consulting services. Enable consortium arrangements for larger projects.
Material Supplier SMEs (Local manufacturers, distributors)	<ul style="list-style-type: none"> High investment costs for sustainable materials production. Lack of product certification capacity. Limited market demand creates uncertainty. Competition from cheaper conventional products. Insufficient technical support for innovation. 	<ul style="list-style-type: none"> Provide grants and low-interest loans for equipment upgrades. Subsidize third-party testing and certification. Create demand through public procurement preferences. Establish tax incentives for sustainable material production. Connect SMEs with research institutions for product development. Develop local supply chain mapping and networking.

8.3.1. Cross-Cutting SME Support Mechanisms

To maximize SME participation in Jamaica's green building transition, the following cross-cutting support mechanisms should be prioritized:

- Capacity Building: Establish a national Green Building Training Center offering affordable, certification-aligned courses specifically designed for SME practitioners.
- Financial Access: Create a dedicated Green SME Financing Facility with flexible terms, technical assistance, and reduced documentation requirements.
- Market Development: Implement progressive procurement policies requiring minimum SME participation percentages in public green building projects.
- Knowledge Sharing: Develop digital platforms and peer networks for SMEs to share experiences, challenges, and solutions.
- Recognition Programs: Establish awards and public recognition for SME green building leadership to enhance market visibility.
- Simplified Standards: Create tiered certification pathways allowing SMEs to progressively adopt green practices without prohibitive upfront costs.

8.4. Stakeholder Mapping and Power/interest Matrix

In order to support the development and implementation of the Green Buildings Toolkit for Jamaica, it was necessary to identify, categorize, and assess the key stakeholders influencing sustainable construction and climate adaptation in the country. Understanding the roles, motivations, and capacities of these actors provides a foundation for strategic engagement and cross-sectoral collaboration.

The stakeholder mapping exercise was designed to identify both the level of institutional influence (power) and the degree of alignment with the objectives of green and resilient construction (interest). The Power/Interest Matrix is a widely used strategic tool that enables this type of classification. It allows project teams and decision-makers to prioritize engagement strategies, identify potential champions, and anticipate gaps or resistance in policy uptake or implementation.

8.4.1. Scoring Framework

To ensure transparency and analytical rigor, each stakeholder sector was evaluated under ten diagnostic criteria: five related to institutional power and five to interest or alignment with project goals. These criteria were derived from the stakeholder interviews, institutional mandates, and observed behavior in the Jamaican built environment.

Table 15. Stakeholder Evaluation Criteria for Power and Interest Mapping

Power Criteria	Interest Criteria
1. Regulatory Authority	1. Alignment with adaptation/resilience goals
2. Financial or Investment Capacity	2. Explicit engagement in sustainability initiatives
3. Technical Implementation capability	3. Participation in climate-relevant partnerships
4. Operational reach / territorial footprint	4. Institutional openness to innovation or change
5. Operational reach / territorial footprint	5. Demonstrated willingness to collaborate across sectors

8.4.2. Results of Stakeholder Categorization

Based on the scoring framework (Table 2), stakeholders were positioned along the two axes of the matrix: power and interest (Table 1). Their placement allows for an interpretation of their relative potential to influence or support the objectives of the Green Buildings Toolkit.

Table 16. Scoring framework - Stakeholder Evaluation Criteria for Power and Interest Mapping

Sector	Power Score (avg / 20)	Interest Score (avg / 20)	Final Position in Matrix
Public Sector	17	17	High Power / High Interest
Financial Sector	16	12	High Power / Medium Interest
Private Sector	15	10	High Power / Medium Interest
Civil Society & NGOs	08	18	Low Power / High Interest
Academic & Professional Institutions	17	17	Low Power / High Interest
Consulting & Technical Cooperation	14	19	Medium-High Power / High Interest

8.4.3. Matrix results

The Power/Interest Matrix presents a visual summary of stakeholder positioning. It highlights four strategic quadrants:

High Power / High Interest (Strategic Catalysts)

Sectors in this quadrant possess both institutional authority and technical engagement. The Public Sector can institutionalize climate adaptation into policies, licensing, and procurement, while Environmental Consultants and Technical Cooperation agencies can operationalize these principles in real-world projects. These actors should form the backbone of implementation efforts and receive support to scale their leadership roles.

High Power / Lower-medium Interest (Sectors to Activate)

The Private Sector and segments of the Financial Sector hold operational power and influence market dynamics. However, their engagement with climate goals is often conditional on regulatory clarity, cost-benefit visibility, or external incentives. Tailored strategies (such as preferential financing, policy simplification, or pilot demonstration) are required to shift their role from passive compliance to active contribution.

Low Power / High Interest (Critical Support Base)

Though lacking formal power, Civil Society and Academic actors bring local legitimacy, advocacy, and technical capacity-building. They are essential for ensuring that adaptation efforts are inclusive, socially grounded, and culturally resonant. These sectors can build public trust and help embed climate resilience into education, discourse, and community practice.

Low Power / Low Interest

No stakeholder sectors currently fall into this quadrant. This suggests an ecosystem that is engaged and aware, though with varying degrees of leverage and technical depth.

8.4.4. Results of Stakeholder Categorization

- This stakeholder categorization provides insights into where the Toolkit will find support, where it may face inertia, and which relationships are most critical to strengthen. Specifically:
 - Strategic Catalysts, such as public institutions and technical consultants, should be engaged early and continuously.
 - Financial and private sector actors require structured engagement to align incentives, clarify standards, and reduce perceived risk.
 - Civil society and academic institutions offer unique strengths in legitimacy, education, and community mobilization, and must be integrated to ensure inclusive outcomes.

The matrix also underscores the need for a coordinated, multisectoral implementation strategy that leverages the comparative advantage of each group. It suggests that Jamaica has a favorable institutional landscape for advancing sustainable and resilient construction, provided that gaps in communication, technical capacity, and incentives are addressed in a coherent and targeted way.

8.5. Conclusions

The cross-sectoral analysis carried out for the development of the Green Buildings Toolkit for Jamaica reveals a dynamic and engaged ecosystem with varying degrees of influence, technical capacity, and institutional commitment. While stakeholders differ in their mandates and operational approaches, there is broad convergence on the need to transition toward a built environment that is both low-carbon and climate-resilient.

This analysis reinforces the idea that sustainable construction is not merely a technical or environmental agenda; it is a societal challenge that requires coordinated action across planning, finance, regulation, professional training, and community development. Against the backdrop of Jamaica's acute climate vulnerability (including coastal erosion, storm intensification, drought risk, and aging infrastructure), the built environment has emerged as a frontline domain for adaptation and mitigation. Stakeholders recognize that buildings and urban systems are vulnerable to climate impacts; at the same time, they are also capable of driving resilience, economic inclusion, and environmental performance when designed and managed appropriately.

8.5.1. Closing Remarks

The transition to a sustainable and climate-resilient built environment in Jamaica represents both an imperative and an opportunity that cuts across the entire national landscape—economic, social, institutional, and environmental. The analysis of stakeholder perspectives has underscored several core themes: the growing recognition of climate risk, the significant but underutilized potential for innovation, and the importance of coordinated action to overcome persistent barriers.

The **public sector** has a unique responsibility in providing leadership, establishing a consistent regulatory framework, and aligning policy instruments to bridge the gap between national ambitions and on-the-ground implementation. Recent policy advances show promise, but sustained attention is needed to address fragmentation, streamline procedures, and operationalize resilience standards in ways accessible to all actors, especially local governments and smaller enterprises.

The **private sector**—as principal investor, developer, and deliverer of Jamaica's infrastructure—possesses the resources and market reach to drive rapid transformation. Yet, the widespread adoption of sustainable practices will depend on clarifying incentives, reducing perceived costs and risks, and mobilizing greater access to technical and financial support. The pivotal role of SMEs must be acknowledged: these firms operate at the intersection of innovation and community relevance, yet face disproportionate barriers in scaling their contribution.

The **financial sector** will act as the enabler, channeling investment and risk-sharing mechanisms toward sustainable construction. Momentum is building: green loan products, risk assessment tools, and insurance models are slowly emerging. Unlocking greater capital flows will require standardizing definitions and data, improving collaboration across institutions, and creating financial products tailored to Jamaica's context—particularly for underserved SMEs and community-level projects.

Civil society and NGOs offer credibility, local knowledge, and a vital channel to ensure that climate resilience efforts are socially inclusive and responsive to community needs. Their contributions in monitoring, outreach, and piloting social innovation broaden the definition of "green" buildings beyond technical criteria to include habitability, equity, and accessibility. Strengthening their voice in decision-making and providing sustainable resources to amplify their work will be crucial.

Academic and professional institutions supply the intellectual and technical backbone for systemic change. Their role in education, applied research, and standard setting is essential for mainstreaming sustainability and resilience within the next generation of professionals. Closing the gap between research, practice, and policy—while modernizing curricula and facilitating continuous learning—will sharpen Jamaica's global competitiveness and local adaptive capacity.

Consulting firms and technical cooperation agencies bring operational expertise in translating policies into tangible projects. Their cross-cutting role—spanning design, compliance, and stakeholder facilitation—positions them to accelerate the scaling of best practices. Long-term partnerships, harmonized tools, and upstream involvement in policy design will allow these actors to maximize their contribution to sectoral transformation.

Moving forward, progress will depend on integrating the diverse strengths of all stakeholder groups, cultivating strategic partnerships, and building adaptive mechanisms that keep pace with emerging climate realities. Policy clarity, financial innovation, knowledge transfer, and inclusive governance must operate in tandem to unlock both private initiative and public value.

Jamaica stands at a critical juncture: the building blocks for transformation are in place or emerging, but realizing their potential will demand shared vision, mutual accountability, and sustained investment in both institutional and human capacities. By deepening collaboration among sectors and focusing on scalable, inclusive solutions, Jamaica can position itself as a regional leader in climate-resilient construction—delivering benefits for the economy, society, and future generations.

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