USAID
FROM THE AMERICAN PEOPLE

TECHNICAL REPORT

VULNERABILITY ASSESSMENT OF JAMAICA'S TRANSPORT SECTOR

March 2018

This document was produced for review by the United States Agency for International Development. It was prepared by Chemonics for the ATLAS Task Order.

This document was produced for review by the United States Agency for International Development. It was prepared by Chemonics International for the Climate Change Adaptation, Thought Leadership and Assessments (ATLAS) Task Order No. AID-OAA-I-14-00013, under the Restoring the Environment through Prosperity, Livelihoods, and Conserving Ecosystems (REPLACE) IDIQ.

Chemonics contact:
Chris Perine, Chief of Party (cperine@chemonics.com)
Chemonics International Inc.
1717 H Street NW
Washington, DC 20006

ATLAS reports and other products are available on the Climatelinks website: https://www.climatelinks.org/projects/atlas

Cover Photo: National Works Agency, 2010; a completed section of Segment 3 - Northern Coastal Highway Improvement Project.

VULNERABILITY ASSESSMENT OF JAMAICA'S TRANSPORT SECTOR

March 2018

Prepared for:

United States Agency for International Development

Climate Change Adaptation, Thought Leadership and Assessments (ATLAS)

Prepared by:

Maria Fernanda Zermoglio and Owen Scott (Chemonics International Inc.)

This report is made possible by the support of the American people through the United States Agency for International Development (USAID). The contents of this report are the sole responsibility of the author or authors and do not necessarily reflect the views of USAID or the United States government.

CONTENTS

LIST OF FIGURES AND TABLES

ACRONYMS

AAJ	Airports Authority of Jamaica
CCD	Climate Change Division
CSGM	University of the West Indies Mona – Climate Studies Group
DRR	Disaster Risk Reduction
GCI	Global Competitiveness Index
GDP	Gross Domestic Product
GIS	Geographical Information System
GOJ	Government of Jamaica
IPCC	Intergovernmental Panel on Climate Change
JMD	Jamaican Dollars
JRC	Jamaica Railway Corporation
JUTC	Jamaica Urban Transit Company
KCT	Kingston Container Terminal
MEGJC	Ministry of Economic Growth and Job Creation
M&E	Monitoring and Evaluation
MGI	University of the West Indies Mona – Geoinformatics Institute
MLGCD	Ministry of Local Government and Community Development
MSJ	Meteorological Service of Jamaica
MTM	Ministry of Transport and Mining
MTWH	Ministry of Transport, Works and Housing
NEPA	National Environment and Planning Agency
NTP	National Transport Policy
NWA	National Works Agency
ODPEM	Office of Disaster Preparedness and Emergency Management
PAJ	Port Authority of Jamaica
PIOJ	Planning Institute of Jamaica
RCP	Representative Concentration Pathway
SIDS	Small Island Developing States
TSP	Vision 2030 Transport Sector Plan
TWG	Thematic Working Group
UN	United Nations
USAID	United States Agency for International Development
USD	United States Dollars
UWI Mona	University of the West Indies, Mona Campus
WRA	Water Resources Authority

MESSAGE FROM THE MINISTER

Hon. Michael Henry, C.D., M.P.

It has been proven over and over that the fundamental principle of cooperation underpins a relatively safe and efficient transport system. Effective transportation of people, goods and services support the economic, social and cultural development of our nation and by extension our region. Everyone must therefore, ensure that he or she plays his or her role in advancing our transportation system to achieve its greatest potential.

This Government remains totally committed to developing a safe and efficient Transport Sector. Since 2007 this administration has embarked on various initiatives to develop and implement a seamless multi-modal system of transportation involving land (road, rail), sea and air using the already existing road, rail connection to the sea and for the future the air.

This study is therefore instrumental in providing information that is vital to addressing some of the country's challenges in developing a sustainable transport system. The analysis provides a clear view of priority areas for intervention and certain vulnerabilities in our systems for our attention.

The average climate of the Caribbean Region is changing and will experience even further changes as global warming increases. As temperatures continue to rise, extreme weather events possibly increase, and sea levels continue to rise, it is extremely important that we are aware of the challenges we are faced with in order to plan ahead and recognise how important the air links are for the Region of the Caribbean.

Our highly heterogeneous topographic environment remains at risk to natural hazards, which impact the transport sector, our people and economic activities. As Minister with responsibility of the development of an integrated transport system (road, rail, sea and air), it is important that we implement strategies that are in line with this objective.

Growth and development are significant elements of any progressive nation. These are among the characteristics that provide a platform for continuity. The team at the Ministry is cognisant that our success is dependent on the involvement of external entities and the adaptation of global best practices. We are also aware that the assessment process is one that needs to be treated with utmost importance and must be consistent with international norms and standards.

I therefore use this opportunity to endorse partnerships as essential to mitigate the threats associated with the natural hazards of the country's climate to the Transportation Sector.

As we continue to work towards Jamaica achieving its vision of sustainability, let us use the findings of this report to guide our plans and decisions, as we work to making "Jamaica the place to live, work, raise families and do business".

Honorable Michael Henry, C.D., M.P.
Minister of Transport and Mining

EXECUTIVE SUMMARY

OVERVIEW

Jamaica's transportation system is already affected by weather extremes. Damage to roads, bridges and supporting infrastructure such as drains and culverts is commonplace, both as a result of extreme events as well as outdated design and inadequate maintenance. This document examines the vulnerability of the transport sector's assets to weather, climate variability and climate change, and identifies locations within the system that currently experience and are likely to experience future negative impacts. The analysis sheds light on priority regions and specific vulnerabilities. With the upcoming revision of Jamaica's National Transport Policy (NTP), this assessment aims to offer guidance on how to climate-proof future and current investments in light of a changing and more variable climate.

WHAT CLIMATE RISKS DOES JAMAICA FACE AND HOW WILL THIS IMPACT THE TRANSPORT SECTOR?

Weather and climatic conditions experienced in the Caribbean region are a product of both human-induced climate change and natural cyclical climate patterns. Climate experts agree that the average climate of the Caribbean region is changing and will undergo significant changes as global warming continues, even if key mitigation efforts were taken today to reduce the emission of greenhouse gases (IPCC 2007, others). The following is a summary of these changes:

Temperatures will continue to rise. When compared with the 1986–2005 time period, Jamaica is expected to experience a significant rise in temperatures across all seasons of about 0.85–1.8°C by mid-century, and up to 4°C by the end of the century. By themselves, increases in temperature can have a significant impact on critical transport sector functions. For example:

- *Higher temperatures and increased heat extremes* can increase not only the discomfort for those using public transportation but also the risk from heat exposure, especially for children and the elderly.
- *Higher temperatures and increased heat extremes* may require an alteration of maintenance and construction crew schedules, to protect workers from heat risks.
- *Higher temperatures* can increase the need for and costs of maintaining adequate cooling in public transportation vehicles.
- *Higher temperatures and more heat extremes could result in aircraft payload restrictions, flight cancellations and service disruptions, which would have critical impacts on the tourism industry*. Extreme heat can cause buckling of runways. Aircraft lift may also be affected, as the less dense, hotter air reduces the mass flow necessary over the wing to create lift. If runways are not long enough for large aircraft to build speed to generate lift, their weight must be reduced. In extreme cases, flights will need to be cancelled.
- *Higher temperatures could lead to more frequent buckling of pavements and misalignment of rail lines.* Concrete and reinforcement structures of rail lines expand and

contract due to moisture absorption, which could, in cases of extreme heat, lead to buckling.

Extreme weather events could increase. Extreme events have had a significant impact on Jamaica's economy, environment and people. Five major storm events between 2004 and 2008 reportedly caused USD1.2 billion in losses and damage (Neufville/IPS 2012). More intense tropical storms are a likely result of climate variability and change. With respect to the transport sector, four extremes are relevant: hurricanes, precipitation, wind and storm surges.

- *Stronger storms generally extend the periods of intense precipitation and strong winds, and cause tidal surges that can devastate the transport sector*. Jamaica lies in the path of Atlantic hurricanes and spends upwards of JMD72 billion, or approximately 3 percent of its gross domestic product (GDP), dealing with the impacts (Burgess 2015).
- *Excessive rainfall and flooding can damage road infrastructure*. Because many coastal roadways serve as evacuation routes during hurricanes, their vulnerability may increase coastal areas' overall vulnerability to climate risks. Furthermore, severe storms can disrupt traffic, potentially leading to more accidents and delays.
- *Heavy rains* increase the risk of exposure to the elements and challenge those most in need of public transportation, including children and the elderly.

Sea levels will continue to rise. Port infrastructure, including facilities such as the Montego Bay and Ocho Rios cruise terminals, as well as Port Antonio are important transport assets with long design lives. They are sensitive to sea level rise, with decking and wharves more frequently exposed to larger wave forces, resulting in increased scour of foundations of marine structures. They are also vulnerable to increased risk of overtopping during storm surges. Many airports are located near the coast and vulnerable to rising seas, including Norman Manley International Airport, which sits at an average elevation of 3 meters (m) above sea level and is also vulnerable to flooding. Projections suggest a minimum of 2–3 millimeters (mm) rise in sea levels per year during the first half of the century. At a minimum, these impacts are likely to result in more weather delays and periodic interruptions.

> "Where climate change is concerned, everything up to 10 meters is vulnerable. That will put all our critical facilities at risk, our transshipment port in Kingston, both major airports and the north-south coast – that is effectively 70 percent of our GDP."
> **— Maurice Mason, Environmental Economist**

WHAT MAKES JAMAICA'S TRANSPORT SECTOR VULNERABLE TO CLIMATE VARIABILITY AND CLIMATE CHANGE?

A highly heterogeneous topographic environment. Jamaica has an extensive coastline and rugged mountains that are subject to landslides, extreme weather (inclement weather) and seismic events, as well as a diverse network of rivers and streams. These all contribute to its vulnerability to hydro-meteorological hazards, which impact the transport sector, people and economic activities. The interior of the island, particularly in the east, is characterized by steep, well-weathered slopes, highly fractured geological formations and well-developed networks of rivers and natural drains (gullies) draining north and south from a central east–west-trending

mountainous axis. As such, erosion and landslides are serious problems affecting the transport and other sectors.

Limited scheduling and financing of infrastructure maintenance. Transport infrastructure assets have a limited lifetime, after which they may need to be reconstructed to meet the new construction codes, climate risks and demand realities. This lifetime, however, is also dependent on a proper operations and maintenance regime, including drainage, cleaning and repairs, so that assets continue to fulfill their function. There is a case to be made for the value of operations and maintenance investments in the country's transport network, especially in light of the fact that many if not most of the floods that negatively impact the sector are a function of improper drainage and insufficient maintenance.

Unregulated land use change and outdated construction codes. Sidewalks, pavement, roads and other impermeable surfaces have reduced the absorptive capacity of the landscape, exacerbating erosion from flooding caused by extreme storm events as the water essentially gets channeled through these impermeable surfaces. Construction on steep terrain and removal of the native forests that helped to stabilize the soil have increased erosion and landslide risk. Design criteria for the country's principal drainage system are outdated and do not properly consider the changing climate dynamics, including the occurrence of more intense storms that require, for example, larger culverts. Given the various stakeholders involved in building and permitting the road network, even well-designed systems can suffer adverse impacts from nearby developments, forcing drainage systems to absorb more than their intended flows.

Inconsistent planning and limited consideration related to increased urbanization and population growth. Jamaica has seen rapid population growth, coupled with significant migration from rural agricultural areas to cities. In 1960, 34 percent of the population lived in urban areas; in 2011 that figure was at 54 percent, and the United Nations (UN) projects that it will rise to 65 percent by 2050 (Tindigarukayo 2014). This growth and migration over the last several decades was unplanned, often resulting in squatter occupation of available lands, in many cases in high-risk areas such as those prone to landslides and flooding. Inconsistent land use planning and limited capacity to enforce existing regulations allowed for uncontrolled urban expansion into high-risk areas such as those on steep slopes or along the banks of tributaries.

A highly concentrated coastal population. Jamaica's population is concentrated in coastal areas that are vulnerable to storm surges and flooding. Given the tourism sector's prominence in the country's economy, development of the coastline is likely to continue. Many cities and towns occupy highly vulnerable locations such as riverbanks, unstable hillsides, deforested lands or fragile water catchments. Access roads to these areas often require navigating fords and bridges that are themselves subject to the negative impacts of floods, storm surge and rising sea levels.

Policies and planning measures that lack sufficient climate change considerations. Neither the NTP nor the Vision 2030 Transport Sector Plan (TSP) includes meaningful climate change considerations. As a result, the sector developed rapidly over the past 20 to 30 years

with limited consideration for disaster risk and little planning for a changing climate. While certain projects have accounted for climate change in their design, a comprehensive approach will be needed to climate-proof existing infrastructure.

Insufficient climate and weather data for decision making. Recent efforts by the University of the West Indies, Mona Campus (UWI Mona) Climate Studies Group (CSGM) and by the Meteorological Service of Jamaica (MSJ) have worked to address this issue, but reliable data on return periods, rainfall, disaster risk and climate projections continue to be insufficient and difficult to access. Where data do exist, many of the transport stakeholders involved in policy, planning and implementation do not have sufficient in-house expertise to analyze the data and incorporate them in a meaningful way into decision making and design.

PRIORITY VULNERABILITIES

Roads: Vulnerable roads include those in both northern and southern Clarendon Parish, the coastal region of St. Elizabeth Parish and the Blue Mountain regions of St. Andrew, Portland and St. Thomas Parishes. Other vulnerable regions include Hanover Parish, as well as the south coast roads of St. Thomas Parish, the north coast roads of St. Mary Parish, and the Junction thoroughfare linking north to south on the eastern end.

Public Transport Network: Six critical route sections were identified as at risk from climate-induced flooding and rising seas, which can result in delays and loss of service to users. These include: (1) Newport West to Spanish Town Road, which serves at least 2,900 people daily; (2) Ferry/Hydel to 6 mile terminal, and (3) Bull Bay to 11 miles, both serving over 7,000 users daily; (4) Great Circle House to Fairfax Drive, serving over 4,800 people daily; (5) Caymaras to Waterford, serving at least 400 users daily; and (6) Spanishtown to Newport west, which provides service to at least 200 people daily.

Airports: Donald Sangster International Airport in Montego Bay, where the majority of the runway and terminal access is located below 1 m elevation, is particularly vulnerable to rising seas. According to a Water Resources Authority (WRA) assessment, the main road access along the airport is prone to flooding. The risk is less pronounced for Kingston's Norman Manley International Airport, where only a few stretches of the access road and peripheral areas are at extremely low elevation. Nevertheless, Manley International is also subject to more intense wave run-up and storm surge from hurricanes and tropical storms. Seawall defenses will need reinforcements and in some cases redesign to cope with the potentially more damaging hurricane forces projected in the future.

Ports: Falmouth Cruise Ship Pier, already subject to the impacts of floods due to increasingly more intense rainfall events, is significantly vulnerable to sea level rise, with the majority of the road network providing access at risk from flooding and the tourist areas also subject to high flood risks. A similar risk profile exists for Montego Bay. On the other hand, while the principal access roads to Kingston Container Terminal (KCT) are less at risk of flood and sea level rise,

the container terminal itself, particularly the storage areas in the south terminal, has significant areas located below 1 m in elevation.[1]

RECOMMENDATIONS

This study demonstrates that as the impacts of climate change (i.e., rising temperatures, more extreme heat events, more intense rainfall events, rising seas) manifest, the burden of risks to Jamaica's transport sector is expected to increase unless additional investments are made. Some projected additional losses, for example from landslides, are potentially preventable if high-risk areas are identified and design criteria for transport networks take these risks into account. Reducing transport sector risks will require modifying current policies and programs and implementing new ones to explicitly consider climate variability and change. Adaptation actions should focus on building a more climate-resilient transport system, reducing overall vulnerability and developing specific system capacities. Entry points include: 1) investments and finance, 2) leadership and governance, specifically regarding institutions and planning mechanisms, and 3) information systems. Specific actions to align with Jamaica's Vision 2030 document are detailed below.

INVESTMENTS AND FINANCE

Conduct additional assessment(s) on scope of financing needs. Navigation and port facilities, roads and drainage infrastructure, and other transport assets have a design lifetime, after which they may need to be reconstructed to meet the climate and demand realities of the day. Furthermore, this lifetime is dependent on proper maintenance and repairs to guarantee asset performance. For example, a typical asphalt road may be designed to last 26 years but will require resealing sometime during the first 13 years depending on traffic volumes and vehicle weights. This assessment clearly points to the need to budget for and undertake consistent maintenance of the country's transport network to guarantee full functionality, particularly with respect to drainage, maintenance and cleaning. Additionally, some nearshore roads, seawalls and bridges will increasingly require repair, and if the sea level rise is augmented by increased storm activity, the impact will necessitate redesign to new standards.

Further assessment should be undertaken to understand the scope of financing needs by cataloguing the design lifetime of major infrastructure (e.g., roads, bridges, ports) and costing out improved maintenance regimes for different types of infrastructure.

LEADERSHIP AND GOVERNANCE - Institutions

Increase capacity for the Ministry of Transport and Mining (MTM) to coordinate and convene the relevant expertise to build climate resilience and disaster risk reduction (DRR) approaches into plans and operations. The MTM does not currently have a unit dedicated to DRR under its technical services or planning and research departments, despite the climate-related impacts on the sector. Nevertheless, several external agencies (National Works Agency/NWA on road design; Climate Change Division/CCD on climate adaptation;

[1] Note that risks to ports in this assessment focused on access and function rather than infrastructure damage, since a full infrastructure risk assessment would require a detailed engineering analysis.

Office of Disaster Preparedness and Emergency Management/ODPEM on disaster risk management) do have relevant expertise that could be brought to bear on the subject. CCD or other external consultants should conduct training for other MTM staff, particularly those involved in developing policy, action plans, and monitoring and evaluation (M&E) plans. Topics could include: understanding climate change impacts on the transport sector; crafting policy to reduce impacts from climate-related risks; devising strategies and actions to increase the climate resilience of transport infrastructure; and developing relevant indicators and targets to track performance over time. Such a training could position and prepare MTM staff to convene and coordinate the analyses and discussion necessary to climate-proof transport operations.

Establish a task force for NTP revisions and a Transport Sector Thematic Working Group (TWG) under Vision 2030. A task force similar to the one that leads the TSP process should be created within the MTM to lead NTP policy revision and coordinate with stakeholders. A dedicated task force with representatives from multiple agencies will ensure all subsectors are adequately addressed in the policy and that consultations are conducted with the wide network of sector stakeholders.

TWGs in other sectors have proven successful as a mechanism to support the implementation and M&E of Vision 2030 sectoral plans. They provide an important forum that brings in voices outside of government from civil society, the private sector and development partners, and can assist with planning, tracking progress, addressing shortfalls, identifying and mobilizing resources, sharing information and ensuring coordination among stakeholders.

Increase capacity of other transport sector stakeholders to understand and address climate risks within the context of the expected lifespan of investments. From the technical personnel in parish councils to government agencies responsible for oversight and regulation of transport infrastructure, additional capacity is strongly needed to 1) better understand and cope with climate risks, and 2) better understand the scientific basis for improved design and planning, as well as the more important development implications of new investments and their coordinated operations.

Include tailored climate change adaptation clauses on all new concession agreements, and review and amend existing concession agreements where possible. With the update of the NTP, as well as the creation of the Climate Change Policy Framework, all new agreements (and where possible, existing agreements) should ensure concessionaires' operations are in compliance with provisions of national transport and climate change policies, as well as with national environmental laws and international standards.

LEADERSHIP AND GOVERNANCE - Planning mechanisms

Develop a strategy, action plan and M&E plan to accompany the revised NTP. Policy must be accompanied by planning mechanisms such as a medium-term strategic plan, an action plan with defined tasks, and an M&E plan that assigns responsibility for collecting data and sets clear indicators and targets. The action plan should consist of discrete tasks that can be implemented, measured and completed, and should assign responsible parties and timeframe,

along with budget estimates. The M&E plan should establish a methodology for monitoring the progress of tasks, along with indicators that clearly measure efforts to implement the action plan, as well as a system to collect indicator data.

Incorporate climate change considerations into the revised NTP. Three main areas, at a minimum, should be addressed: climate data to be used in analysis; design criteria; and risk screening requirements. The NTP should set requirements for the use of climate data (including historical and future projections of rainfall, flooding, storm surge and tropical storms) when making planning and investment decisions. Design standards for infrastructure and best practices for operations and maintenance informed by climate information and international best practice should also be included in the policy. The NTP should also designate the types (in terms of capital expenditure or extent of construction) of investments that should be screened for climate risk and define the tool(s) to be used as well as a standard process for screening.

Establish partnerships to help address indirect issues, such as solid waste management, construction waste and drainage, that cause or exacerbate flooding and infrastructure deterioration. While aspects of solid waste management and drainage fall under the responsibility of the National Solid Waste Management Authority (NSWMA) and WRA, the MTM has purview over certain elements. Examples of issues to incorporate into the revised NTP include: setting requirements for storm drain cleaning, establishing standards for road drainage, and setting policy and enforcement mechanisms for road repair and post-repair waste removal, among others. The Vision 2030 TWG for transportation would be a logical entity to liaise with others to guarantee consistency of operations across related sectors.

Develop a hazard mitigation strategy and disaster response strategy for each subsector. Following on plans from the NTP, TSP and the Climate Change Policy Framework, the MTM should follow through on developing formal hazard mitigation and disaster response strategies for each of the transport subsectors (roads, airports, seaports and possibly railways). These strategies, developed together with the revised NTP, will guide action to address and respond to natural disasters. The strategies should also be developed and refined through stakeholder consultations to ensure broad-based input during the drafting phase.

Update urban development plans. In coordination with the Ministry of Local Government and Community Development (MLGCD), municipal corporations need to update urban development plans to reflect the changing risk profile for floods and landslides to the parish road networks. Updated plans also need to be aligned with the Master Drainage Plan developed by NWA.

INFORMATION SYSTEMS

Conduct analyses to inform revisions to design criteria for all assets, taking into account a changing climate. For example, bridges and culverts are currently designed using standards and river flow models developed prior to 1960. Shifting rainfall patterns need to be considered in new design criteria to safeguard investments. Novel ways of incorporating the large volume of debris and vegetation being carried into drains, culverts and channels need to be devised, as the current structural guidelines accommodate only pure water flows. Design criteria, land use

regulations and other related regulations are contained in a variety of documents, including the National Building Code, the Main Roads Act, the Parochial Roads Act, the Town and Country Planning Act, the Local Improvements Act, the Beach Control Act, and Volume 3 of the National Environment and Planning Agency's (NEPA) Development and Investment Manual.

Improve quality and maintenance of existing data. Significant data are available on the road network and road conditions, bridge locations and conditions, airport and seaport infrastructure, flood- and landslide-prone areas, floodplain maps, river and gulley networks, watersheds, soil condition and composition, weather and climate, and a host of other relevant information. These data can be used in transport infrastructure management and investment planning, but they are often available only within the ministries or agencies that developed them. In addition, the quality of data varies across datasets. However, the dispersed and uncoordinated natural hazards records pose significant challenges for the formulation of plans and projects to deal with current and emerging risks. Dissemination mechanisms within the key institutions responsible for risk management currently also impede the use and application of available studies. A database housed within the National Spatial Data Planning Division that integrates climatic, geophysical and infrastructure data in a meaningful way, along with a plan and team dedicated to curating these data, would be useful across the sector.

Develop more detailed hazard assessments for specific assets at finer spatial scales. According to Brabb (1993) and others, at least 90 percent of the losses due to landslides, for example, could be avoided if detailed information and responses were available to engineers and communities. While this assessment begins to unpack these risks, additional information is required for the regions and assets specified as vulnerable to determine appropriate safeguards to put in place.

Conduct detailed vulnerability assessments for specific assets. A deeper dive into the vulnerability of specific investments could offer important information on the need to climate-proof the assets. For example, the Airports Authority of Jamaica's (AAJ) planned vulnerability assessment of Norman Manley International Airport will, over the course of at least nine months, collect and model vulnerability to storm surges, wave run-up and other risks within the confines of the airport facilities and their access roads. This information is critical for prioritizing investments. This assessment points to the need to prioritize such analyses for the country's parochial road network, for which limited information is available.

Conduct a public education program that helps to raise awareness of the risks from floods and other climate changes. A public education program can offer salient advice on new developments in sensitive areas. In the long term, this may also help to raise awareness of officials in municipal corporations, which in large part approve construction in high-risk zones. Leveraging and capitalizing on the collective experiences of CARICOM (Caribbean Community) countries and the Caribbean Community Climate Change Centre could help to bring island-appropriate knowledge and insights to the task.

INTRODUCTION

OVERVIEW

The island nation of Jamaica is highly vulnerable to the impacts of climate-related hazards, which result from hydro-meteorological extremes and the exacerbating impacts of human activities. Jamaica is exposed to a variety of natural phenomena that can drive disasters, with consequent loss of life and natural resources and damage to economic activities. Key risks to the transport sector, particularly maritime, road, rail and air networks, include:

- Destruction of roads and bridges caused by flooding, as well as more minor damage such as rutting and potholes caused by extreme precipitation and rising temperatures.
- Damage to sea and air port facilities from increasingly severe storm events and sea level rise.
- Warping of rail tracks caused by rising temperatures and undermining of track beds caused by heavy rain.

OBJECTIVES

The main objective of this study is to evaluate the vulnerability of the country's transport sector to climate variability and change and recommend potential adaptive strategies and planning gaps that can build the sector's resilience to climate risks now and in the future. The report is structured as follows:

- Section 1 offers an overview of the transport sector as well as a summary of current and expected changes in hazards to the sector.
- Section 2 outlines current institutional arrangements and provides a situational analysis of the National Transport Policy (2007) and Vision 2030: Transport Sector Plan.
- Section 3 provides an assessment of the sector's vulnerability (risks) to climate variability and change.
- Section 4 offers recommended fit-for-purpose adaptation measures that reflect Jamaica's specific realities and challenges.
- Section 5 identifies adaptation measures to reduce the risks from climate variability and change based on experiences and best practice from other Small Island Developing States (SIDS).

THE JAMAICAN TRANSPORT SECTOR

The Jamaican transportation sector consists of an extensive network of roads and bridges, railways, ports and airports (Table 1). The following offers an overview of the sector's assets with a discussion of their current condition and operational integrity. This discussion is the basis of the subsequent analysis of vulnerabilities.

Table 1. Transportation assets in Jamaica

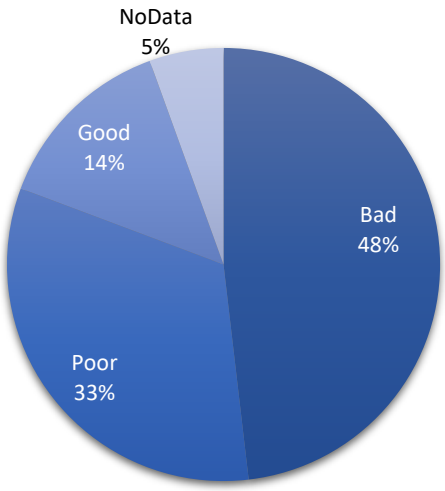
ASSET	CHARACTERISTICS
Main Roads[2][3]	Total 4,922 km
Class A	826 km
Class B	624 km
Class C	2,955 km
Undefined class	517
Parochial and other roads[4]	17,155 km
Bridges	736 bridges
Airports	3 international airports, 3 public aerodromes, 2 Defense Force aerodromes and 34 private or other classification aerodromes
Seaports	11 specialized seaports and 3 public deep-water ports
Railway lines and stations	330 km of track, 6 privately owned railway lines

Source: Authors' calculations and information from the National Works Agency, 2016.

ROADS

Jamaica's road network consists of both publicly and privately operated and maintained national roads that fall under the purview of NWA, as well as an extensive arterial (parochial) road network that is maintained by the respective municipal corporations. Over 48 percent of the national main road network is classified as being in "bad" condition, with potholes, poor drainage and other conditions that compromise their functional integrity (Figure 1). Another 33 percent are classified in "poor" condition. Information on condition is not available for the more than 10,000 kilometers (km) of parochial roads, though it is likely that

Figure 1. Condition classification of Jamaica's main roads



Source: Data from NWA Road Condition Survey, 2011.

[2] Roads that fall within the purview of NWA.

[3] Road classes are defined by a collection of attributes including traffic and maintenance. For example, Class A roads are characterized by high traffic flows, while Classes B and C are those of less importance in terms of traffic.

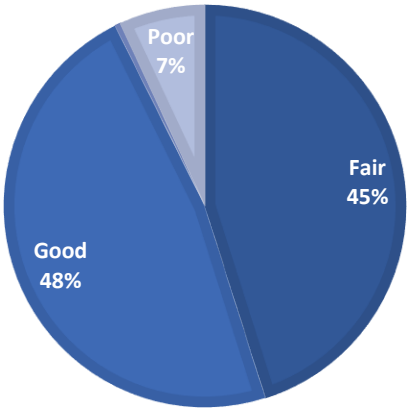
[4] Includes farm and forest roads.

these are in the same or worse condition, as they tend to be more remote, unpaved and less frequently maintained.

PUBLIC TRANSPORT NETWORK

In Kingston, St. Andrew and Saint Catherine Parishes, the Jamaica Urban Transit Company (JUTC) operates 122 bus routes, providing public access to over 250,000 people daily across a network that stretches for 2,747 km. The bus route network includes 43 passenger terminals, 80 percent of which protect passengers from the elements with shelters in varying conditions. Another 855 bus stops dot the network, and their quality and level of establishment also vary. For example, only 60 percent of these stops have posted signs of the route (with some containing route information and schedules). Roughly 69 percent of JUTC's bus stops have shelters for waiting passengers, and their condition also varies (Figure 2).

Figure 2. Condition of shelters available across the network



Source: Data from Jamaica Urban Transit Company.

AIRPORTS

Jamaica's airport network has seen continued growth in all segments of operations, from passenger traffic at the three international airports (up 4.3 percent from the previous year in 2015-2016), to air freight (including cargo and mail – up 2.3 percent in the same period) and other air movements (up 1.8 percent). Donald Sangster International, especially, is often ranked as the leading airport in the Caribbean, while Norman Manley International was recognized as the Most Improved Airport for 2015 by Airports Council International. MBJ Airports Limited, the operating concessionaire of Sangster International, recently participated in a United Nations Conference on Trade and Development (UNCTAD) project that undertook a case study exploring "Climate change impacts on coastal transport infrastructure in the Caribbean: Enhancing the adaptive capacity of Small Island Developing States (SIDS)." The study highlighted the need to climate-proof runways, facilities and access roads to address a changing climate and the related infrastructure risks. The risks described were primarily a function of their location along vulnerable coastlines but also included effects of hotter temperatures on airlift, runway length, energy costs for cooling facilities, and tarmac exposure, as well as sea level rise. A total of 42 aerodromes dot the country though little information is available on their condition (Table 2).

Table 2. Number of aerodromes in Jamaica, by parish

PARISH	NUMBER OF AERODROMES
Clarendon	5
Hanover	1
Manchester	3
Portland	2
Kingston & St. Andrew	3
St. Ann	5
St. Catherine	6
St. Elizabeth	5
St. James	3
St. Mary	2
St. Thomas	2
Trelawny	1
Westmoreland	4
Total	**42**

Source: Jamaica Civil Aviation Authority, 2014.

PORTS

Marine transportation infrastructure includes ports, harbors and supporting intermodal terminals, and the ships and barges that use these facilities. Sea transportation is often the only mode of transportation for moving freight within the Caribbean. Jamaica is also an important destination for cruise tourism, which contributes significantly to the tourism sector. The country's newest and most extensive cruise ship terminal, Historic Falmouth Cruise Ship Pier, was built in 2011 and is operated by Falmouth Jamaica Land Company, a partnership between Royal Caribbean Cruise Lines and the Port Authority of Jamaica (PAJ). In spite of its prominence in the tourism industry (accounting for approximately 50 percent of total cruise ship passenger arrivals to the country), the port suffers from poor connectivity, with only one roadway access point, off Trelawny Street in the town of Falmouth. Because of the port's location, it is impossible to access without driving through the small town's narrow, potholed roads, which are susceptible to flooding due to poor drainage. A second critical port facility is KCT, in operation since 1975. It handles roughly 8 million metric tons of cargo each year. While improvement works are underway for all facilities, few plans, if any, consider engineering requirements to deal with a changing climate.

RAILWAYS

The majority of Jamaica's railways were constructed prior to the 1950s, initially to promote passenger travel on the island and later to support a growing bauxite mining industry. Many of these railroads were closed during the 1970s due to concerns about operational deficits. Today, only a single line offers mine-to-port connectivity. The condition of existing stations is primarily categorized by the Jamaica Railway Corporation (JRC) as very poor or deplorable (Table 3). Significant investments would be required to revitalize them.

Table 3. Location and condition of JRC railway stations

NUMBER	STATION	PARISH	LINES	STATUS
1	Kingston	Kingston	Montego Bay	Very Good
2	Gregory Park	St. Catherine	Montego Bay	Destroyed by Fire
3	Grange Lane	St. Catherine	Montego Bay	Very Poor
4	Spanish Town	St. Catherine	Montego Bay	Very Poor
5	Bogwalk	St. Catherine	Port Antonio	Very Poor
6	Riversdale	St. Catherine	Port Antonio	Very Poor
7	Troja	St. Catherine	Port Antonio	Vandalized
8	Richmond	St. Mary	Port Antonio	Very Poor
9	Highgate	St. Mary	Port Antonio	Very Poor
10	Albany	St. Mary	Port Antonio	Destroyed by Fire
11	Annotto Bay	St. Mary	Port Antonio	Demolished
12	Buff Bay	Portland	Port Antonio	Very Poor
13	Orange Bay	Portland	Port Antonio	Good
14	Hope Bay	Portland	Port Antonio	Very Poor
15	St. Margaret's Bay	Portland	Port Antonio	Destroyed by Fire
16	Port Antonio	Portland	Port Antonio	Poor
17	Linstead	St. Catherine	Ewarton	Very Poor
18	Ewarton	St. Catherine	Ewarton	Abandoned
19	Old Harbour	St. Catherine	Ewarton	Very Poor
20	Bodles Junction	St. Catherine	Ewarton	Poor
21	May Pen	Clarendon Park	Montego Bay	Demolished
22	Suttons	Clarendon Park	Frankfield	Good
23	Chapleton	Clarendon Park	Frankfield	Demolished
24	Morgan's Pass	Clarendon Park	Frankfield	Very Poor
25	Crooked River	Clarendon Park	Frankfield	Demolished
26	Trout Hall	Clarendon Park	Frankfield	Demolished
27	Frankfield	Clarendon Park	Frankfield	Demolished
28	Jacob's Hut	Clarendon Park	Frankfield	Poor
29	Four Paths	Clarendon Park	Montego Bay	Poor
30	Clarendon Park	Clarendon Park	Montego Bay	Poor
31	Porus	Manchester	Montego Bay	Very Poor
32	Williamsfield	Manchester	Montego Bay	Very Poor
33	Kendal	Manchester	Montego Bay	Destroyed by Fire

NUMBER	STATION	PARISH	LINES	STATUS
34	Greenvale	Manchester	Montego Bay	Very Poor
35	Balaclava	St. Elizabeth	Montego Bay	Deplorable
36	Appleton	St. Elizabeth	Montego Bay	Very Poor
37	Maggotty	St. Elizabeth	Montego Bay	Destroyed by Fire
38	Ipswich	St. Elizabeth	Montego Bay	Deplorable
39	Stonehenge	St. James	Montego Bay	Poor
40	Catatupa	St. James	Montego Bay	Very Poor
41	Cambridge	St. James	Montego Bay	Deplorable
42	Montpelier	St. James	Montego Bay	Very Poor
43	Anchovy	St. James	Montego Bay	Very Poor
44	Montego Bay	St. James	Montego Bay	Deplorable

Source: Jamaica Railway Corporation, 2017.

CLIMATE VARIABILITY AND CLIMATE CHANGE AND EVENTS THAT IMPACT THE TRANSPORT SECTOR

Weather and climatic conditions experienced in the Caribbean region are a product of both human-induced climate change and natural cyclical climate patterns. Climate experts agree that the average climate of the Caribbean region is changing and will undergo significant changes as global warming continues, even if key mitigation efforts were taken today to reduce the emission of greenhouse gases (IPCC 2007, others).

CSGM undertook an extensive analysis to produce the *State of the Jamaican Climate 2012*. This analysis was based on data from MSJ and the Climatic Research Unit at the University of East Anglia, as well as future projections from large-scale global circulation models (GCMs) in the Intergovernmental Panel on Climate Change's Fifth Assessment Report, two regional circulation models (RCMs), and outputs from a statistical downscaling exercise. Highlights are presented below and summarized in Table 4.

Temperatures will continue to rise. When compared with the 1986–2005 time period, Jamaica is expected to experience a significant rise in temperatures across all seasons of about 0.85–1.8°C by mid-century, and up to 4°C by the end of the century. By themselves, increases in temperature can have a significant impact on critical transport sector functions. For example:

- *Higher temperatures and more heat extremes could result in aircraft payload restrictions, flight cancellations and service disruptions, which would have critical impacts on the tourism industry*. Extreme heat can cause buckling of runways. Aircraft lift may also be affected, as the less dense, hotter air reduces the mass flow necessary over the wing to create lift. If runways are not long enough for large aircraft to build speed to generate lift, their weight must be reduced. In extreme cases, flights will need to be cancelled.

- *Higher temperature could lead to more frequent buckling of pavements and misalignment of rail lines.* Concrete and reinforcement structures of rail lines expand and contract due to moisture absorption, which could, in cases of extreme heat, lead to buckling.
- *Higher temperatures and increased heat extremes* can increase not only the discomfort for those using public transportation but also the risk from heat exposure, especially for children and the elderly.
- *Higher temperatures* can increase the need for and costs of maintaining adequate cooling in public transportation vehicles.

Extreme weather events could increase*.* Extreme events have had a significant impact on Jamaica's economy, environment and people. Five major storm events between 2004 and 2008 reportedly caused USD1.2 billion in losses and damage (Neufville/ IPS 2012). More intense tropical storms are a likely result of climate variability and change. With respect to the transport sector, four extremes are relevant: hurricanes, precipitation, wind and storm surges.

- *Stronger storms generally extend the periods of intense precipitation and strong winds, and cause tidal surges that can devastate the transport sector*. Jamaica lies in the path of Atlantic hurricanes and spends upwards of JMD72 billion or approximately 3 percent of its GDP dealing with the impacts (Burgess 2015).
- *Excessive rainfall and flooding can damage road infrastructure*. Because many coastal roadways serve as evacuation routes during hurricanes, their vulnerability may increase coastal areas' overall vulnerability to climate risks.
- *Heavy rains* increase the risk of exposure to the elements and challenge those most in need of public transportation, including children and the elderly.

Sea levels will continue to rise*.* Port infrastructure, including facilities such as the Montego Bay and Ocho Rios cruise terminals, as well as Port Antonio are important transport assets with long design lives. They are sensitive to sea level rise, with decking and wharves more frequently exposed to larger wave forces, resulting in increased scour of foundations of marine structures. They are also vulnerable to increased risk of overtopping during storm surges. Many airports are located near the coast and vulnerable to rising seas, including Norman Manley International Airport, which sits at an average elevation of 3 m above sea level and is also vulnerable to flooding. Projections suggest a minimum of 2–3 mm rise in sea levels per year during the first half of the century. At a minimum, these impacts are likely to result in more weather delays and periodic interruptions.

Table 4. Changing and future climate projections for Jamaica

TEMPERATURES	
Historical	**Projected**

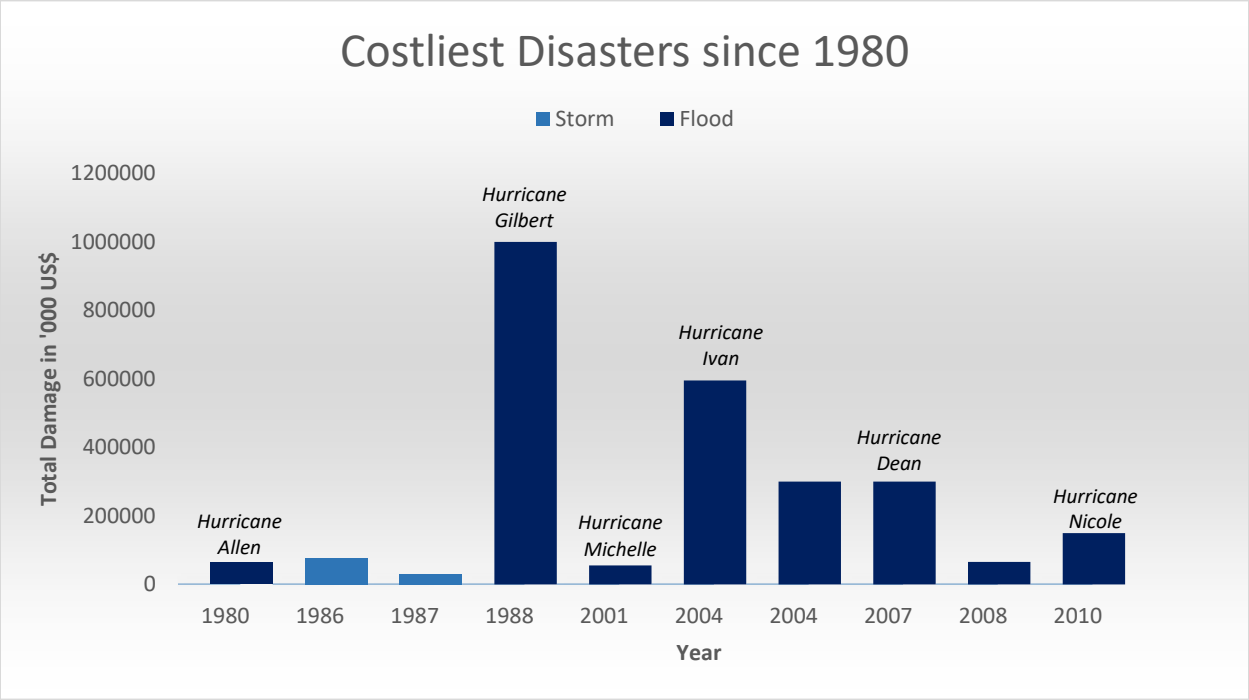
• Rising maximum, minimum and mean temperatures
• Minimum temperatures increasing faster (~0.27 °C/decade) than maximum temperatures (~0.06 °C/decade)
• Mean temperatures increasing at a rate of 0.16 °C/decade
	• Minimum, maximum and mean temperatures increase
	• Projected mean temperature increases include:
	  ○ 0.49–0.57°C by the 2020s
	  ○ 0.65–0.84°C by the 2030s
	  ○ 0.85–1.80°C by the 2050s and
	  ○ 0.82–3.09°C for 2081–2100 relative to 1986–2005
	• RCMs suggest higher magnitude increases for specific downscaled grid boxes: up to 4°C by end of century
	• Coastal regions show slightly smaller increases than interior regions
	• Mean daily maximum temperature each month at the Norman Manley International Airport station is expected to increase by 0.8–1.3°C across all Representative Concentration Pathways (RCPs) by early (mid-) century
	• Annual frequency of warm days in any given month at Norman Manley International station may increase by 2–12 days across all RCPs by early (mid-) century

RAINFALL	
Historical	**Projected**
• Significant year-to-year variability due to the influence of phenomena such as the El Niño Southern Oscillation (ENSO) • Insignificant upward trend • Strong decadal signal with wet anomalies in the 1960s, early 1980s, late 1990s and mid- to late 2000s, and dry anomalies in the late 1970s, mid- and late 1980s and post-2010 • Intensity and occurrence of extreme rainfall events increasing from 1940-2010	• Mid-2020s will see 0–2% less rainfall in the annual mean. The 2030s will be up to 4% drier, the 2050s up to 10% drier, while by the end of the century the country as a whole may be up to 21% drier for the most severe RCP scenario (RCP8.5) • Change in summer rainfall is the primary driver of the drying trend • Dry season rainfall generally shows small increases or no change • Spatial variation across the country and even within blocks, with the south and east showing greater decreases than the north and west

HISTORICAL OCCURRENCE OF DAMAGE TO THE TRANSPORT SECTOR

Historically, climate events in Jamaica have caused considerable damage to transport infrastructure. The costliest disasters in the country were due to floods and storms (Figure 3). For example, in 2004, Hurricane Ivan's storm surge caused heavy damage to the highway connecting Kingston and Norman Manley International, while related flooding and landslides cut off entire sections of other roads, blocked and destroyed drains and culverts, and damaged retaining walls and bridge approaches. Overflowing rivers and streams caused collapse on many road sections. Prior to the arrival of Hurricane Dennis in 2005, the island had received above normal rainfall, resulting in a high level of soil saturation. This exacerbated the impact of the hurricane and associated flooding, landslides and debris flows. The estimated cost to repair the road network was USD51.6 million and airport repairs reached USD60 million.

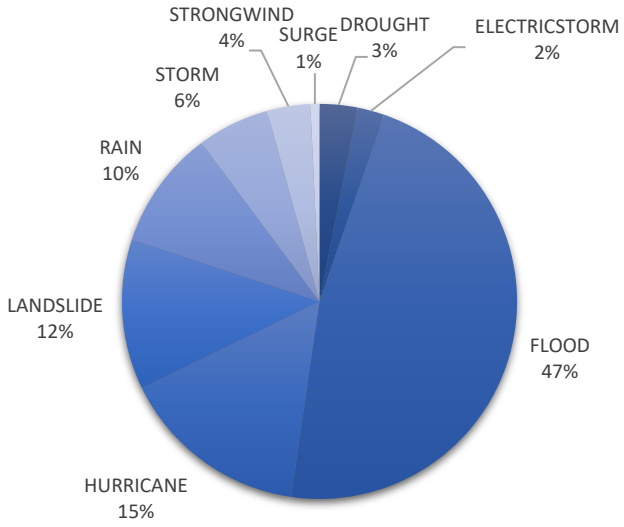
Figure 3. Costliest disasters in Jamaica since 1980



Source: EM-Dat.

Over 60 percent of all hazards/disasters registered in the country's disasters database (covering the period 1973–2014) were related to weather phenomena (Figure 4).

Figure 4. Disasters by type, 1973–2014

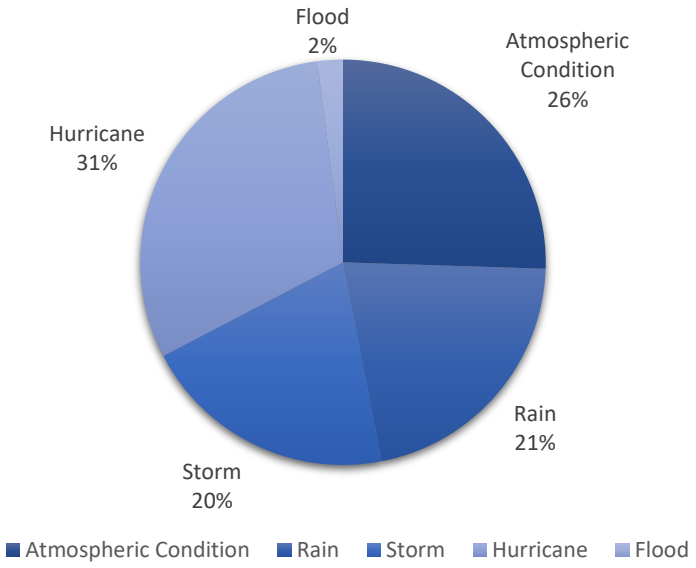


Source: Desinventar Jamaica database.

Between 1979 and 2015, 10 percent of the disaster records noted damage to the transport sector due to hurricanes, rain, storms, floods and atmospheric conditions such as dust and wind

(Figure 5). This low number, however, could be a function of underreporting within the Desinventar database.

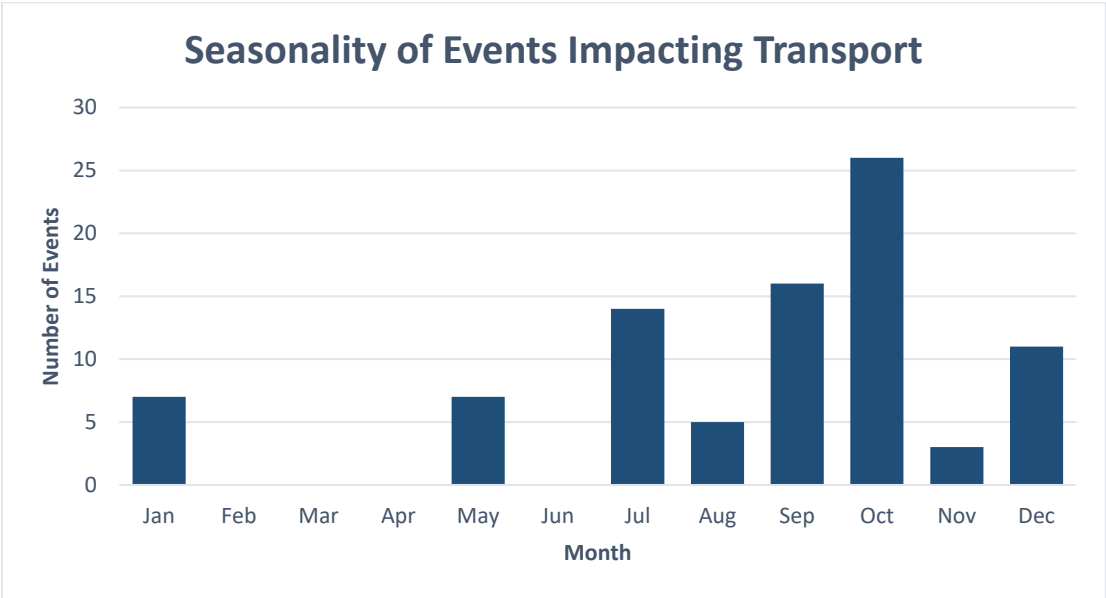
Figure 5. Weather-related damages to Jamaica's transport sector by cause, 1973–2014



Source: Desinventar Jamaica database.

The occurrence of major weather events within the year mirrors Jamaica's rainfall climatology, which has a bimodal pattern with a minor peak between April–June and a maximum between September–November (Figure 6).

Figure 6. Timing of registered weather-induced disasters with noted impacts to the transport sector, 1973– 2014

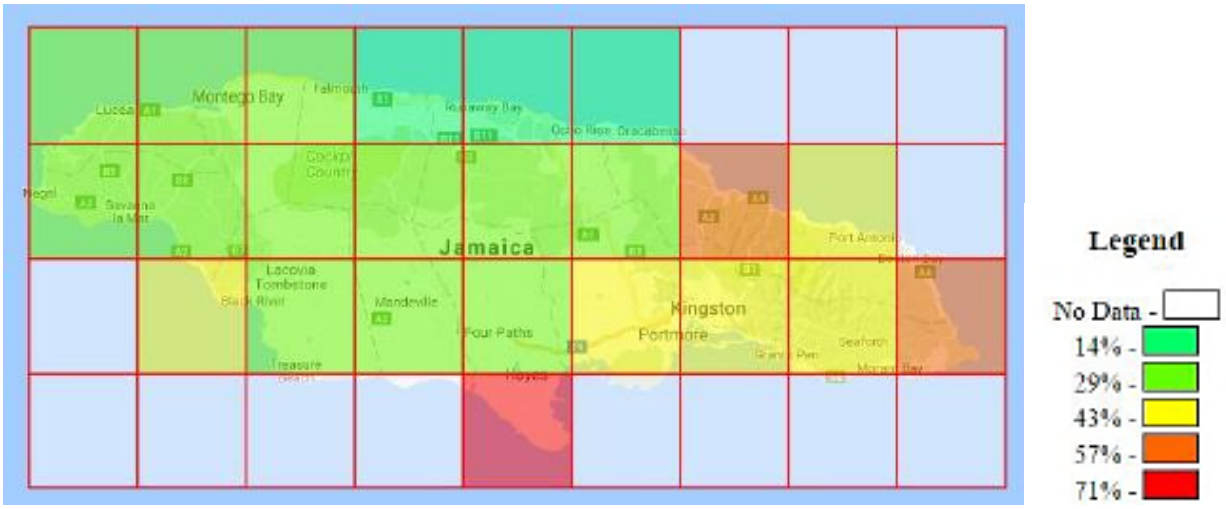


Source: Desinventar Jamaica database.

HURRICANES AND ASSOCIATED HEAVY RAINS

Between 1950 and 2015, 10 hurricanes (typically categories 3 and 4 in strength) and an equal number of tropical storms passed within 200 km of Jamaica, with the highest impacts felt along the southeastern and southernmost tip of the country (Figure 7). These events bring intense rainfalls and severe storm surges, resulting in extreme impacts on streams and rivers. Hurricane-induced peak flows are often in excess of maximum channel capacities, leading to extensive overbank inundation, debris flow, landslides and soil erosion. This causes devastation to houses, agriculture and infrastructure such as bridges and roads, among others. Wind strength, direction and forward speed of the hurricane, along with the amount of rainfall it brings, are major determinants of the extent and location of the impacts.

Figure 7. Probability of a hurricane passing within 50 km of a grid box, based on 66 years (1960–2015) of historical data



Source: *State of the Jamaican Climate 2015*.

HEAVY RAIN-INDUCED FLOODING, LANDSLIDES, LANDSLIPS AND DEBRIS FLOW

Jamaica's steep and rugged mountainous terrain, geology, rivers and location on a seismically active plate boundary fault zone all combine to make the island particularly susceptible to extreme events. This is especially true in the east of the country's Blue Mountain range, which reaches elevations of 2,254 m within only 10 km of the coast, making watersheds very steep. In addition, many inland regions of Jamaica suffer from flooding, landslides, landslips and debris flows resulting from heavy rains. The risks posed by these events are likely to continue, as the intensity of heavy rains from 1940–2010 increased, in terms of both maximum single day and 5-day precipitation and increased soil saturation.

Flood damage to roads and bridges results from debris flow and rivers overtopping their banks. Drainage systems are often overwhelmed as existing design standards for intensity duration frequency (IDF) curves are based on historical records. These may see more frequent exceedance during intense rainfall events, which could negatively impact 10,700 km of rivers and drains, and 5,612 km of roads (Burgess 2015). These impacts are compounded by

underlying vulnerabilities including poor planning mechanisms, uncontrolled population growth and limited financial resources for maintenance and repairs.

SEA LEVEL RISE AND COASTAL STORM SURGE

Global sea levels have risen between 0.05–0.17 m, mirroring levels in the Caribbean. Key findings of the *State of the Jamaican Climate 2012* with respect to sea level rise are summarized below:

- Satellite measurements show a rate of sea level rise of about 3 mm/year since the early 1990s (Bindoff et al. 2007), with the potential to affect an estimated 102 km^2 of some of the most densely populated coastal areas of the country.
- By the end of the century, sea level is expected to rise by 0.21–0.48 m under an A1B scenario using 2007 Intergovernmental Panel on Climate Change (IPCC) projections, but the models exclude future rapid dynamical changes in ice flow. A recent study of ice flow suggests that the rate of rise may actually double or be even greater than that (Hay et al. 2015). Evaporation is also projected to increase by approximately 0.3 mm/day over the sea. The changes over land may be less.
- According to the UWI Mona, a 1–2 m rise in sea levels would "*devastate low-lying coastal areas and key installations, including major power generation facilities, the oil refinery, airports and seaports. It would also have a serious impact on the natural protection of the Kingston harbour*" (CSGM 2012).
- For the tourism sector, which contributed 27.2 percent of GDP in 2014, sea level rise poses a significant threat even under the smallest sea level rise scenarios (0.5 m), which suggest, for example, that 35–68 percent of the highly valued beach resources in Portland Parish could be lost (Simpson et al. 2008).

INSTITUTIONAL ANALYSIS

Vision 2030 transport-related national strategies

- Expand and rationalize land transport infrastructure and services
- Develop a modernized public transport system
- Expand domestic and international air transport infrastructure and services
- Expand and diversify maritime infrastructure and services
- Develop Jamaica as a regional logistics hub with multimodal transport linkages

Despite Jamaica's rank as 162nd in the world in size, its transport system is uncharacteristically complex, with one of the densest road networks in the world, three international airports and three domestic aerodromes, a railway network, and 14 major seaports (Vision 2030). The Government of Jamaica (GOJ) acknowledges that developing and maintaining a strong transportation system is crucial to economic development. In the Vision 2030 Jamaica – National Development Plan, the national outcome "Strong Economic Infrastructure" includes five (of seven) national strategies focused on transportation.

The transport sector is also highly vulnerable to natural disasters and the effects of climate change, as discussed in the previous section. In 2011, the Planning Institute of Jamaica (PIOJ) conducted an overall damage and loss assessment of nine major weather-related natural disasters over the past decade. From that assessment, PIOJ estimated that the total cost of these nine events was JMD111.4 billion (USD869 million); the transport sector accounted for 40 percent of the overall cost, with losses of JMD44.4 billion (USD346.5 million) (PIOJ 2011).

The challenge of maintaining and developing this critical and vulnerable network falls to a complex network of public and private institutions, including three ministries, eight agencies, more than a dozen private sector operators and 14 municipal corporations (see Table 5 for owners and operators of the country's primary assets). Integrating climate change and disaster management further broadens the list of stakeholders, adding in CCD, ODPEM, PIOJ, MSJ and NEPA, among others.

Table 5. Infrastructure owners and operators

INFRASTRUCTURE TYPE	OWNER	RESPONSIBLE PARTY/OPERATOR
Roads		
Motorways (Highway 2000)	National Road Operating & Constructing Company Limited (NROCC)	TransJamaican Highway (TJH) / Jamaican Infrastructure Operator (JIO)
Main roads (Class A, B & C)	National Works Agency (NWA)	National Works Agency (NWA)
Parochial roads	Municipal corporations (i.e., parishes)	Municipal corporations (i.e., parishes)
Farm roads	Rural Agricultural Development Authority (RADA)	Rural Agricultural Development Authority (RADA)
Airports		
Norman Manley International	Airports Authority of Jamaica (AAJ)	NMIA Airports Limited
Donald Sangster International	Airports Authority of Jamaica (AAJ)	MBJ Airports Limited

INFRASTRUCTURE TYPE	OWNER	RESPONSIBLE PARTY/OPERATOR
Ian Fleming International	Airports Authority of Jamaica (AAJ)	Airports Authority of Jamaica (AAJ)
Domestic airports (Tinson Pen Aerodrome, Negril Aerodrome, Ken Jones Aerodrome)	Airports Authority of Jamaica (AAJ)	Airports Authority of Jamaica (AAJ)
Major Seaports		
Kingston Container Terminal (KCT)	Port Authority of Jamaica (PAJ)/GOJ	Kingston Freeport Terminal Limited (KFTL)
Port of Montego Bay	Port Authority of Jamaica (PAJ)/GOJ	Port Handlers Limited
Ocho Rios Cruise Port	Port Authority of Jamaica (PAJ)/GOJ	Lannaman & Morris Shipping
Falmouth Port	Port Authority of Jamaica (PAJ)/Royal Caribbean Cruises International	Royal Caribbean Cruises International
Reynolds Bauxite Pier	Jamaica Bauxite Mining Limited	Jamaica Bauxite Mining Limited
Railway		
Railway network	Jamaica Railway Corporation (JRC)	Jamaica Railway Corporation (JRC)
Mining rail system	Jamaica Railway Corporation (JRC)	WINDALCO

The section below provides an overview of institutions that govern the transport sector; a situational analysis of the 2007 National Transport Policy and the Vision 2030 Transport Sector Plan; and an evaluation of the readiness of the transport sector to climate-proof infrastructure investments.

EXISTING INSTITUTIONS IN THE TRANSPORT SECTOR

The transport sector is governed and influenced by a complex network of ministries, agencies, private sector actors and local municipal corporations. Overall, three ministries lead policy and oversee implementation: The MTM, the Ministry of Economic Growth and Job Creation (MEGJC), and the MLGCD. Three key agencies under those ministries lead implementation and provide regulatory oversight (NWA, PAJ and Airports Authority of Jamaica/AAJ) along with 14 municipal corporations. Table 6 summarizes the major institutions involved in the transport sector, along with their primarily role.

Table 6. Institutions involved in Jamaica's transport sector

NAME	ROLE
National Government – Ministries	
Ministry of Transport and Mining (MTM)	MTM is primarily concerned with transport policy and has regulatory responsibility for the safety of all modes of transportation, whether publicly or privately operated. This includes airports, aerodromes, airline operators, seaports, shipping traffic and public land transportation as well as road infrastructure and road safety. With the move of NWA and PAJ under the MEGJC, the ministry is now less focused on infrastructure development and maintenance.
Ministry of Economic Growth and Job Creation (MEGJC)	Created in 2016, MEGJC has broad authority over any government function related to economic growth. On transport, it oversees the main road network and port development and regulation, as well as related areas such as land development and utilization, land policy and administration, land titling, civil works, environmental regulation, and town and country planning.

NAME	ROLE
Ministry of Local Government and Community Development (MLGCD)	MLGCD develops policy and the legal framework for local governments, as well as provides technical and administrative assistance to municipal corporations. As a function of its oversight of municipal governments, MLGCD is the national-level ministry responsible for the country's extensive parochial road network (approximately10,000 km).
National Government – Agencies	
Agencies under MEGJC	
National Works Agency (NWA)	NWA is primarily responsible for the approximately 5,000-km main road network (consisting of arterial, secondary, tertiary and urban roads) as well as some 800 bridges. In addition to technical assistance with policy and infrastructure planning, NWA oversees road asset maintenance and development, road optimization and congestion improvement, road safety management, flood/sea damage control, and road transport efficiency and effectiveness.
Port Authority of Jamaica (PAJ)	A statutory corporation, PAJ is the principal maritime agency responsible for the regulation and development of Jamaica's port and shipping industry. PAJ is responsible for the safety of all vessels navigating the ports of entry and regulation of the tariffs charged on goods passing through the public wharves.
Planning Institute of Jamaica (PIOJ)	PIOJ is responsible for initiating and coordinating the development of policies, plans and programs for the economic, financial, social, cultural and physical development of Jamaica; it also oversees Vision 2030. PIOJ provides technical review of the economic, financial and technical feasibility of new development projects, and coordinates the implementation of ongoing projects.
National Environment and Planning Agency (NEPA)	NEPA is responsible for developing environmental conservation, protection and management policies, legislation, regulations, standards and programs. It also processes applications to provide recommendations for decisions on licenses and permits for all infrastructure development.
Meteorological Service of Jamaica (MSJ)	MSJ consists of two branches: the Weather Branch, which is concerned with the observation and forecasting of weather conditions over and around the island; and the Climate Branch, which is responsible for maintaining a current database of the climate of Jamaica and supporting its use in sectoral planning.
Climate Change Division (CCD)	CCD oversees the climate change framework policy and coordinates the mainstreaming across ministries of climate change mitigation and adaptation in policy formulation, development planning and decision making. It also provides technical guidance in developing specific adaptation measures to address key vulnerabilities, and actions to reduce greenhouse gas emissions through fossil fuel reduction, conservation and switching to renewable and cleaner energy sources.
National Spatial Data Management Division (NSDMD)	NSDMD coordinates the development, implementation, maintenance and management of a national spatial data infrastructure for Jamaica and promotes the sharing and use of GIS data. It also serves as the secretariat for the Land Information Council of Jamaica (LICJ).
Agencies under MTM	
Airports Authority of Jamaica (AAJ)	An independent statutory body, AAJ maintains ownership of all international and domestic airports, oversees the (private) management of the country's two main international airports, and operates and maintains three domestic airports. It also engages in long-term planning and development of airport infrastructure.
Caribbean Maritime Institute (CMI)	CMI is a certified institution and the region's Centre of Excellence for tertiary maritime, logistics, engineering training, research and consultancy. It is currently transitioning to full university status.
Jamaica Railway Corporation (JRC)	JRC is a statutory body with sole responsibility for the operation of rail services in Jamaica. Public train service is currently suspended, but the JRC maintains ownership of the public rail network and oversees the operation of privately owned rail lines.
Jamaica Urban Transit Company (JUTC)	This government-owned company provides public bus service throughout the Kingston Metropolitan Transit Region. JUTC manages a network of approximately 450 buses that provide service to an average of 250,000 passengers daily.

NAME	ROLE
Maritime Authority of Jamaica (MAJ)	MAJ is responsible for promoting the development of shipping, as well as regulating merchant shipping.
Transport Authority of Jamaica (TAJ)	TAJ is responsible for regulating and monitoring the public transportation system in Jamaica.
Island Traffic Authority (ITA)	ITA administers the provisions of the Road Traffic Act, including vehicle licensing and inspection, traffic regulation and control, and accident reporting.
Jamaica Civil Aviation Authority (JCAA)	JCAA regulates the Jamaican aviation industry, including air navigation and all matters relating to safety and security in civil aviation.
Other agencies	
Office of Disaster Preparedness and Emergency Management (ODPEM)	Located directly under the Prime Minister, ODPEM is responsible for developing and implementing policies and programs for the purpose of achieving and maintaining an appropriate state of national preparedness for natural disasters and other emergency events.
Rural Agricultural Development Authority (RADA)	Housed under the Ministry of Industry, Commerce, Agriculture and Fisheries, RADA is responsible for the farm roads network and overseeing maintenance and development of farm roads. It currently manages the JDM1.22 billion National Farm Road Rehabilitation Programme, which is rehabilitating 70 farm roads across 13 parishes.
Private Sector	
Kingston Freeport Terminal Limited (KFTL)	This private company has a concession agreement to finance, expand, operate, maintain and transfer the Kingston Container Terminal.
Port Handlers Limited	This private company manages and operates Montego Bay Port.
Lannaman & Morris Shipping	This private company, manages and operates Ocho Rios Cruise Port.
Bauxite and Alumina Trading Company (BATCo)	This private company owns, manages and operates the Reynolds Bauxite Pier.
Royal Caribbean Cruises International	This private company entered into a joint venture with the GOJ to build and operate the Falmouth Cruise Ship Pier.
National Road Operating & Constructing Company Limited (NROCC)	This government-owned company engages in the construction, operation, management, maintenance and financing of highways in Jamaica. NROCC operates Highway 2000, a tolled highway; oversees the design and construction of the project, provides contingent support, and acquires land necessary for the construction and operation of the highway.
TransJamaican Highway (TJH)	This private company is the developer of Highway 2000; it coordinates the development of the highway network, including its financing and construction.
Jamaican Infrastructure Operator (JIO)	This private company operates Highway 2000.
NMIA Airports Limited	This wholly owned subsidiary of Airports Authority of Jamaica (AAJ) is the operator of Norman Manley International Airport.
MBJ Airports Limited	This private company engages in the development, construction and operation of Sangster International Airport through a concession agreement.
Civil Society, Academic Institutions and NGOs	
University of the West Indies Mona – Geoinformatics Institute (MGI)	MGI serves as the GIS hub for the University of the West Indies Mona Campus. It delivers GIS courses for various departments, participates in campus research activities, and provides GIS services to the public and private sectors.
University of the West Indies Mona – Climate Studies Group (CSGM)	CSGM comprises faculty members, consultants, technical staff and postgraduate students; it conducts research and modeling on climate change and its impacts on Jamaica and the region.

SITUATIONAL ANALYSIS OF TRANSPORT POLICY

Over the past 20 years, Jamaica has seen a steady increase in the development and use of its transport network. In 2016, Manley and Sangster International Airports accommodated more than 5.4 million passengers. Cruise ship ports (Falmouth, Ocho Rios and Montego Bay) received more than 1.6 million passengers (AAJ 2015), and the cargo terminals in Kingston and Montego Bay processed more than 8.2 million metric tons of cargo (PAJ 2017). Major highway projects have been undertaken, most notably, the Highway 2000 project linking Ocho Rios, Kingston and May Pen. The railway system, which has been out of service since 1994, has plans to revitalize the network and resume tourist and public rail travel, beginning with the line connecting Montego Bay and Appleton Estate in St. Elizabeth Parish.

Over that period of growth and development, numerous efforts were made to institutionalize an overarching policy for the transport sector, including stalled efforts in 1993 and 1998. As a result, the transport sector evolved significantly without a guiding policy framework, and the provisions of the 2007 NTP had to address a wide-ranging list of issues, including competition, cost recovery, economic development, consultation, private sector participation, environmental protection, equal access to transport, energy efficiency and land use. Shortly after the approval of the NTP, Jamaica began the Vision 2030 process, which sought to lay out an economic growth roadmap for the next 20 years. As a part of this effort, the TSP emerged as one of 31 sectoral plans (see Annex B for a complete list of transport policies, plans, reports and studies).

The subsections below examine the content of the NTP and TSP, including their climate change-specific provisions, progress to date on achieving policy objectives, and gaps and challenges of both policies that should be addressed during any revision process (with emphasis on gaps in addressing climate variability and change).

POLICY OVERVIEW

National Transport Policy: The NTP is intended to be a policy framework that guides all aspects of the transport sector. The current NTP, finalized in 2007 after almost a decade of work with assistance from Transport Canada, is the first transport policy approved and adopted by the GOJ. The NTP identifies priority goals and issues, differentiates the roles of the national government, the numerous transport authorities and the private sector, and provides strategic objectives for the sector.

The NTP is structured around nine principles of policy development in the sector, as well as nine strategic objectives that build on these principles (Table 7).

Table 7. NTP policy principles and related strategic objectives

POLICY PRINCIPLE	PRINCIPLE OBJECTIVE	RELATED STRATEGIC OBJECTIVE
Competition	Market forces should guide investments in transport infrastructure.	n/a
Cost recovery	Transport systems should strive to recover some or all of the costs associated with the system through user fees.	Have users pay for the costs of transport services

POLICY PRINCIPLE	PRINCIPLE OBJECTIVE	RELATED STRATEGIC OBJECTIVE
Economic development	The transport system should facilitate and drive economic growth.	n/a
Consultation	The public should be consulted on funding and spending decisions related to transport infrastructure.	Create policy awareness and further participation in policy development
Private sector participation	As much as possible, the private sector should provide transport services.	Encourage greater private sector participation
Environmental protection	Transport services and development should have minimal environmental impact, and user fees should help pay for recovery efforts.	Ensure adequate regulations are in place to meet international environmental and safety standards
Equal access to transport	Reasonable accommodations should be made to ensure everyone has access to transport.	Increase access to transport and transport services in rural areas Ensure transparent access to subsidies for the provision of transport services for social and economic benefit
Energy efficiency	All modes of transportation should move toward energy efficiency improvements.	Promote energy conservation and environmental protection
Land use	The NTP should spawn sectoral plans that conform to the country's larger development plans.	n/a

Two additional strategic objectives, not directly tied to a principle, seek to improve management, planning and coordination within the transport sector: 1) improved coordination in intermodal transport; and 2) integration of transport planning across modes. Under each strategic objective, a number of issue or policy statements define a problem that needs to be addressed or propose an action.

The following subsectors each have their own vision, policy statements and strategic objectives:

- Land transport (divided into roads/infrastructure, public transport, traffic management, general and nonmotorized transport)
- Railways
- Air transport
- Maritime transport
- Nontraditional modes of transport
- Poverty alleviation and transport for the vulnerable

In these subsections, the strategic objectives do not necessarily align with transport sector-wide strategic objectives. For example, under roads, the strategic objective "to plan, construct and maintain a road system which serves the transport needs of people and industry" does not appear to have been developed taking into consideration the sector-wide strategic objectives, whereas "encourage and facilitate greater private sector participation in the construction, management and maintenance of the road network" is clearly aligned with a specific sector-wide objective. The NTP is a standalone document, and is not accompanied by a strategic plan, an implementation plan or an M&E framework. This has led to the treatment of policy statements within the NTP as target outcomes.

The NTP includes policy statements related to sustainable development and environmental protection, generally linked to infrastructure development, but does not include any mention of

climate change or any actions related to increasing resiliency to the future effects of a changing climate in Jamaica. Disaster preparedness is included under the roads/infrastructure subsection of land transport through the following policy statement: “The Government will develop a hazard mitigation strategy to limit the adverse impact of natural, environmental or technological disasters on the country’s road transport network. The Government will also formulate a disaster response strategy to maintain the integrity of a functioning road system following any natural disasters or catastrophic events.”

Vision 2030 Transport Sector Plan 2009–2030: The TSP serves as the other half of policy guidance for transport sector stakeholders. Development of the TSP began in 2007 and it was formally approved in 2009. The NTP served as the basis for developing the TSP. However, the TSP was developed under the Vision 2030 framework (specifically under National Outcome #9 “Strong Economic Infrastructure”), which focuses on economic development. As such, other than sharing a vision statement with the NTP, the TSP is a separate document with different strategic goals, expected outcomes and indicators.

The TSP lays out two primary strategic goals: 1) improvement of the domestic transport system; and 2) development of Jamaica as a regional, hemispheric and global transport and logistics hub. To achieve those overarching goals, the TSP lays out seven goals with one to six outcomes per goal (Table 8).

Table 8. TSP goals and outcomes

GOALS	OUTCOMES
1.0: A sustainable road transport system that serves the economic and social needs of the country	1.1: Properly constructed and maintained road network
	1.2: A public transportation system that facilitates the movement of people, goods and services throughout Jamaica in a safe and efficient manner
	1.3: Improved management of traffic on the road network
	1.4: A road transport system which accommodates nonmotorized transport
	1.5: Increased provision and efficiency of road transport services
2.0: A country with adequate and high quality domestic and international air transport infrastructure and services	2.1: Expanded domestic air transport infrastructure and service
	2.2: Expanded international airport infrastructure
	2.3: Expanded international air service
3.0: A globally competitive and diversified maritime transport subsector	3.1: Short sea shipping established as a viable option for coastal transport of cargo and passengers
	3.2: Diversification of maritime cargo
	3.3: Development of key maritime infrastructure
	3.4: Development of human and technical resources for maritime transport
	3.5: Creation of Maritime Center

GOALS	OUTCOMES
	3.6: Growth of shipping fleet
4.0: A viable railway system that supports economic and social development	4.1: Railway system that supports a major logistics hub and movement of passengers and cargo on critical corridors
5.0: Establishment of Jamaica as a major integrated multimodal logistics hub	5.1: Development of efficient and effective institutional framework and supporting services for logistics hub
	5.2: Development of efficient and adequate infrastructure for logistics hub
6.0: Comprehensive policy, legislative, regulatory and institutional framework for transport sector	6.1: Development of efficient and effective policy, legislative, regulatory and institutional framework for transport sector
7.0: Environmentally sustainable transport sector	7.1: Environmentally sustainable transport infrastructure and services
	7.2: High levels of energy security, conservation and efficiency in the transport sector

Unlike the NTP, the TSP includes an implementation framework that defines which institutions are accountable for achievement of the goals, as well as requirements for resource allocation. The TSP also includes an M&E framework that defines indicators and measurable targets for the plan, assigns data collection responsibilities to specific institutions, and lays out data sources and reporting requirements. Most importantly, the TSP contains an action plan that includes 72 strategies consisting of 256 individual actions to achieve the outcomes and, ultimately, the goals. The action plan assigns a responsible agency (or agencies) to each action, as well as a timeframe, but does not include any cost estimates or budgetary requirements.

Due in part to the fact that Vision 2030 addresses climate change through *National Outcome #14 – Hazard Risk Reduction and Adaptation to Climate Change*, the TSP includes some acknowledgement of climate change and natural hazards. For example, the Strengths, Weaknesses, Opportunities, and Threats (SWOT) analysis conducted lists climate change and natural disasters as an external threat to certain portions of the transport sector. The road network in particular is mentioned as vulnerable to damage caused by natural hazards, particularly hurricanes, tropical storms and associated rainfall and flooding, including sediment floods.

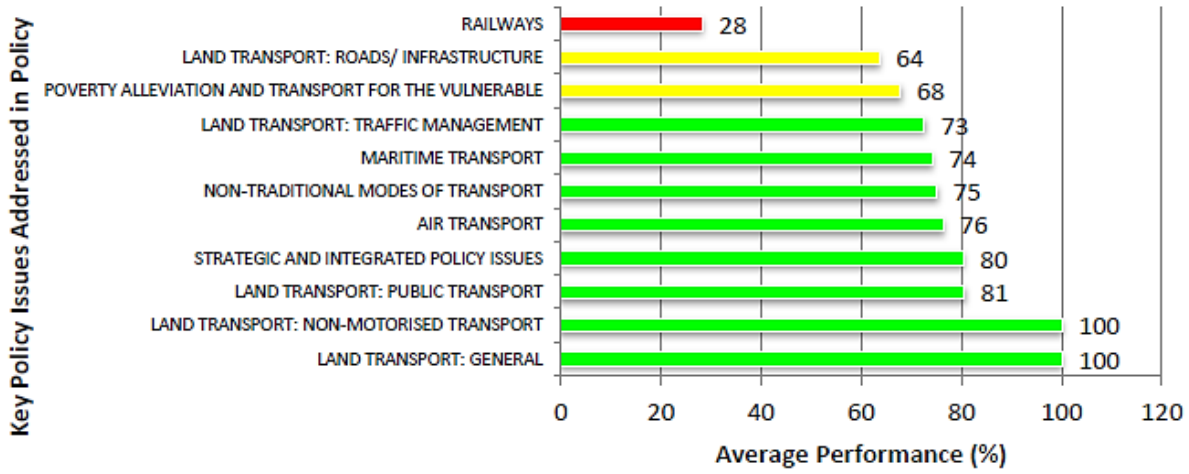
The action plan includes a number of specific actions aimed at addressing climate risk and natural hazards, including "*Incorporate climate change adaptation and mitigation considerations in the design and construction of transport infrastructure*" under strategy 7.1.6, and "*Design, build and retro-fit road infrastructure to meet current and projected hazard events*" under strategy 1.1.5. The action plan also includes a number of more general action items under those same strategies, such as "*Strengthen resilience of transport sector to natural and manmade hazards*."

PROGRESS TO DATE IN ACHIEVING POLICY OBJECTIVES

National Transport Policy*:* In 2015, the Ministry of Transport, Works and Housing (MTWH) (now known as the Ministry of Transport and Mining) conducted a preliminary evaluation of

progress to date on the NTP. The evaluation examined all strategic objectives and target outcomes across the 11 areas covered by the policy and evaluated the level of achievement using a simple scale of "completed," "work in progress" or "no work started." From this evaluation, the MTWH determined that 71 percent of target outcomes had been achieved, with some subsectors lagging behind (e.g., railways, roads/infrastructure), while others had met 100 percent of their targets (e.g., nonmotorized transport and general land transport) (Figure 8). Of the 29 percent of target outcomes that were not achieved, remedial actions are expected to be developed and included in the National Transport Strategy (NTS) 2015–2020, which has yet to be developed.

Figure 8. Proportion of target outcomes met by key policy area, 2008–2015



Source: Ministry of Transport, Works and Housing 2015.

Despite this evaluation, it is difficult to ascertain the actual level of achievement due to the lack of specificity in the targets measured. For example, a target outcome to achieve the strategic goal of *encourage greater private sector participation* is "legal or regulatory environment to facilitate private investment." The indicator of this outcome is "*legal or regulatory environment for private investment*." That outcome is marked as achieved, without further discussion of which specific laws or regulations were expected to be developed, and which were passed. Similarly, the target outcome "*road improvement (including bridges) works in rural areas*" is marked as completed for the strategic objective *increased access to transport and transport services in rural areas.* Without a numerical target, however, such as kilometers of roads rehabilitated, it is impossible to say with certainty that the target has been met.

As mentioned in the policy overview section, the NTP does not contain any references to climate change or any policy statements related to climate resiliency. As a result, there is nothing against which to benchmark progress. In terms of disaster preparedness, the NTP committed to develop hazard mitigation strategy and a disaster response strategy for the road network. In the 2015 assessment, the hazard mitigation strategy is marked as "some work done." Although there is no indication that the plan was developed, steps related to hazard mitigation were undertaken, including a Flood Damage Programme through which NWA

cleaned hundreds of drains and gulleys across the island to help reduce flooding. In addition, a Master Drainage Plan was finalized in 2017, but has yet to be implemented.

"Formulating a disaster response strategy" is marked as "complete" in the 2015 assessment, despite the fact that a formal national disaster response strategy document has not been developed and is still listed as a pending action. Progress was made in this area, however, including establishing an Emergency Operation Centre at NWA that provides rapid recovery services and responds to damage reports. NWA also strengthened its data collection and coordination mechanisms, including establishing a National Disaster Response GIS team, participating regularly in the National Disaster Committee, and revitalizing the Damage Assessment Committee within ODPEM.

Vision 2030 Transport Sector Plan 2009–2030*:* Unlike the NTP, which required an ex post facto evaluation, Vision 2030 established indicators with baselines and targets, both at the sector and national level (Table 9).

Table 9. TSP outcome indicators

OUTCOME INDICATOR	BASELINE (2007)
Infrastructure Index (adapted from the Global Competitiveness Index/GCI)	3.54
User satisfaction with public transport	n/a
% of roads in "good" condition	12%
% change in total passengers through international airports	2.1%
% change in total cargo through international airports	9.8%
% change in total number of vessel visits	-7.5%
% change in volume of cargo	1.4%
% of JRC railway tracks that are active	27.5%

Vision 2030 is implemented through three-year Medium Term Socio-Economic Policy Frameworks (MTFs), which identify the priority outcomes, strategies and actions for each three-year period (e.g., 2009–2012, 2012–2015, 2015–2018). Through these MTFs, data are collected on progress toward targets for each of the indicators. MTFs are done at the national level however, so only the primary indicator for the transport sector is updated. It is unclear what process is being used to update the other seven indicators. The indicator chosen to measure progress in the transport sector is the infrastructure subindex of the Global Competitiveness Index (GCI), results of which are displayed in Figure 9.

Figure 9. Vision 2030 transport sector indicator

National Outcome # 9 – Strong Economic Infrastructure											
Indicators	Baseline	Actual						Targets			
	2007	2010	2011	2012	2013	2014	2015	2012	2015	2018	2030
Infrastructure Index	3.54	3.91	3.74	3.59	3.49	3.75	3.74	3.69	3.84	4.0	4.59

Source: *Vision 2030 National Development Plan.*

Overall performance, as reflected in the scores above from the infrastructure subindex of the GCI, suggests that domestic infrastructure has improved from the baseline in 2007, but does not reflect a year-to-year improvement. In fact, until 2014, scores were declining, and the target for 2015 was not met. In the most recent GCI report from 2016–2017, Jamaica scored a 3.90 in this category (WEF 2016), suggesting that recent efforts to correct this issue have proven successful. Progress has been made on large transport infrastructure projects since 2012, including the rehabilitation and protection of the Palisadoes Peninsula, completion (but not implementation) of the Master Drainage Plan, further progress on the North-South and East-West Link of Highway 2000, and completion of major privatization initiatives, most notably with Norman Manley International Airport and KCT. However, no comprehensive review similar to the NTP assessment has been conducted on the status of the 256 actions listed in the TSP, so other than anecdotal evidence, it is not possible to evaluate progress to date.

The TSP has no indicators specifically related to natural disasters or climate change (either mitigation or adaptation). The Vision 2030 document does have an indicator under outcome #14 that simply measures cost of damage caused by natural disasters as a percentage of GDP (Figure 10). This indicator does not provide much value in determining if investments in the transport sector are increasing its resiliency, as the indicator is influenced by a variety of external factors, including the year-to-year change in the country's GDP and the variability in the intensity and frequency of storms.

Figure 10. Vision 2030 hazard risk reduction and climate change adaptation indicator

National Outcome # 14 – Hazard Risk Reduction and Adaptation to Climate Change										
Indicator	Baseline	Actual					Targets			
	2007	2010	2011	2012	2013	2014	2012	2015	2018	2030
Cost of damage caused by disasters as % of GDP	3.4	1.9	0.1	0.8	n/a	n/a	2.5	1.5	1.3	≤1

Source: *Vision 2030 National Development Plan*.

It is possible to evaluate progress on individual actions related to hazard risk reduction and climate change adaptation. Two strategies (1.1.5 and 7.1.6) directly address the two areas through six actions, all of which have a completion timeframe of "ongoing," indicating that the actions refer to long-term solutions rather than short-term projects or activities. Table 10 gives a general summary of progress to date on those actions.

Table 10. TSP hazard risk reduction and climate change adaptation actions

STRATEGY	ACTION	STATUS
1.1.5: Increase resilience of road network to hazards	1.1.5.1 Participate in integrated national watershed management and hazard mapping programmes	Some progress made: Master Drainage Plan completed; multiple actors including the Mines & Geology Division of MTM, NWA, ODPEM, WRA and UWI Mona have developed floodplain maps for numerous rivers, landslide hazard maps, and inventories of areas and roads prone to flooding, as well as mapping of rivers, watersheds and gulley networks.

STRATEGY	ACTION	STATUS
	1.1.5.2 Undertake flood damage mitigation measures	Some progress made: Work was completed by the NWA under the Flood Damage Programme to clean gulleys and culverts and through river training programs. Implementation of items from 1.1.5.1 (e.g., Master Drainage Plan) have not yet begun.
	1.1.5.3 Produce and implement a formal hazard mitigation strategy and a disaster management contingency plan for the road transport sector	Little progress made: This action is a carryover from the NTP, and while some coordination occurred related to this activity, no progress was made on drafting a hazard mitigation strategy or a disaster management contingency plan.
	1.1.5.4 Design, build and retro-fit road infrastructure to meet current and projected hazard events	Some progress made: Rehabilitation and protection of the Palisadoes Peninsula was completed in 2012, and major new projects (e.g., Highway 2000) typically include design criteria built to a 1-in-100 return period. Little evidence exists of retrofitting existing infrastructure, however, particularly of urban and secondary roads.
7.1.6:Strengthen resilience of transport sector to hazards and climate change	7.1.6.1 Strengthen resilience of transport sector to natural and manmade hazards	Some progress made: Progress made on this action is largely the result of progress under other actions. Strengthening of transport sector institutions and coordination mechanisms has had little progress.
	7.1.6.2 Incorporate climate change adaptation and mitigation considerations in the design and construction of transport infrastructure	Some progress made: Outside of road construction, little new major transport infrastructure has occurred during the period since 2009, with the exception of the Falmouth Port in 2011. Construction plans for the port underwent a full environmental impact assessment, which called for all pier structures to be set 3 m above chart datum.

GAPS AND CHALLENGES

While the NTP provided much needed context and guidance for the development of the transport sector, numerous challenges remain that should be addressed during the NTP revision process set to get underway in 2018. Below is a summary of general policy challenges as well as climate change-specific gaps that should be addressed by the revised policy.

- The NTP was developed as a standalone policy without an implementation plan or strategic action plan necessary for adequately implementing its provisions. This led to interpretation of policy statements in the NTP as action items, and tasks, responsible agencies and timeframe were either developed ad hoc, or not developed at all.

- Many of the policy statements in the NTP and the strategies and actions in the TSP lack specificity and are not necessarily linked to achieving the larger objectives. Many of the actions contain language such as “strengthen capacity of,” “participate in,” “strengthen resilience of” or “maintain,” which allude to the desired outcome but do not guide action (for example, “Strengthen capacity to regulate, license and monitor activities in road network” or “Strengthen resilience of transport sector to natural and manmade hazards”).

- Based on the data and reports provided, tracking of progress on actions and strategies is insufficient, particularly for the NTP. The only tracking done on NTP implementation status appears to be the 2015 evaluation; lack of quarterly or annual M&E will severely limit the ability of the MTM and other agencies to identify lagging areas of implementation and develop corrective actions. In the evaluation, it is difficult to identify how the status of an activity is determined, and often the analysis appears subjective rather than evidence-based. For the TSP, which does have indicators with targets, the

indicators are not sector-specific, which limits the ability to drill down to transport subsectors. While the infrastructure index indicator provides some level of relevance and rigor, the indicator tracking progress on climate resilience does not adequately capture an increase or decrease in the resilience of the country's transport network.

- Both the NTP and the TSP lack budget estimates (either at the strategy or action item level) and direct connection to the budget planning process. As a result, overall cost implications of the policy or action plan are unknown; during the annual budget planning process, costs for individual action items are developed separately from the action plan. This results in reactive decision making – for example, maintenance and repair take priority over development and improvement – that impedes budget planning for larger or longer-term initiatives.

- Resources to implement many of the activities included in the NTP and TSP are generally lacking. In the 2016 budget, the budget estimate for road construction and repair across the five ministries or agencies that deal with roads (MEGJC, MTM, MLGCD, NWA and municipal corporations) is JMD2,306,608,000 (USD49,838,900) (MOF 2016). Analysis shows that 92 percent of that expenditure is marked for maintenance, rehabilitation and disaster management, leaving less than 8 percent for new construction or climate-proofing of existing infrastructure.

- As a result of both the need to spend local revenue on maintenance and the large size of the road network, many rehabilitation and development projects are foreign-funded loans. Examples include the USD50 million Transport Infrastructure Rehabilitation Programme and the USD10 million Road Improvement Programme, both funded by the International Development Bank, and the USD300 million Major Infrastructure Development Project funded by China. This limits the ability to implement new projects based on the willingness of development partners to provide grants and loans.

- Responsibility for the transport sector is spread out between three ministries, eight agencies, more than a dozen private sector operators and 14 municipal corporations (Table 6). Coordination between the various actors remains a challenge. With a recent reorganization, resulting in the creation of the MEGJC and the subsequent move of NWA and PAJ from the MTM to the MEGJC, strengthening coordination and cooperation remains a critical area for improvement.

- Many of the transport sector stakeholders were not fully consulted during development of the NTP. While this issue was addressed by a transport task force during the drafting of the TSP, transport does not currently have a TWG under Vision 2030. For the revised NTP to adequately reflect the needs of all transport sector actors, extensive stakeholder consultations should occur before and during the drafting of the policy. A dedicated task force should be created to both draft the policy and liaise with stakeholders. Similarly, a TWG should be created under Vision 2030 to ensure coordination with the NTP task force.

- Over the past decade, the GOJ has pushed to privatize both international airports, all major ports and a number of toll highways, largely through concession agreements. The government maintains ownership of all infrastructure but its role has changed from operator to regulator over a relatively short period of time. A revised transport policy will need to carefully consider this new role and craft regulation that promotes competition,

provides equitable rates and fees, maintains safety standards and ensures that infrastructure is maintained and improved upon.

- Except for one mention of disaster management planning, climate change was not considered in the NTP, nor was natural hazard mitigation. As a result, climate change adaptation and resiliency measures have been incorporated into infrastructure design on a project-by-project basis (e.g., Highway 2000, Falmouth Port), often on the requirements of the developer, private financer or private insurer.

- Availability of climate data for planning purposes is insufficient. For example, return period data (data used to develop a statistically measurement of the likelihood of an event reoccurring) need to be updated, as they are over 30 years old. Ten-, fifty- and one hundred-year events (as currently defined) are occurring more often than predicted, leading to insufficient design standards and infrastructure damage. Meteorological data are also often insufficient to determine weather conditions that lead to flooding, landslides and storm surge damage. MSJ is currently working with the World Bank to increase the number of automated weather stations, but additional work will need to be done to continue to increase the data gathered, as well as data processing, analysis and sharing among multiple agencies and ministries with differing levels of capacity to interpret climate and weather data.

- Climate change policy screening was not available during the development of the NTP and was later introduced during the Vision 2030 planning process. A revised NTP will need to be screened by PIOJ and CCD to ensure climate change resiliency is sufficiently and properly incorporated into the policy, and additional strengthening of NEPA's climate change screening during the permitting process should also be considered.

EVALUATION OF STAKEHOLDER READINESS TO CLIMATE-PROOF INVESTMENTS

The following section examines the readiness of the key stakeholders – the MTM, NWA, AAJ and PAJ – to climate-proof their respective infrastructure investments. Readiness in this section is defined as having the appropriate staff, data and political will to begin to assess and prioritize investments, and to allocate budget or seek additional external funding to support climate-proofing activities.

GOVERNMENT OF JAMAICA

As a whole, the GOJ has taken significant steps in the past 15 years to address climate change. In the past five years alone, the GOJ submitted its second communication to the United Nations Framework Convention on Climate Change in 2011 and is currently drafting an updated third communication. The government submitted its Intended Nationally Determined Contribution in November 2015 and approved the Nationally Determined Contribution in April 2017. The government is working with USAID, the German development agency GIZ and the nongovernmental organization NAP Global Network, among other entities, to develop 12 sector strategies and action plans for key sectors (the combined equivalent of a National Adaptation Plan) that seek to mainstream climate change into ministerial policies, plans and budgets.

At an institutional level, the GOJ and several ministries have taken steps to ensure the appropriate resources are in place to address climate change. Most notably, CCD was created in 2013 with a mandate to oversee the newly approved Climate Change Policy Framework. The framework has five main objectives, for which CCD holds primary responsibility: 1) to mainstream climate change considerations into national policies, development plans and ministerial budgets; 2) to support the national-level institutions responsible for climate change research, data collection, analysis and projections to facilitate informed decision making; 3) to coordinate the national response to the impacts of climate change and promote low carbon development; 4) to communicate climate change impacts and adaptation- and mitigation-related opportunities to decision makers and the general public; and 5) to mobilize climate financing for adaptation and mitigation initiatives (MWLECC 2013).

In support of one of the most crucial aspects of the framework – mainstreaming climate change – CCD also oversees the Climate Change Focal Point Network. Each focal point from relevant ministries, departments and agencies is responsible for coordinating the development and implementation of its respective sectoral climate change strategies and actions, and ensuring climate change considerations are integrated into the ministry's policies and plans by using climate risk screening tools and training provided by CCD. A Climate Change Advisory Board recently approved by Cabinet brings together 14 board members from academia, the private sector, civil society and the public sector to advise the Prime Minister and the MEGJC on climate change issues. This Board is a strengthened framework superseding the Climate Change Advisory Committee, which had the same representation albeit a much larger membership (at least 50 members).

Outside of CCD, other critical agencies that affect the transport sector have incorporated climate change into their review processes. PIOJ, which reviews all policies, in the past years began to screen policies for climate mitigation and adaptation components to ensure sectoral policies adequately address climate risk and promote low carbon development. NEPA also incorporated climate screening into its terms of reference for all environmental impact assessments to provide basic assurances that all new infrastructure development projects that require an environmental permit take climate risk into consideration. NEPA is one of the few agencies to have a Climate Change Response Strategy (which expired in 2015) that if fully implemented would mainstream climate change considerations for the main policies and plans falling within its responsibility. It is also worth noting that Jamaica has strong support for climate change projections from CSGM, which developed the *State of the Jamaican Climate 2012*, and is set to release the updated report this year.

TRANSPORT SECTOR STAKEHOLDERS

Within the transport sector, overall readiness levels and capacity are low but awareness is high. The MTM has a climate change focal point and staff that perform certain disaster management functions, but does not have a full-time staff resource dedicated to climate change issues. As a result, input on climate change considerations (including this assessment) come almost exclusively from external sources, which will make incorporating climate change into the NTP a more difficult and time-consuming process. The TSP, which does mention climate change, did

not have a climate change representative on the task force that developed the document, and the task force and subcommittees were largely driven by the agencies and not the ministry. The result of this is a low starting point to now begin incorporating climate resiliency into policies and planning. Transport was also identified as one of the 12 priority sectors in the Climate Change Policy Framework for which a sectoral climate change strategy and action plan should be developed, but the process remains ongoing.

Roads*:* NWA is the agency best prepared to address climate change, but also faces by far the greatest challenge in the transport sector due to the size of the road network under its responsibility. NWA has established numerous disaster management bodies, including the National Disaster Management Center, the Emergency Operation Center, and the National Disaster Response GIS Team, all of which boost NWA's capacity to respond to natural disaster and collect data. NWA has also taken steps to increase design standards (to a 1-in-100 return period) and now requires hydrological studies for private sector developers of major road projects (most notably the Highway 2000 project). NWA has a strong GIS team generating data (e.g., road network, bridge inventory and condition report, routes prone to flooding) and regularly incorporating climate information (e.g., meteorological data, floodplain maps, landslide data, flood return period) into its planning, placement and design. NWA is able to draw on a small number of major assessments, including the World Bank's *Assessment of the Impact of Floods and Landslides on the Jamaican Transport Infrastructure* and the Master Drainage Plan. Despite relatively high levels of capacity, NWA continues to suffer from budget constraints and issues with data availability and quality. Budget constraints in particular limit NWA's ability to address climate change; as mentioned above, road and bridge maintenance costs consume more than 90 percent of the annual budget, often leaving climate-proofing investments to international donors, development banks or the private sector.

The level of readiness decreases dramatically for parochial roads, which fall under the purview of municipal corporations, and make up two-thirds of the total road network in the country. As is often the case at the subnational level, municipal corporations are further constrained by lack of GIS specialists, insufficient budgets, limited access to spatial and climate data and capacity to analyze that data, remoteness of the roads, and low quality of roads (i.e., unpaved).

Airports: As an organization, AAJ has limited capacity and limited staff following the privatization of the two main international airports, and there is no indication that climate-proofing is occurring at the domestic aerodromes that AAJ directly manages and operates. The two main international airports have done little investment in climate-proofing to date, but both are generating data to help guide future investments. Sangster International commissioned a study to calculate future storm surge flood return periods based on projected changes in sea level. Norman Manley International is currently preparing a tender for a full vulnerability assessment that includes collection of primary data. The results of this study will be used to make investment decisions for the airport.

Seaports*:* PAJ has limited capacity to address issues arising from climate variability and change. PAJ's leadership sees climate change as less of an immediate threat than other transport subsectors, largely due to a lack of significant natural disaster damage to port

infrastructure over the past 30 years. No climate change policy or specific climate change-related design criteria are currently in place, but related issues such as hurricane-level winds, wave conditions, wind conditions and currents are factored into design. At Falmouth, the developer took the initiative to include future sea level rise into account, designing the port to accommodate a 3-m rise over 60 years. All five ports owned by PAJ outsourced their operations and maintenance to private companies. At privately owned ports, PAJ only provides regulatory (e.g., safety and maintenance) oversight.

VULNERABILITY ASSESSMENT

The country's transport sector is vulnerable to the vagaries of climate for a number of reasons, including:

- *Geographical*: an abundance of rivers and streams traverse the country, with many steep gullies and canyons (making vast areas prone to flooding) and a long and vulnerable coastline
- *Climatic*: heavy rainfall, tropical storms and cyclones

The impact of weather and climate on the transport sector is often exacerbated by anthropogenic factors, such as poor waste management and inadequate cleaning of gullies and drainage systems, as well as by poor network integrity, limited resources for maintenance, and dated design standards that increase the vulnerability of the transport network.

As a starting point, this assessment recognizes that risk in the transport sector is a function of both direct risk from climate-related hazards as well as the propensity of transport assets to be adversely affected by weather and climate events. Vulnerability is a function of sensitivity, exposure and criticality, where:

The IPCC (2007) defines vulnerability as: *"The degree to which a system is susceptible or unable to cope with the adverse effects of climate change, including variability and climatic extremes."*

- *Sensitivity* is the predisposition to be adversely affected, defined by an asset's design criteria and current condition.
- *Exposure*, a function of location, represents the direct and indirect risk posed by weather- and climate-related hazards.
- *Criticality* identifies the assets that serve critical functions, such as guaranteeing connectivity to municipalities or communities or providing access during times of emergency.

To carry out a vulnerability assessment, it is fundamental to answer questions such as:

- What parts of the transport network are vulnerable and why? (Sensitivity)
- What are they vulnerable to? (Exposure)
- What assets serve critical economic or social protection functions and should thus be prioritized? (Criticality)
- How will their vulnerability change under a changing climate? (Future risk)

To accomplish analyses specific to vulnerability, a spatial database was established and analysis tools were implemented within a GIS environment with the use of the GIS and R statistical software packages. The datasets used in this analysis are listed in Annex A.

The vulnerability indicators evaluated, those that seek to answer the questions posed above, are defined in Table 11. The analysis was carried out at the national, parish and native

resolution scales of the underlying data to offer as much geographic specificity as the data allow.

Table 11. Indicators of vulnerability

CATEGORY	RATIONALE	DATA AND CALCULATIONS
Sensitivity	Represents the propensity to be adversely affected by weather and climate events; is a function of the condition and design criteria of the asset (road, rails, port and airport infrastructure).	Main road condition categorization by the NWA based on percentage of patched sections, potholes, cracking and other criteria Bridge condition per NWA assessment in 2016, including percentage of defective bridges per parish Length in km of roads prone to flooding (data from NWA) JUTC public transport network and bus stop condition assessment
Exposure	Represents the direct risk from climate-related hazards to the asset.	Number of disasters recorded due to floods and storms, hurricanes and surges, and landslides and alluvion Landslide risk assessment and km of roads located in risk zones Km of road within 20-, 50- and 100-year floodplains Selection of parochial and secondary roads located within 100 m of at least 60-degree slope Overlay onto JUTC public transport network
Future Climate Exposure	Includes variables related to principal risks under a changing climate, such as increased hurricane intensity, sea level rise and associated storm surge, and increased intensity of rainfall events.	Historical occurrence of hurricane impacts and landings, sea level rise calculations and current trends in intense rainfall

ASSUMPTIONS AND LIMITATIONS

This vulnerability analysis was designed to offer insights on priority vulnerabilities of the country's transport sector at a national scale, with the hope of providing information for the new iteration of Jamaica's transport policy, specifically in considering climate-proofing the network. While this analysis offers guidance on priorities and risks, more detailed analyses need to be conducted at the individual asset scale (for example, as is being done with Norman Manley International) to define specific engineering investments to safeguard the functional integrity of critical assets (e.g., an airport). Consultations with key stakeholders in Jamaica suggest that while some of these studies are in preparation, others are yet to be planned. The studies will be valuable in setting priorities and appropriately earmarking already limited funds for the tasks that might best safeguard asset integrity.

Jamaica has a substantial collection of data on hazards, climate and other variables of relevance for conducting a vulnerability assessment. Nevertheless, this less-than-perfect data environment necessitates the use of proxy (alternative) measures of certain risks such as those from landslides. The assumptions underlying analyses included in this assessment are described throughout.

A national-level study of this nature requires the integration of disparate datasets from multiple governmental and nongovernmental sources. The challenges of analyzing these datasets together to obtain a clear picture of transport sector vulnerabilities were compounded by:

Road condition classifications were provided by the National Works Agency and are roughly defined as a function of road composition (paved, unpaved), the number of potholes and patches present, and the kilometers of road in need of repair.

- *An apparent lack of an official and standard record of existing assets*. For example, three files showing the parochial and main road networks were received, each with slightly different content, geographic projection and limited metadata. Choosing which one represented the best available record on assets was challenging. In addition, a spot check of data quality (e.g., locations of bridges and roads) by overlaying these records on top of satellite information found many errors. That said, a detailed assessment to control these data would require many months.
- *The data compiled for this analysis varied in both spatial and temporal resolution, requiring many assumptions to integrate them*. For example, the records only contain information on floods occurring in the Yallahs Fording prior to 2002, and certainly prior to the construction of the Yallahs Bridge, which now safeguards that river's section of road from damage.

SENSITIVITY – WHAT PARTS OF THE TRANSPORT NETWORK AND ITS USERS ARE VULNERABLE AND WHY?

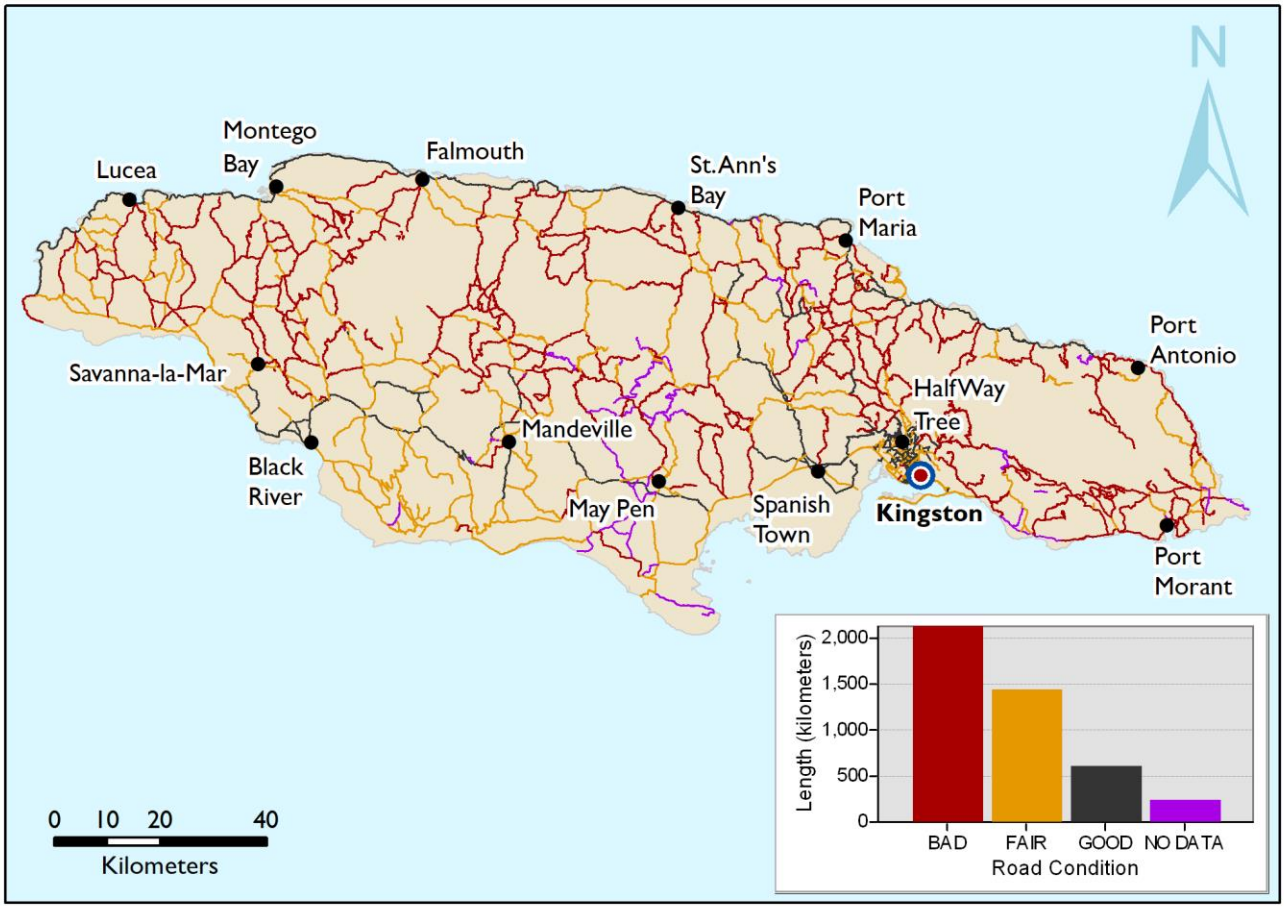
The propensity to be affected by a climate-induced event is in part a function of the current condition of the asset and its users. If a road in poor condition is flooded, it is more vulnerable to the impact of a flood than if it were in good condition. For example, a road with improper drainage design and many sections with patches is likely to suffer more damage from an extreme rain event than a road with appropriate drainage and a new surface. Similarly, a public transport network user's experience is a function of the road conditions across the network as well as protections and safeguards put in place to protect him from the elements, including shelters to guarantee access during periods of intense rain and cooling systems on fleets to offer respite from heat exposure.

ROAD CONDITIONS

The sensitivity analysis examines road conditions using available NWA information and offers insight on roads and road sections potentially at greater risk from damage from weather- and climate-induced hazards, given their poor structural condition (Figure 11). The results of the sensitivity analysis show that Clarendon Parish has the most kilometers of roads classified in bad condition, largely concentrated in the upper reaches of the Rio Minho Basin (Figure 12). The eastern Blue Mountain Parishes of St. Andrew, Portland, St. Thomas and St. Mary, as well as the northwestern Trelawny Parish, all have a relatively high percentage of major road

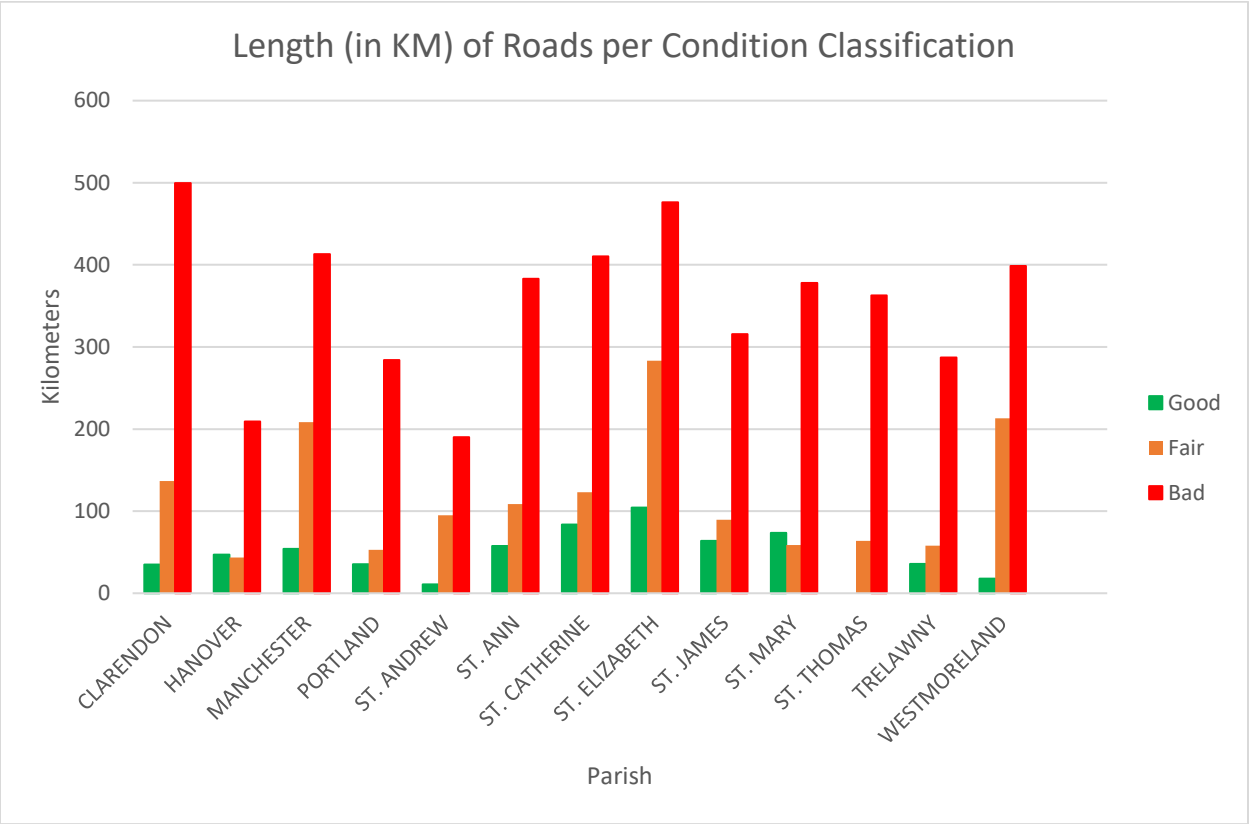
networks classified in bad condition. Adding the kilometers also classified as being in fair condition to the assessment suggests that a majority of parishes face severe challenges regarding road condition, most notably Westmoreland and St. Andrew Parishes, both with over 90 percent of their road network classified as either bad or fair. Countrywide, the functional integrity of a total of 3,904 of the 4,770 km of major roads, equivalent to 82 percent of the network, is already compromised, making the road network more vulnerable to the risks posed by extreme weather events.

Figure 11. Location and condition of Jamaica's road network



Source: National Works Agency.

Figure 12. Number of kilometers classified as good, fair and bad, by parish



Source: National Works Agency.

Given the limited information available on the condition of the parochial and secondary road network, a proxy assessment of the network was conducted. This involved selecting sections of the network located within a slope of at least 60 degrees; this feature served as an indication of the steepness of the road and its potential sensitivity to debris flow induced by more intense rainfall events. The results show that 184 km of the country's secondary roads are located in areas with steep slopes, making them more vulnerable to debris flows just based on their gradient (Table 12). The highest concentration of severely steep roads is located in Portland Parish, where nearly 32 percent of the parochial road network is characterized by a severely steep gradient.

Table 12. Parochial roads considered steep and subject to debris flow

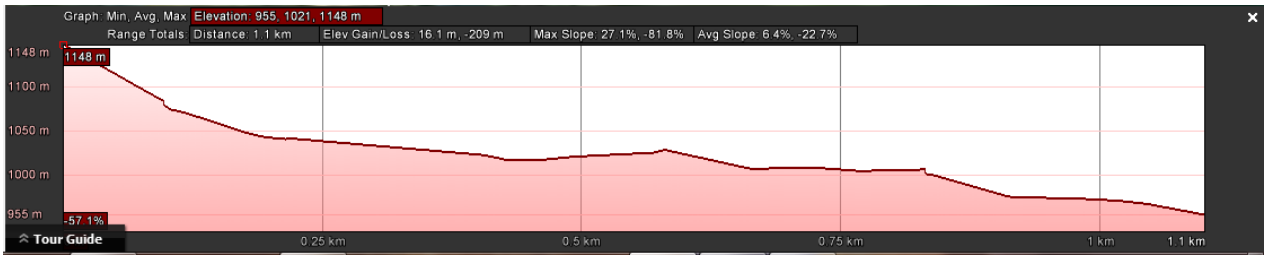
PARISH	Percent of total roads considered severely steep
Clarendon	2.69
Hanover	2.62
Kingston	12.99
Manchester	4.00
Portland	31.77
St. Andrew	23.28
St. Ann	1.88
St. Catherine	3.29
St. Elizabeth	2.86

PARISH	Percent of total roads considered severely steep
St. James	2.77
St. Mary	6.90
St. Thomas	24.35
Trelawny	4.16

Source: Authors' calculations.

This is particularly marked in St. Andrews Parish in the Blue Mountains, where a road can experience an elevation change of 700 m over distances of less than 1 km (Figure 13).

Figure 13. Typical elevation profile of parochial roads considered most at risk from landslides



Source: Google Earth calculations of parochial roads with steep gradient.

DRAINAGE INFRASTRUCTURE

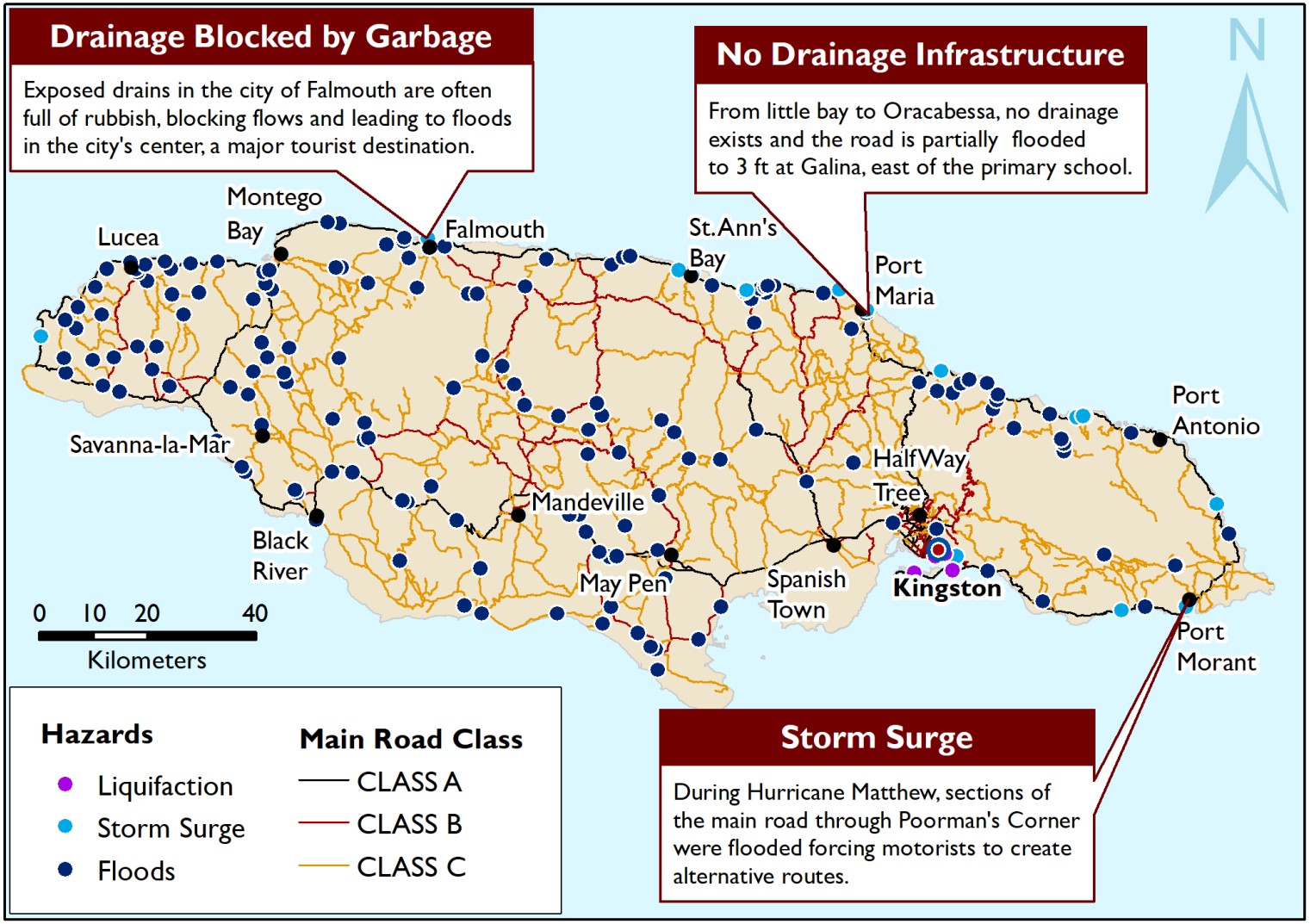
As noted earlier, flood events that affect the country's transport network are often a function of:

- Improper drainage, in terms of both:
  - Design criteria that are outdated or unable to cope with new building structures that increase drainage demands (as is often the case where parochial roads intersect with the country's main road network), and
  - Rivers overflowing their banks – thus a function of, in some cases, outdated return period design criteria.
- Inadequate maintenance and cleaning of drainage infrastructure, leading to clogged or blocked drainage systems.
- Insufficient sea defenses, leading to wave run-up and overtopping.

Maps showing the recorded locations of these events along the country's main and secondary road networks are provided in Figures 14 and 15. Unfortunately, the available records have limited information on the dates of these events, which could offer invaluable evidence on their relationship with changing weather extremes.[5]

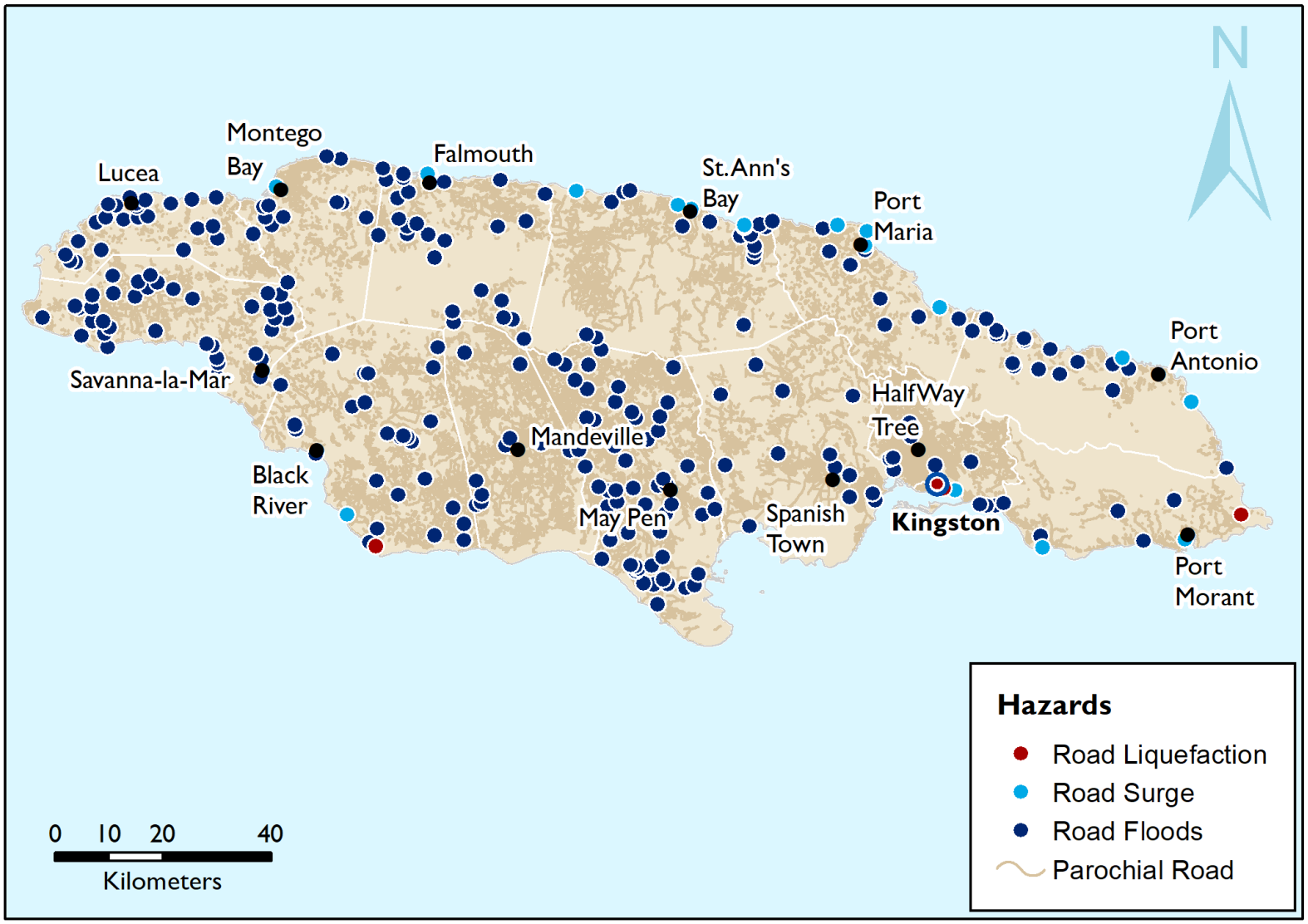
[5] The disaster events database maintained by ODPEM obtained for this study noted dates of flood events between 1996 and 2002 only.

Figure 14. Recorded flood, storm surge and risk of liquefaction along Jamaica's main road network



Source: Compiled from WRA, ODPEM and various other records. Dates unknown.
Note: Callout boxes points to specific information available for a few locations in the existing records, and highlight the challenges posed to the transport network.

Figure 15. Recorded floods and storm surge along Jamaica's parochial and secondary roads

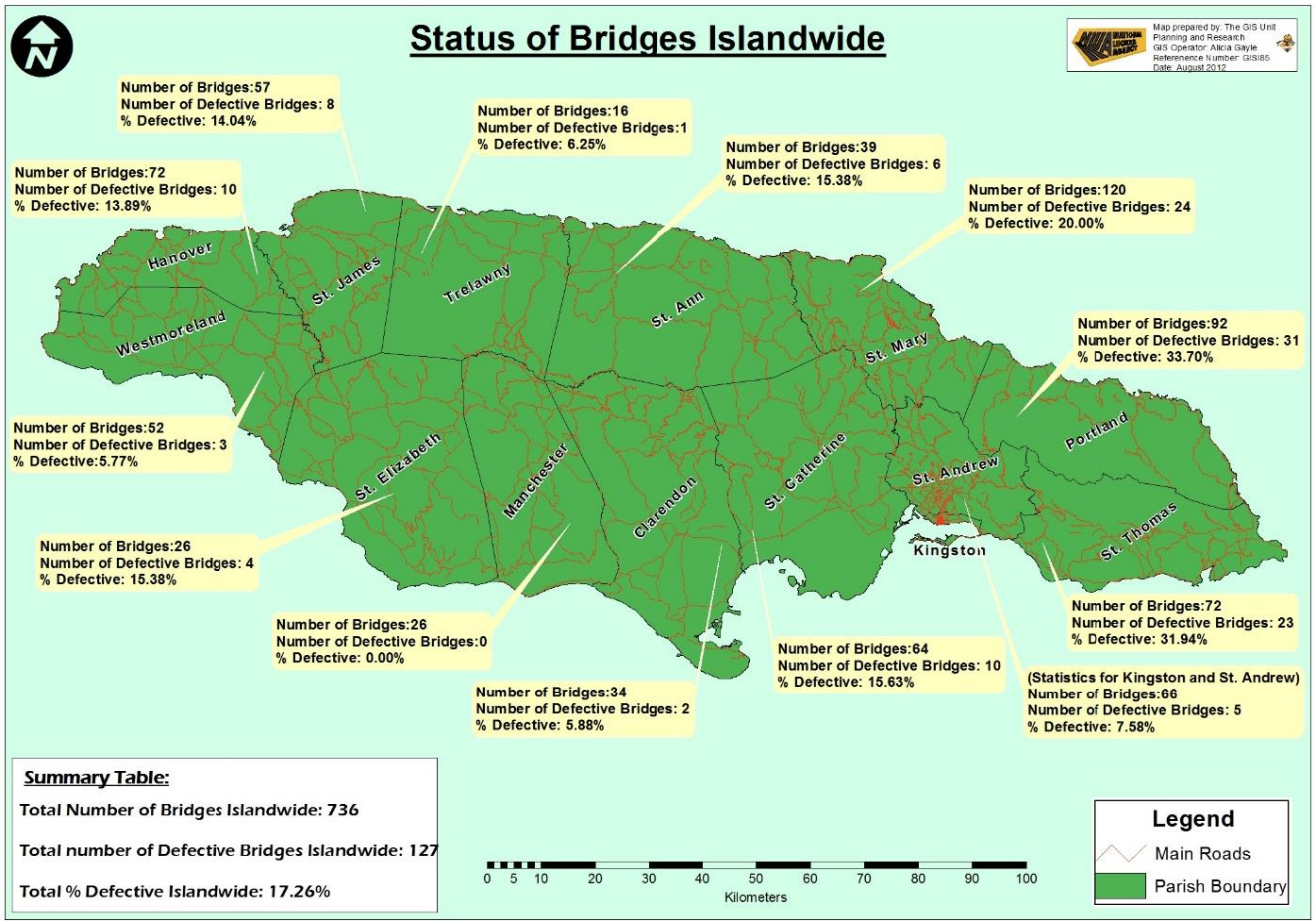


Source: Compiled from WRA, ODPEM and other records. Dates unknown.

STATUS OF THE COUNTRY'S BRIDGES

The complex and extensive network of rivers, streams and gullies that traverse the country's transport system means that a large number of bridges are required for network connectivity. According to NWA, a total of 736 bridges, including established fordings, exist across Jamaica, many of which were built prior to the 1950s and are in need of both repair and redesign. The greatest numbers of defective bridges are found in Portland and St. Mary Parishes, where 33 percent and 20 percent of bridges, respectively, are considered defective (Figure 16). Even with new bridge projects, current design criteria consider 100-year return periods but are not updated to reflect the new climate realities. What this translates to, in essence, is that new bridge bases will suffer significant scouring and damage during floods, with the worst-case scenario being total bridge loss.

Figure 16. Status of Jamaica's bridge network



Source: National Works Agency.

STATUS OF THE COUNTRY'S PRINCIPAL PUBLIC TRANSPORTATION NETWORK

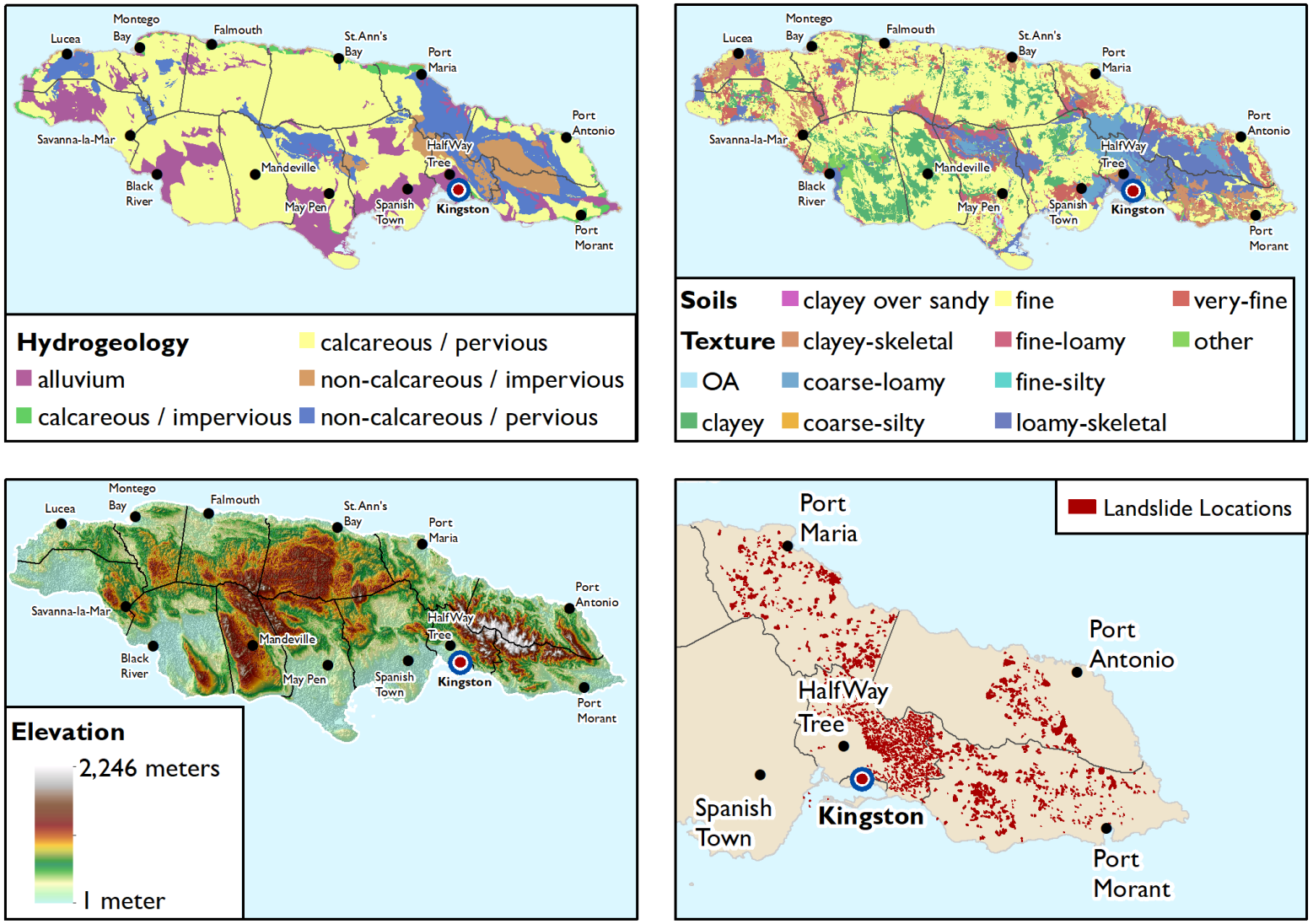
Climate-induced impacts on the country's public transport sector can lead to disruptions and delays in service, as well as expose users to increasing vulnerabilities such as intense rainfall events where shelters are insufficient or simply not available at stops. The sensitivity analysis examined road conditions along the country's four main public transit routes using available information from JUTC combined with data on road conditions available from NWA. It aims to

offer insight on two fronts: 1) identifying route sections that are potentially at greater risk from damage from weather- and climate-induced hazards, given their poor structural condition; and 2) evaluating customer experience with respect to these climate hazards. Poor road conditions can also reduce the lifespan of public bus fleets in operation, increasing operational costs that must be offset by increasing fees charged to customers and potentially leading to delays and loss of service to critical areas.

EXPOSURE: WHAT ARE THE ASSETS AND SYSTEM USERS VULNERABLE TO?

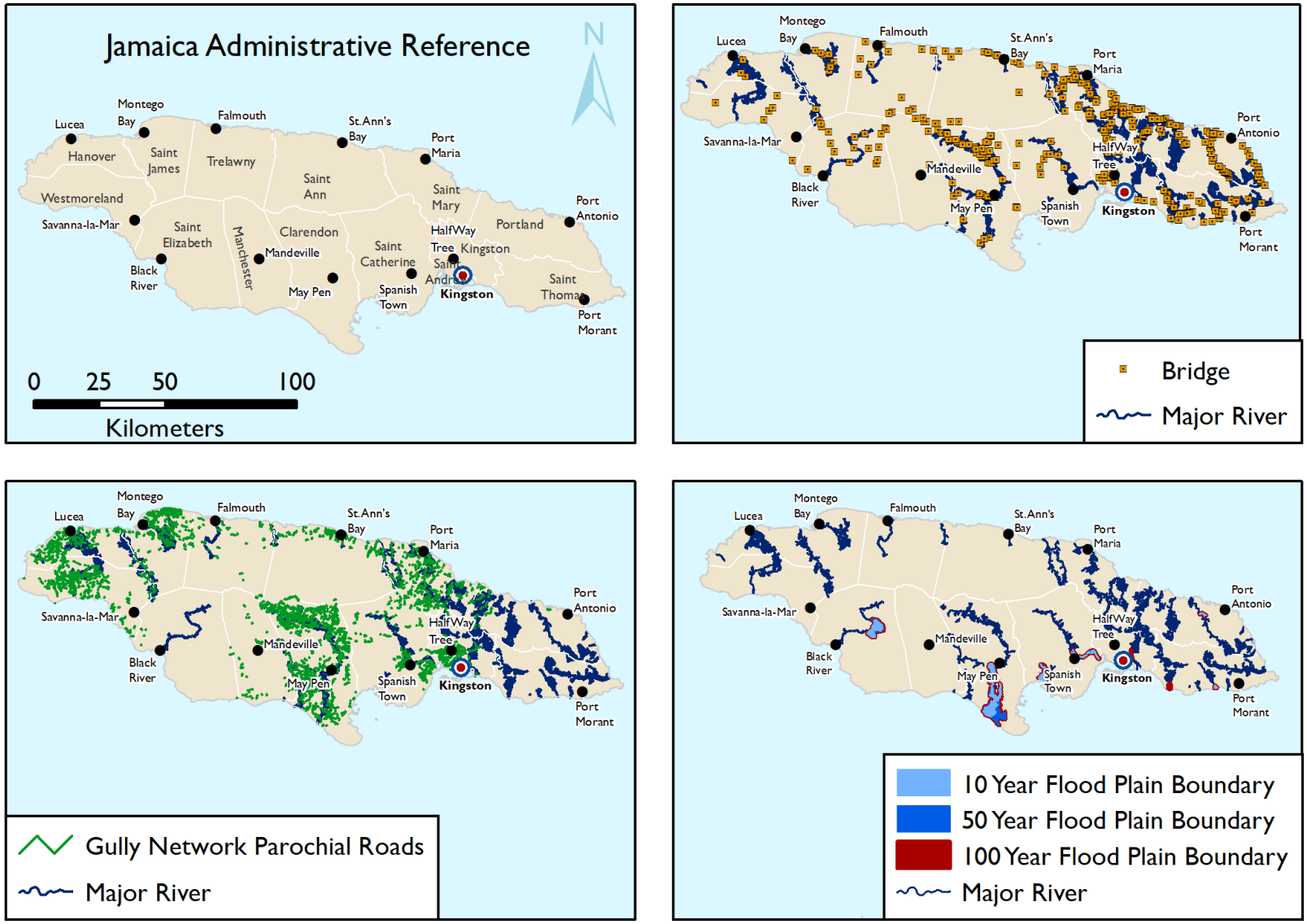
Exposure, a function of location and geography, is the extent to which the transport asset or those using the asset are subject to risks posed by biophysical dynamics as well as weather and climate extremes. The variables selected to evaluate exposure aim to capture the major risks to the country's transport sector and users, including those posed by landslides, floods and storm surge due to hurricanes. Figures 17 and 18 summarize these spatially.

Figure 17. Biophysical factors considered when determining landslide risk



Source: Hydro-geology, soils and landslide locations – data originally from Geology and Mines but received from the World Bank; Slope – authors' calculation based on 90-meter resolution shuttle topo radar mission (STRM) data from NASA.

Figure 18. Baseline data layers used to calculate flood risks



Source: Authors' calculations based on data provided by NWA and WRA.

LANDSLIDES

The majority of landslides registered occurred on the eastern side of the island in clay soils characteristic of the Richmond beds,[6] Newcastle porphyry, and Wagwater conglomerates; a lesser but important number of recorded landslides occurred on shales, conglomerates and tuffs on loamy-skeletal and fine soils. Average slopes of the landside regions were over 60 degrees. Geographically, these were predominantly in the Blue Mountains near Cuffy Gully in St. Mary Parish and Hall's Delight in St. Andrew Parish. A weighted overlay analysis was conducted using a simple multivariate statistical method assigning weights based on the relationship of a combination of potential landslide causative factors that were defined based on existing landslide inventories. These yielded a categorized map of high-, medium- and low-risk areas for landslides across the country (Figure 19). A kilometer distance of road sections at risk under this categorization was subsequently conducted and is shown in the figure. As the history of landslides shows, St. Mary and St. Thomas Parishes have the greatest number of kilometers of road potentially at risk from landslides, as do Clarendon and Hanover Parishes.

FLOODS

Flood risk was examined by combining information from known flooded localities with 10-, 25-, 50- and 100-year floodplain extent data for the country's major river systems, yielding a calculation of the length of roads that could be potentially affected by significant increases in the frequency and intensity of rainfall periods. The data, shown in Figure 20, show that Clarendon Parish – located in the watersheds of the Rio Minho and Black Rivers – has the highest length of roads at risk from flooding, with over 60 combined kilometers of main and parochial roads vulnerable to flooding. Other vulnerable road sections are concentrated in St. Elizabeth (especially along the New River, the Horse Savanna River and the Blake River), Portland (along the Rio Grande River), St. Catherine (Coleburn's Gully and Rio Cobre) and St. Thomas Parish (along the lower Morant River) (Table 13).

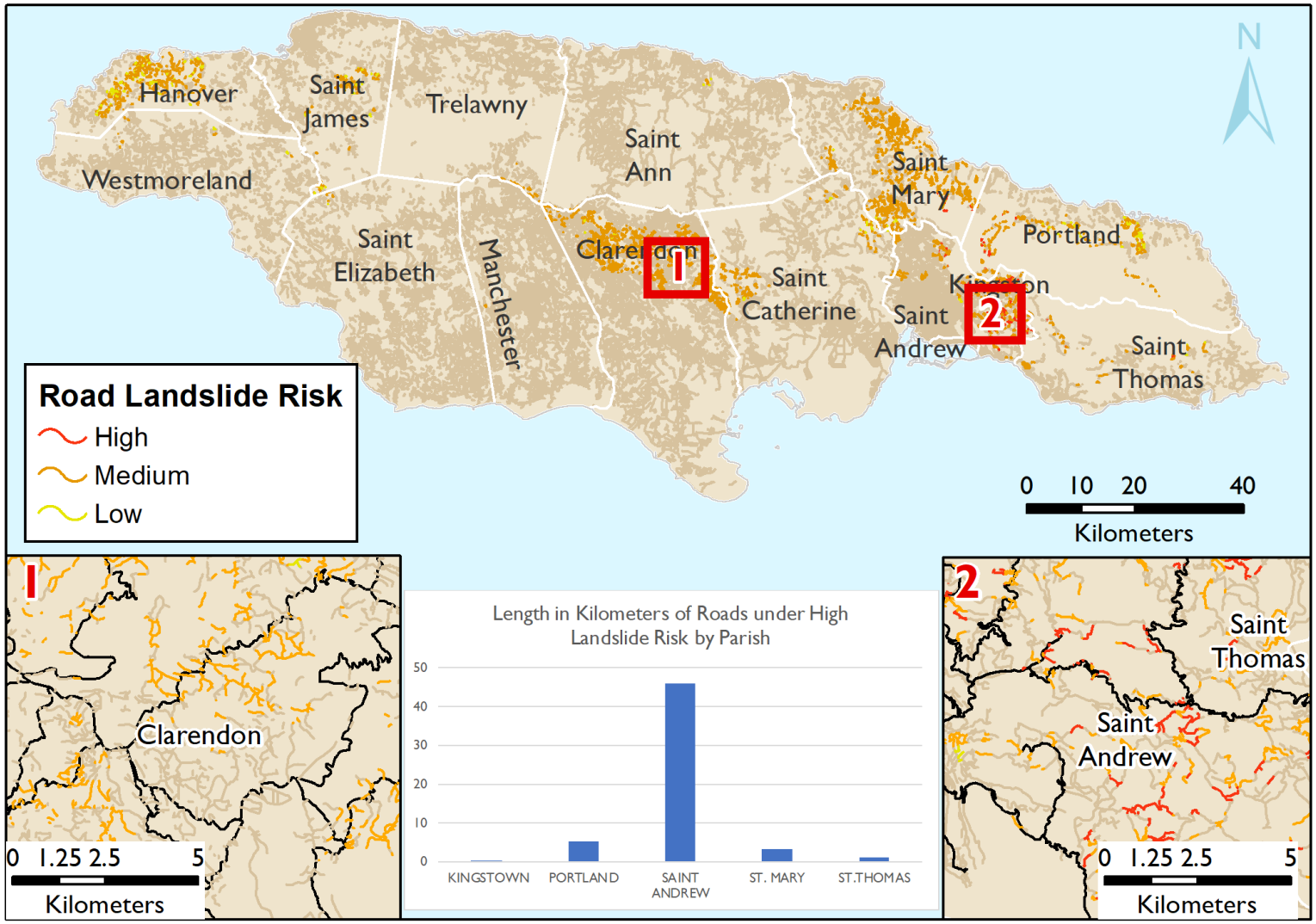
Table 13. Total length (km) of road sections at risk from flooding, by parish

Parish	Main road network	Parochial network
Clarendon	29	18
Portland	9	3
Saint Andrew	<1	1
Saint Catherine	2	5
Saint Thomas	2	9
Saint Elizabeth	<1	6

With respect to the country's public transport network, an analysis of flood-prone road sections under the parameters discussed above point to six critical route sections were at risk from climate-induced flooding and rising seas, which can result in delays and loss of service to users (Figure 21). These include: (1) Newport West to Spanish Town Road, which serves at least 2,900 people daily; (2) Ferry/Hydel to 6 mile terminal, and (3) Bull Bay to 11 miles, both serving over 7,000 users daily; (4) Great Circle House to Fairfax Drive, serving over 4,800 people daily; (5) Caymaras to Waterford, serving at least 400 users daily; and (6) Spanishtown to Newport west, which provides service to at least 200 people daily.

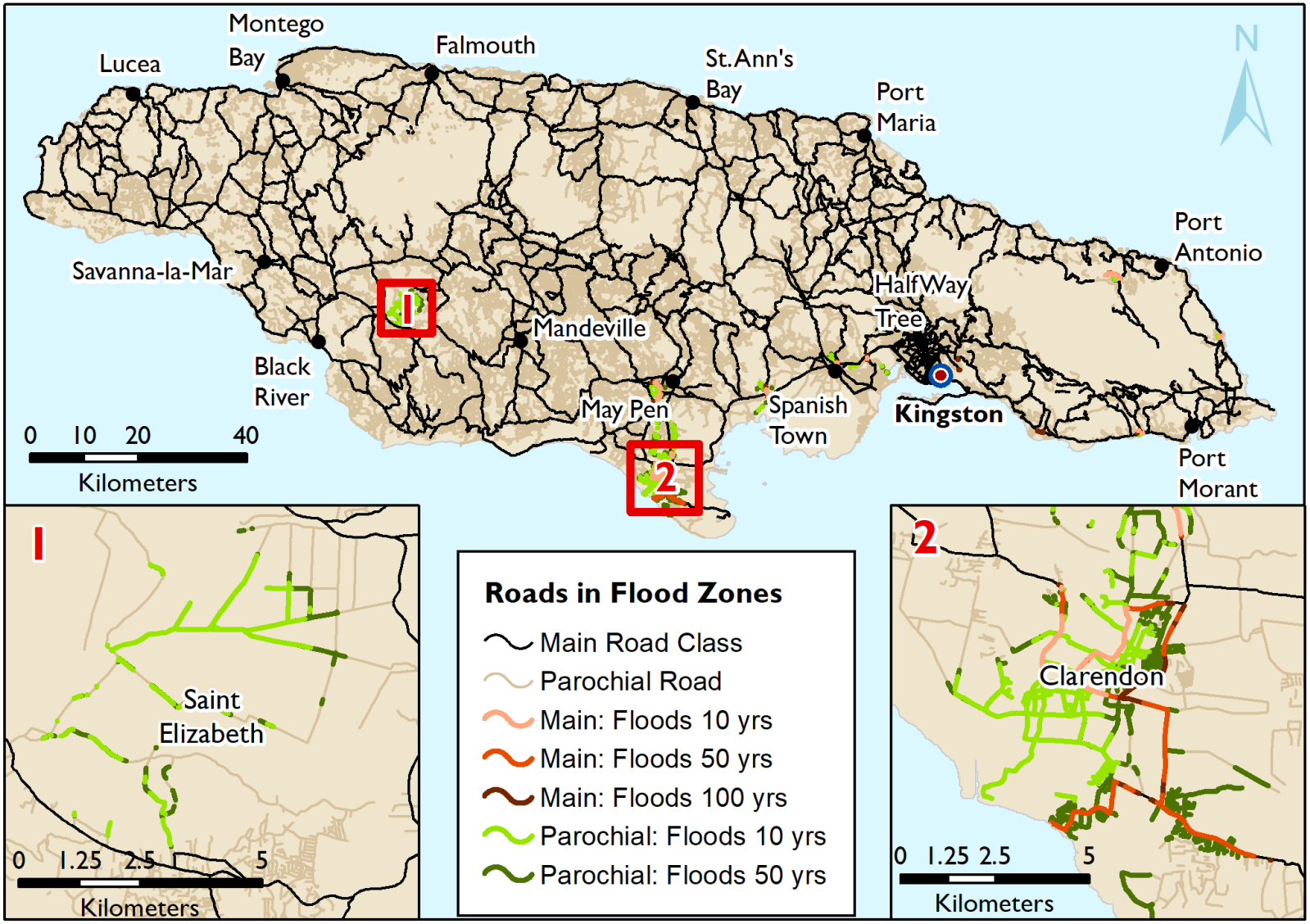
6 No. 41 - Belfield Clay Loam No. 43 - Highgate Clay No. 46 - Halls Delight Channery Clay No. 47 - Llandewey Clay Loam. http://www.moa.gov.jm/InternationalPercent20YearPercent20ofPercent20Soils/MAJORPercent20SOILPercent20TYPES.pdf

Figure 19. Major road network at risk from landslides



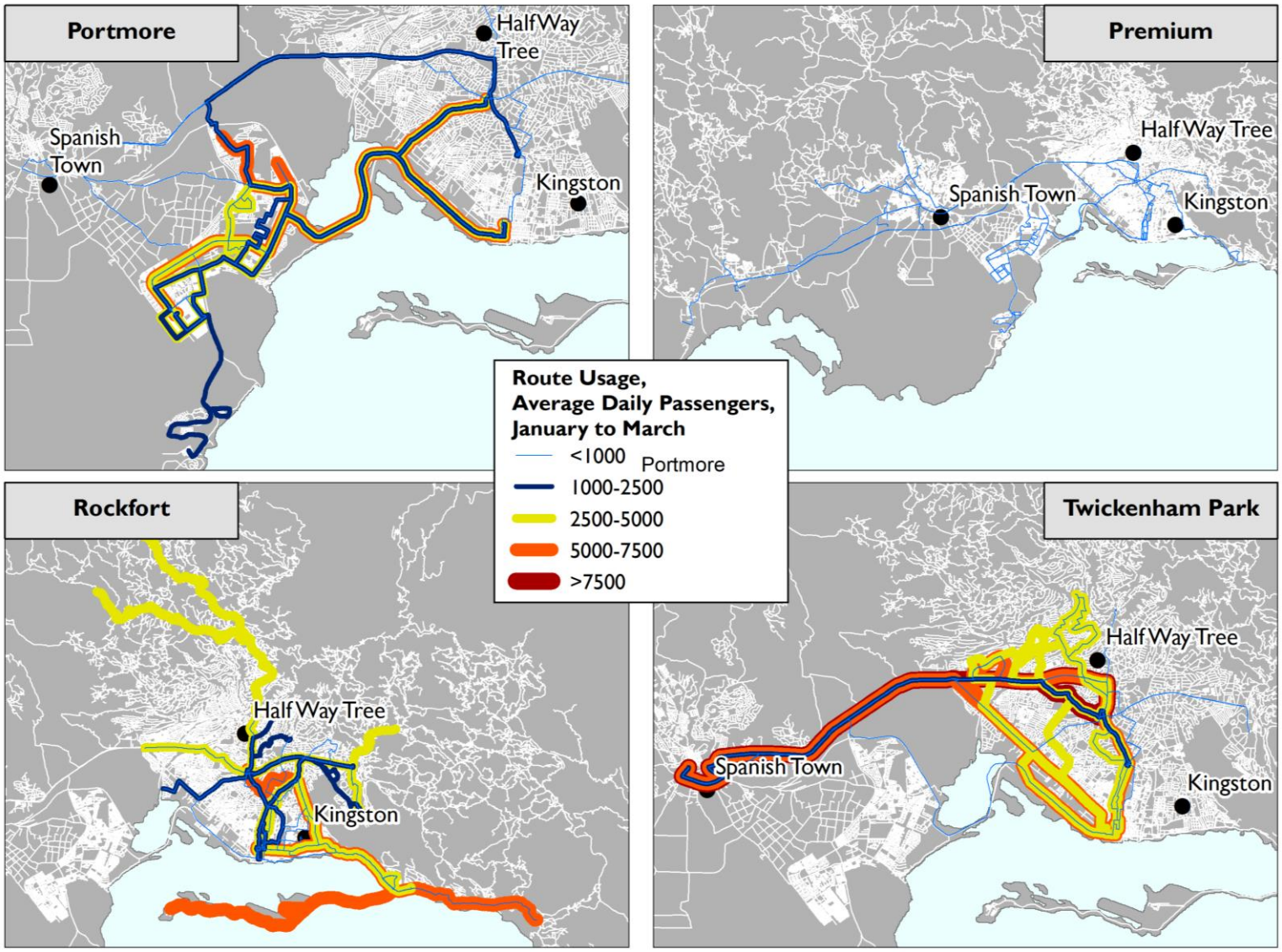
Source: Authors' calculations based on data provided. Note: Top: countrywide view with risk categorization of major roads. Insets: magnified views of some of the most affected areas of the country's road network. Left, Clarendon and surrounds. Right, the St. Andrew, Portland and St. Thomas region. Bottom: calculation of total kilometers of road at risk of damage from landsides by parish across all risk categories (low, medium, high).

Figure 20. Road network at risk from floods



Source: Authors' calculations based on data provided. Note: Top: countrywide view with risk categorization of major roads. Insets: magnified views of selected most affected areas. Left, St. Catherine Parish, Right, Clarendon Parish).

Figure 21. Average number of daily passengers on principal JUTC lines, January-March 2017



Source: JUTC user assessment, 3-month average for January–March 2017.

CRITICALITY: BASED ON CRITICAL ECONOMIC OR SOCIAL PROTECTION FUNCTIONS, WHICH ASSETS SHOULD BE PRIORITIZED?

The impacts from transport network malfunctions differ across the different transport modes discussed in this document (e.g., ports versus roads). This implies that differences arise in magnitude from the closing of a few kilometers of road due to a flood versus delays caused in a port from a hurricane, for example. Evaluating overall transport network performance requires assigning a relatively greater importance to some parts of the network over others, otherwise known as an evaluation of criticality. The concept of transport network criticality aims to identify the most critical assets by evaluating the relative importance of the sector assets with respect to: 1) crises and emergency management; 2) linkage to important economic hubs; and 3) prominence in the connectivity of vulnerable communities. A countrywide evaluation of criticality is beyond the scope of this analysis. Nevertheless, two examples, noted below, serve to illustrate a viable approach, given sufficient resources and time.

Crises and emergency management criticality: The current 74 km of Highway 2000 from Spanish Town to May Pen provide critical crisis and emergency management functions during hurricanes and storms. Built with private financing, the Highway 2000 project design standards are meant to safeguard the investment internationally, surpassing those required by the GOJ. As such, the highway is less likely to be affected during a hurricane or storm relative to other assets in the network, and, in fact, serves as safe passage for first responders and evacuees alike.

Economic value: Historic Falmouth Port is a significant contributor to the country's economy. The port receives over 40 percent of Jamaica's visitors and directly and indirectly employs a large workforce. Even so, the port is only accessible by a single roadway that crisscrosses the small town's narrow, potholed roads, which are susceptible to flooding both due to their poor design as well as improper maintenance of drainage infrastructure. As a result, aside from the port itself, the vulnerability of the town's key roads is also linked to changes in sea level, since many of Historic Falmouth's streets are located on low-lying sections susceptible to inundation. Interruptions to passenger and freight traffic caused by transport delays following damage to road infrastructure are already a problem and could intensify as climate changes.

FUTURE RISK

Following the discussion provided above on weather- and climate-related impacts and vulnerabilities to the country's transport sector, the focus of the future risk analysis is to consider the impact of three current and future climate stressors on Jamaica's transportation assets:

- *Heavy rain-induced flooding landslides and landslips* – captured by evaluating the historical occurrence of landslides and landslide risk categorization described above.
- *Hurricanes and associated heavy rains* – assumes stability in future hurricane paths and an increase in the number of category 4 and 5 hurricanes in spite of an overall decrease in frequency. These are concentrated to a large extent in the southern regions of the country.

- *Sea level rise and coastal storm surge* – for areas at or below 1 m of elevation and those with storm surge records, namely the Manchioneal and Morant River Basins (Figure 22).

The results point to priority vulnerabilities concentrated in:

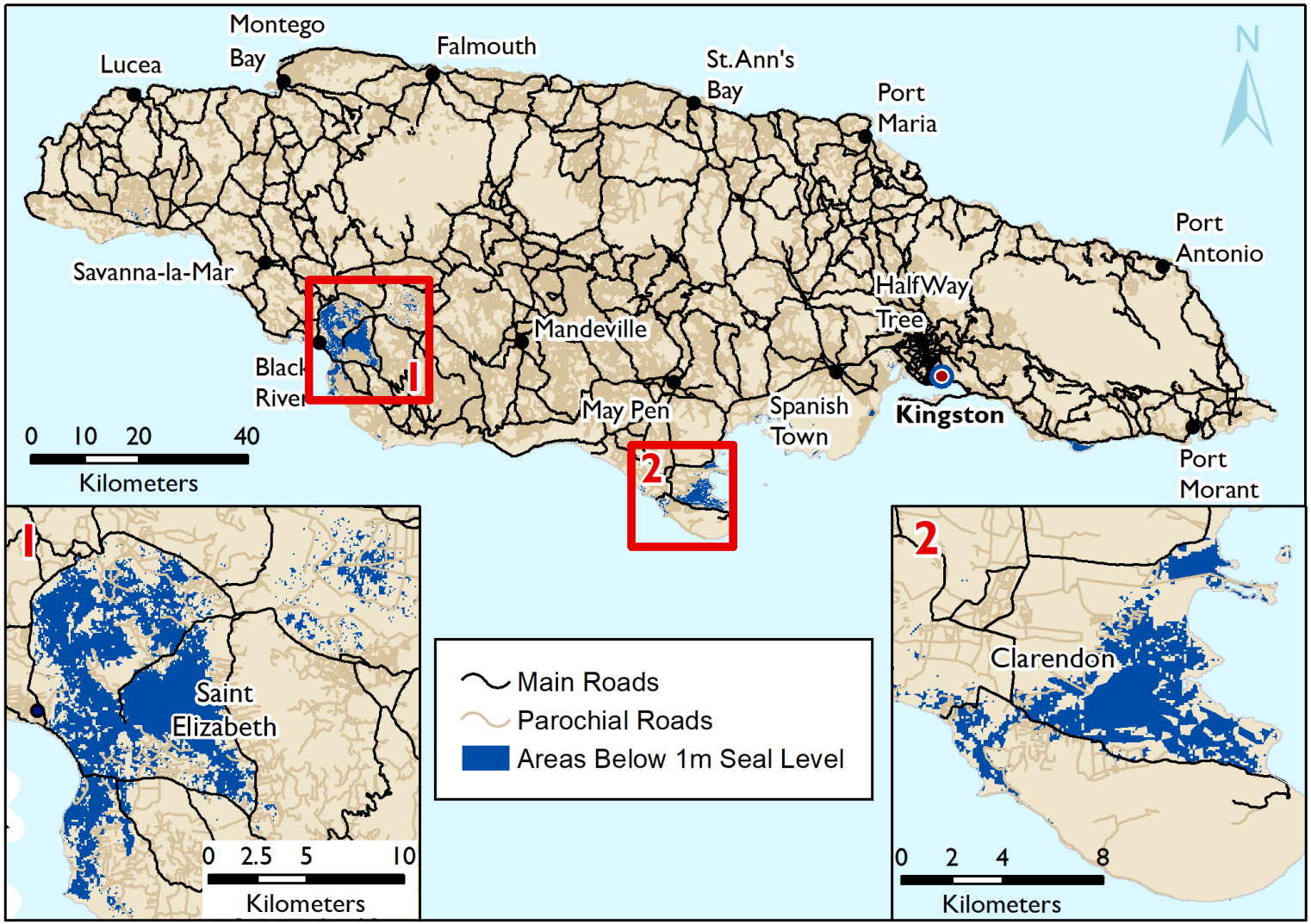
Roads: Vulnerable roads include those in both northern and southern Clarendon Parish, the coastal region of St. Elizabeth Parish and the Blue Mountain regions of St. Andrew, Portland and St. Thomas Parishes (Figures 19, 20 & 22). Other vulnerable regions include Hanover Parish, as well as the south coast roads of St. Thomas Parish, the north coast roads of St. Mary Parish, and the Junction thoroughfare linking north to south on the eastern end.

Public Transport Network: Six critical route sections were identified as at risk from climate-induced flooding and rising seas, which can result in delays and loss of service to users (Figure 21). These include: (1) Newport West to Spanish Town Road, which serves at least 2,900 people daily; (2) Ferry/Hydel to 6 mile terminal, and (3) Bull Bay to 11 miles, both serving over 7,000 users daily; (4) Great Circle House to Fairfax Drive, serving over 4,800 people daily; (5) Caymaras to Waterford, serving at least 400 users daily; and (6) Spanishtown to Newport west, which provides service to at least 200 people daily.

Airports: At Sangster International the majority of the runway and terminal access is located below 1 m of elevation, making the airport particularly vulnerable to rising seas (Figure 23). According to a WRA assessment, the main road access along the airport is characterized as prone to flooding. The situation is less pronounced for Kingston's Norman Manley International, where only a few stretches of the access road and peripheral areas of the main airport are challenged by elevation (Figure 26). Nevertheless, Norman Manley International is also subject to more intense wave run-up and storm surge from hurricanes and tropical storms. Seawall defenses will need reinforcements and, in some cases, redesign to cope with the potentially more damaging hurricane forces projected in the future.

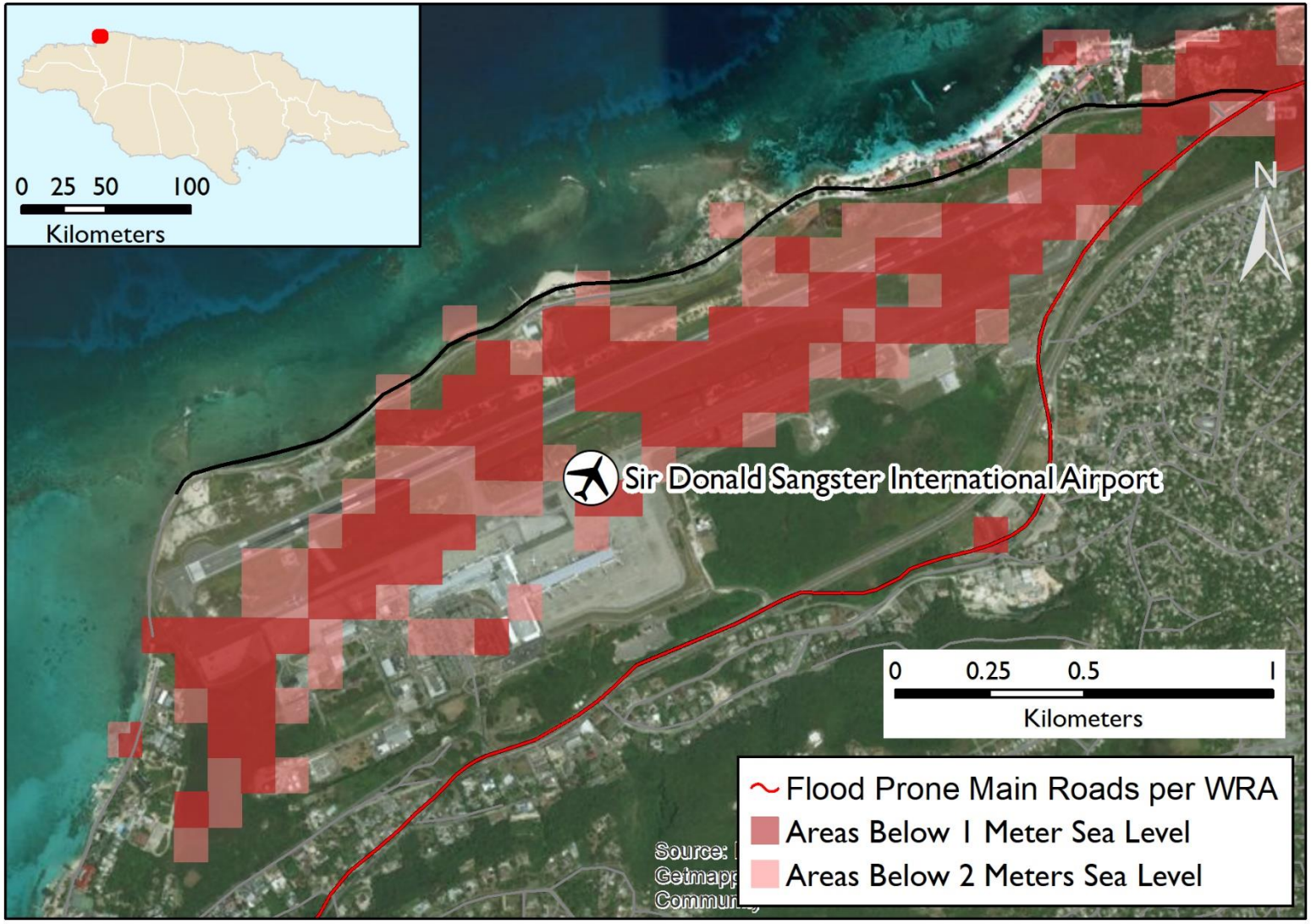
Ports: Falmouth Cruise Ship Pier (Figure 24), already subject to floods due to increasingly more intense rainfall events, is significantly vulnerable to rising seas, with the majority of the road network providing access at risk from flooding, and tourist areas also subject to high flood risks. A similar risk profile exists for Montego Bay. On the other hand, while the principal access roads to KCT are less subject to the risks from floods and rising seas, the container storage areas south of the main port have significant areas located below 1 m of elevation, and its secondary roads are subject to the risks from rising seas (Figure 25).

Figure 22. Road sections at risk from 1-m sea level rise



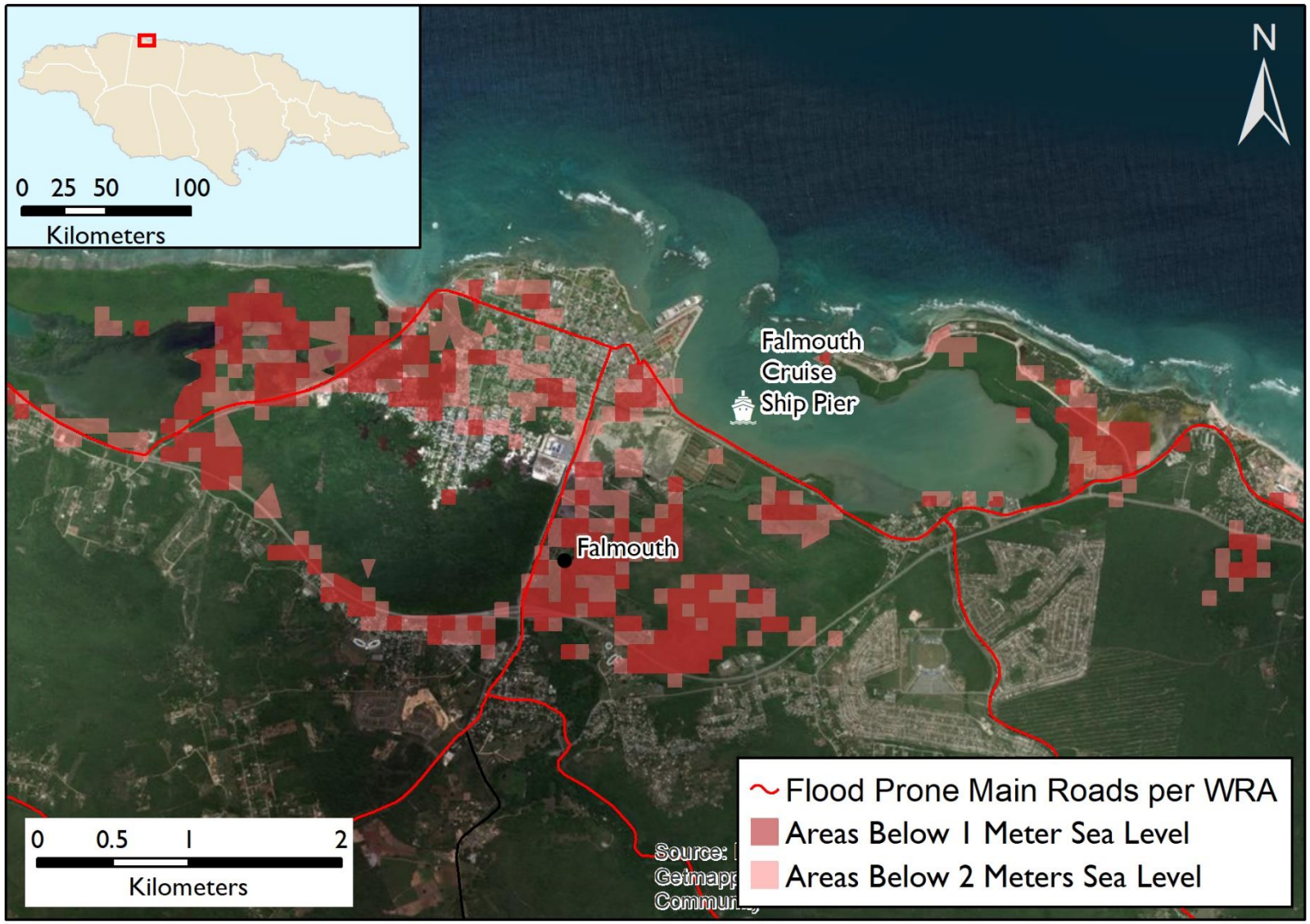
Source: Basemap gallery, World Imagery, ESRI 2017 and authors' calculations.

Figure 23. Zones of risk at Donald Sangster International Airport



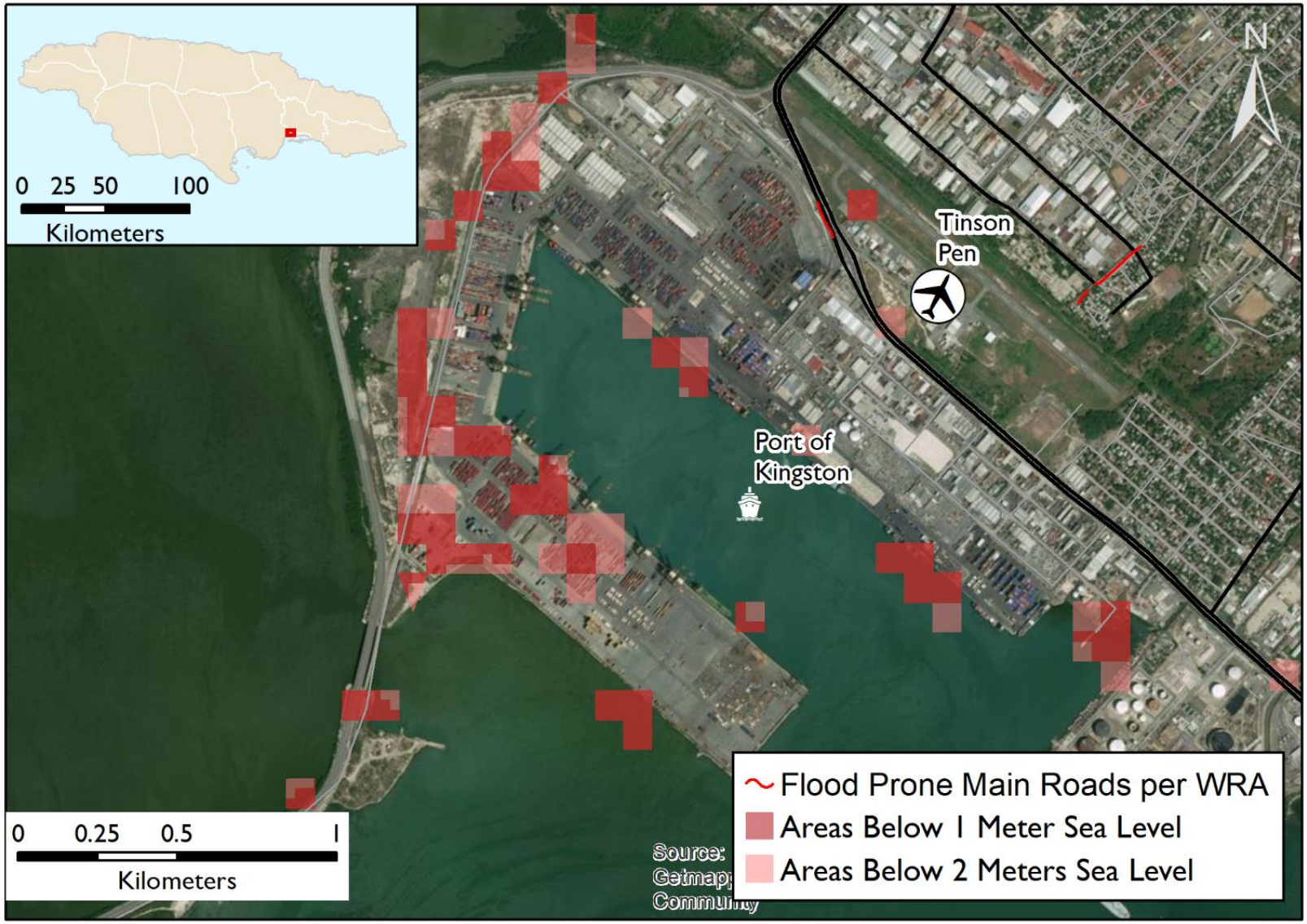
Source: Basemap gallery, World Imagery, ESRI 2017 and authors' calculations.

Figure 24. Zones of risk for Falmouth Cruise Ship Pier



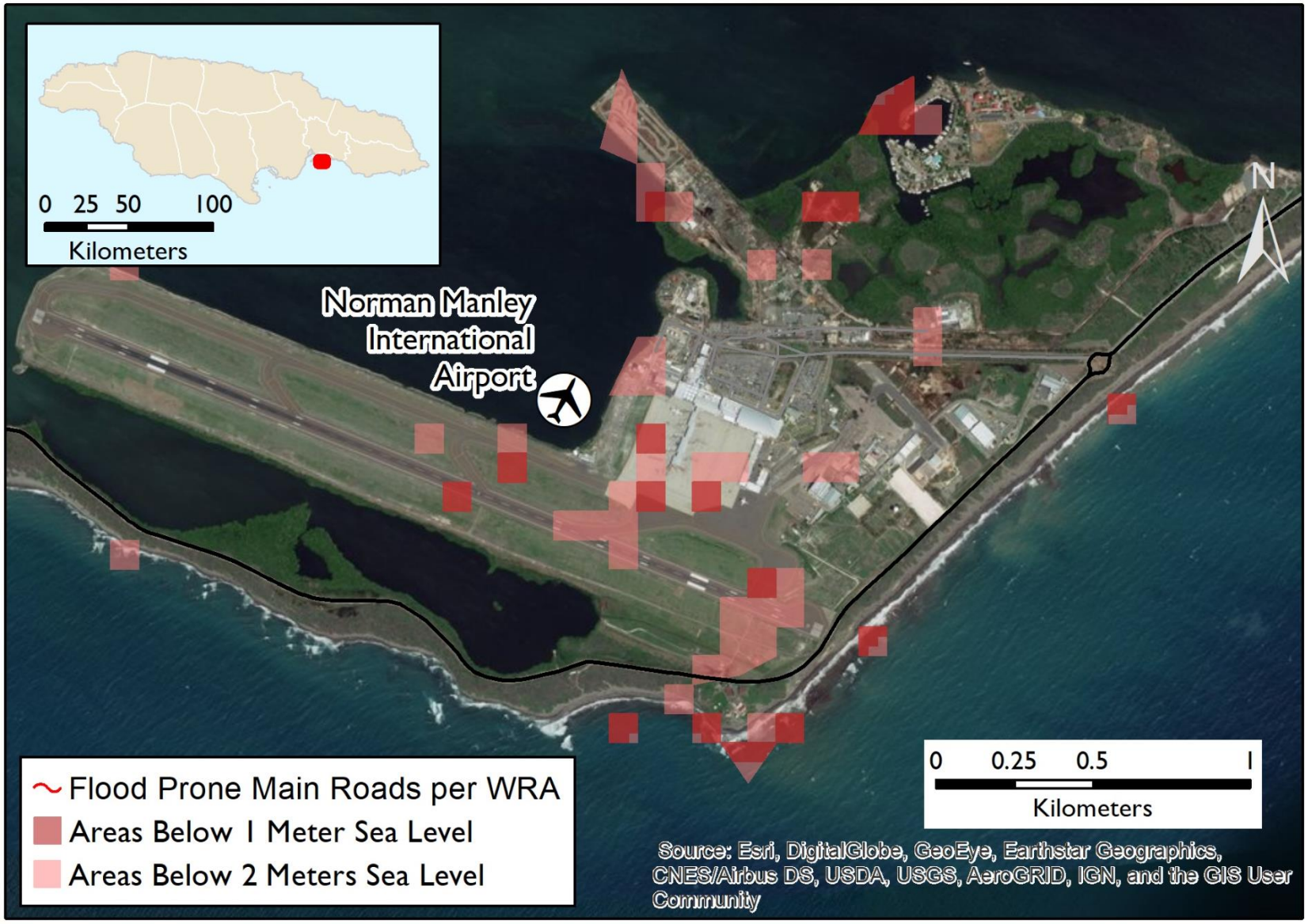
Source: Basemap gallery, World Imagery, ESRI 2017 and authors' calculations.

Figure 25. Zones of risk at the Kingston Container Terminal



Source: Basemap gallery, World Imagery, ESRI 2017 and authors' calculations.

Figure 26. Zones of risk at Norman Manley International Airport



Source: Basemap gallery, World Imagery, ESRI 2017 and authors' calculations.

RECOMMENDATIONS

This study demonstrates that as the impacts of climate change (i.e., rising temperatures, more extreme heat events, more intense rainfall events, rising seas) manifest, the burden of risks to Jamaica's transport sector is expected to increase unless additional investments are made. Some projected additional losses, for example from landslides, are potentially preventable if high-risk areas are identified and design criteria for transport networks take these risks into account. Reducing transport sector risks will require modifying current policies and programs and implementing new ones to explicitly consider climate variability and change. Adaptation actions should focus on building a more climate-resilient transport system, reducing overall vulnerability and developing specific system capacities. Entry points include: 1) investments and finance, 2) leadership and governance, specifically regarding institutions and planning mechanisms, and 3) information systems. Specific actions to align with Jamaica's Vision 2030 document are detailed below.

INVESTMENTS AND FINANCE

Conduct additional assessment(s) on scope of financing needs. Navigation and port facilities, roads and drainage infrastructure, and other transport assets have a design lifetime, after which they may need to be reconstructed to meet the climate and demand realities of the day. Furthermore, this lifetime is dependent on proper maintenance and repairs to guarantee asset performance. For example, a typical asphalt road may be designed to last 26 years but will require resealing sometime during the first 13 years depending on traffic volumes and vehicle weights. This assessment clearly points to the need to budget for and undertake consistent maintenance of the country's transport network to guarantee full functionality, particularly with respect to drainage, maintenance and cleaning. Additionally, some nearshore roads, seawalls and bridges will increasingly require repair, and if the sea level rise is augmented by increased storm activity, the impact will necessitate redesign to new standards.

Further assessment should be undertaken to understand the scope of financing needs by cataloguing the design lifetime of major infrastructure (e.g., roads, bridges, ports) and costing out improved maintenance regimes for different types of infrastructure.

LEADERSHIP AND GOVERNANCE

Institutions

Increase capacity for the MTM to coordinate and convene the relevant expertise to build climate resilience and DRR approaches into plans and operations. The MTM does not currently have a unit dedicated to DRR under its technical services or planning and research departments, despite the climate-related impacts on the sector. Nevertheless, several external agencies (NWA on road design, CCD on climate adaptation, ODPEM on disaster risk management) do have relevant expertise that could be brought to bear on the subject. CCD or other external consultants should conduct training for other MTM staff, particularly those involved in developing policy, action plans, and M&E plans. Topics could include: understanding climate change impacts on the transport sector; crafting policy to reduce impacts from climate-

related risks; devising strategies and actions to increase the climate resilience of transport infrastructure; and developing relevant indicators and targets to track performance over time. Such a training could position and prepare MTM staff to convene and coordinate the analyses and discussion necessary to climate-proof transport operations.

Establish a task force for NTP revisions and a Transport Sector Thematic Working Group (TWG) under Vision 2030. A task force similar to the one that leads the TSP process should be created within the MTM to lead NTP policy revision and coordinate with stakeholders. A dedicated task force with representatives from multiple agencies will ensure all subsectors are adequately addressed in the policy and that consultations are conducted with the wide network of sector stakeholders.

TWGs in other sectors have proven successful as a mechanism to support the implementation and M&E of Vision 2030 sectoral plans. They provide an important forum that brings in voices outside of government from civil society, the private sector and development partners, and can assist with planning, tracking progress, addressing shortfalls, identifying and mobilizing resources, sharing information and ensuring coordination among stakeholders.

Increase capacity of other transport sector stakeholders to understand and address climate risks within the context of the expected lifespan of investments. From the technical personnel in parish councils to government agencies responsible for oversight and regulation of transport infrastructure, additional capacity is strongly needed to better understand and cope with climate risks, and to better understand the scientific basis for improved design and planning, as well as the more important development implications of new investments and their coordinated operations.

Include tailored climate change adaptation clauses on all new concession agreements, and review and amend existing concession agreements where possible. With the update of the NTP, as well as the creation of the Climate Change Policy Framework, all new agreements (and where possible, existing agreements) should ensure concessionaires' operations are in compliance with provisions of national transport and climate change policies, as well as with national environmental laws and international standards.

Planning mechanisms

Develop a strategy, action plan and M&E plan to accompany the revised NTP. Policy must be accompanied by planning mechanisms such as a medium-term strategic plan, an action plan with defined tasks, and an M&E plan that assigns responsibility for collecting data and sets clear indicators and targets. The action plan should consist of discrete tasks that can be implemented, measured and completed, and should assign responsible parties and timeframe, along with budget estimates. The M&E plan should establish a methodology for monitoring the progress of tasks, along with indicators that clearly measure efforts to implement the action plan, as well as a system to collect indicator data.

Incorporate climate change considerations into the revised NTP. Three main areas, at a minimum, should be addressed: climate data to be used in analysis; design criteria; and risk screening requirements. The NTP should set requirements for the use of climate data (including historical and future projections of rainfall, flooding, storm surge and tropical storms) when making planning and investment decisions. Design standards for infrastructure and best practices for operations and maintenance informed by climate information and international best practice should also be included in the policy. The NTP should also designate the types (in terms of capital expenditure or extent of construction) of investments that should be screened for climate risk and define the tool(s) to be used as well as a standard process for screening.

Establish partnerships to help address indirect issues, such as solid waste management, construction waste and drainage, that cause or exacerbate flooding and infrastructure deterioration. While aspects of solid waste management and drainage fall under the responsibility of NSWMA and WRA, the MTM has purview over certain elements. Examples of issues to incorporate into the revised NTP include: setting requirements for storm drain cleaning, establishing standards for road drainage, and setting policy and enforcement mechanisms for road repair and post-repair waste removal, among others. The Vision 2030 TWG for transportation would be a logical entity to liaise with others to guarantee operations across related sectors.

Develop a hazard mitigation strategy and disaster response strategy for each subsector. Following on plans from the NTP, the TSP and the Climate Change Policy Framework, the MTM should follow through on developing formal hazard mitigation and disaster response strategies for each of the transport subsectors (roads, airports, seaports and possibly railways). These strategies, developed together with the revised NTP, will guide action to address and respond to natural disasters. The strategies should also be developed and refined through stakeholder consultations to ensure broad-based input during the drafting phase.

Update urban development plans. In coordination with the MLGCD, municipal corporations need to update urban development plans to reflect the changing risk profile for floods and landslides to the parish road networks. Updated plans also need to be aligned with the Master Drainage Plan developed by NWA.

INFORMATION SYSTEMS

Conduct analyses to inform revisions to design criteria for all assets, taking into account a changing climate. For example, bridges and culverts are currently designed using standards and river flow models developed prior to 1960. Shifting rainfall patterns need to be considered in new design criteria to safeguard investments. Novel ways of incorporating the large volume of debris and vegetation being carried into drains, culverts and channels need to be devised, as the current structural guidelines accommodate only pure water flows. Design criteria, land use regulations and other related regulations are contained in a variety of documents, including the National Building Code, the Main Roads Act, the Parochial Roads Act, the Town and Country Planning Act, the Local Improvements Act, the Beach Control Act, and Volume 3 of NEPA's Development and Investment Manual.

Improve quality and maintenance of existing data. Significant data are available on the road network and road conditions, bridge locations and conditions, airport and seaport infrastructure, flood- and landslide-prone areas, floodplain maps, river and gulley networks, watersheds, soil condition and composition, weather and climate, and a host of other relevant information. These can be used in transport infrastructure management and investment planning. However, these data are often available only within the ministries or agencies that developed them. In addition, the quality of data varies across datasets. However, the dispersed and uncoordinated natural hazards records pose significant challenges for the formulation of plans and projects to deal with current and emerging risks. Dissemination mechanisms within the key institutions responsible for risk management currently also impede the use and application of available studies. A database housed within the National Spatial Data Planning Division that integrates climatic, geophysical and infrastructure data in a meaningful way, along with a plan and team dedicated to curating these data, would be useful across the sector.

Develop more detailed hazard assessments for specific assets at finer spatial scales. According to Brabb (1993) and others, at least 90 percent of the losses due to landslides, for example, could be avoided if detailed information and responses were available to engineers and communities. While this assessment begins to unpack these risks, additional information is required for the regions and assets specified as vulnerable to determine appropriate safeguards to put in place.

Conduct detailed vulnerability assessments for specific assets. A deeper dive into the vulnerability of specific investments could offer important information on the need to climate-proof the assets. For example, AAJ's planned vulnerability assessment of Norman Manley International Airport will, over the course of at least nine months, collect and model vulnerability to storm surges, wave run-up and other risks within the confines of the airport facilities and their access roads. This information is critical for prioritizing investments. This assessment points to the need to prioritize such analyses for the country's parochial road network, for which limited information is available.

Conduct a public education program that helps to raise awareness of the risks from floods and other climate changes. A public education program can offer salient advice on new developments in sensitive areas. In the long term, this may also help to raise awareness of officials in municipal corporations, which in large part approve construction in high-risk zones.

Leveraging and capitalizing on the collective experiences of CARICOM (Caribbean Community) countries and the Caribbean Community Climate Change Centre could help to bring island-appropriate knowledge and insights to the task.

TRANSPORT SECTOR BEST PRACTICE FOR SMALL ISLAND DEVELOPING STATES

Small island developing states (SIDS)[7] vary widely, from relatively large volcanic islands such as Papua New Guinea and Cuba, to extremely small coral atolls such as Tuvalu and the Maldives. Despite the variation in size, topography, geology and location, SIDS share a similar and specific set of challenges, including (UNCTAD 2014; UNESCAP 2016):

- Small size, remoteness and insularity
- Large percentage of population and infrastructure within 1 km of coastline
- High vulnerability to the effects of climate change, in particular sea level rise and increased intensity of tropical storms
- Limited financial resources for infrastructure development and maintenance
- Large dependence on imports, with a limited export base and natural resources
- High transport costs (e.g., transport costs of Caribbean trade are at least 30 percent higher than the world average (Pinnock and Ajagunna 2012)
- Heavy reliance on coastal transport infrastructure (seaports and airports), which provides a critical lifeline for external trade, food, energy, and tourism (cruise ships and air transport)
- Little redundancy in the transport network: most countries are only equipped with one airport, one major port, and a few arterial roads.
- Due to the lack of redundancy, transport disruptions can cripple key economic sectors like tourism, fishing, or agriculture, and cut off access to healthcare, education, and other essential services

To respond to these challenges, national governments, regional organizations, development banks, donor organizations and the private sector have been working together to develop and implement adaptation solutions that address climate change from multiple angles, including infrastructure, policy and financing. Below is a summary of best practices for climate change adaptation in SIDS' transport sectors.

Enhancing existing infrastructure. In many SIDS, efforts have been made to climate-proof existing infrastructure (in particular roads, bridges and drainage systems) to withstand increased

[7] A total of 58 SIDS exist (38 UN members and 20 Non-UN Members/Associate Members of the Regional Commissions) as defined by the UN Office of the High Representative for the Least Developed Countries, Landlocked Developing Countries and Small Island Developing States (UN-OHRLLS). See details here: http://unohrlls.org/about-sids/country-profiles/

precipitation intensity, increased heat and sea level rise. Examples of infrastructure improvements include:

- Raising the height of the roadbed 1–3 additional meters above sea level
- Relocating, rebuilding or building new infrastructure further inland and at a higher elevation
- Installing sea defenses (e.g., breakwaters, seawalls, revetments)
- Installing slope retention structures both below and above roads to prevent landslide damage
- Installing beach erosion controls, including hard engineering solutions (e.g., groynes, breakwaters, increased vegetation) and regulatory measures (e.g., buffers and set-backs)
- Improving drainage and flood management to prevent damage such as scouring, undermining of pavement and washout during heavy precipitation events; this has taken many forms, including:
    - Building drainage systems to remove surface water from pavement
    - Increasing the capacity and size of side drains
    - Increasing the capacity and size of culverts and cross drainage
    - Raising the height of embankments in floodplains
    - Building diversion canals
    - Improving cleaning and maintenance regimes for drainage systems
- Changing composition of building material to safeguard against higher temperatures (e.g., using stiffer bitumen in pavement)
- Increasing bridge clearance above the projected high flood level
- Hardening and protecting bridges against floods and erosion, including increasing the footing depth, increasing the size of the pilings, and installing spur dikes or debris deflectors
- Setting pier structures above chart datum to account for sea level rise
- Hardening critical port infrastructure to resist hurricane-level winds
- Lengthening airport runways to account for longer takeoffs needed with higher temperatures

Improving infrastructure maintenance. Regular infrastructure monitoring and maintenance is often the weak link in SIDS, and is one of the most crucial aspects of increasing resilience. Preventative maintenance is significantly more cost-effective than rebuilding or repairing damaged infrastructure, and can help roads, bridges and ports better resist the effects of extreme weather. However, it is often not included as part of an international loan agreement or grant funding for infrastructure development. Various methods can be used to increase infrastructure maintenance, including: increasing available funding through budget allocation, additional taxes or user fees; strengthening the supply chain of spare parts and materials needed for repairs; and developing maintenance plans that codify monitoring frequency, identify priority infrastructure and allocate resources for specific projects. Another approach employed by numerous SIDS is privatization, typically through “operate and maintain” concession agreements, which places the burden of (and incentive for) maintenance on a private sector

operator. This latter arrangement, however, continues to rely on government capacity to transparently monitor and enforce the concession contact.

Improving data for decision making and updating design standards. Adequate climate and hydrological information is needed to set appropriate design and construction standards and to make decisions about where to locate (or relocate) infrastructure. Data availability varies across SIDS, but a basic set of data, including downscaled climate projections, daily temperature and precipitation data (current and historical), floodplain maps and landslide data, along with accurate GPS-located road network maps, road condition reports, bridge inventory and condition reports, and port locations can improve the quality of decision making. Additionally, adequate climate data will allow SIDS to calculate or recalculate return periods for major events such as hurricanes and floods, which can then be incorporated into design and construction standards for new infrastructure investments, as well as used to guide investments in climate-proofing existing infrastructure.

Incorporating climate risk screening into infrastructure planning or permitting processes. Virtually all transport infrastructure projects should require an environmental impact assessment, and part of that assessment should include the risk to the project from weather events such as extreme heat, extreme precipitation and flooding, sea level rise, and storm surge and strong winds, based on the geographic location and topographic attributes of the proposed investment as well as the physical components of the project (e.g., construction material, construction techniques). Climate risk screening, when coupled with appropriate design standards, can help ensure infrastructure is located in a low-risk area, or is designed appropriately to operate in a higher-risk area.

Incorporating climate change into transport policies, plans, legislation and budgeting. Climate change adaptation considerations should be included at all levels, from legislation to action plans. Legislation and policy can address requirements such as data to be used in analysis, minimum design standards and screening procedures, and can mandate that transport agencies develop and implement climate change adaptation or natural hazard risk mitigation plans for their particular subsector. Policies can also identify specific subsectors – such as air and sea transport infrastructure that are critical lifelines and economic drivers – for increased funding and action. Climate change adaptation can be included in action plans and budgets by identifying key assets that are at risk, identifying climate-proofing measures and then including that additional cost in the development or maintenance budget.

Improving inclusiveness of transport networks. Rural roads are often poorly engineered, unpaved and only accessible in drier seasons, and once construction is complete, their maintenance is usually neglected. Rural roads in particular are highly susceptible to extreme weather, rendering them impassible for long periods of time, further isolating rural communities. While emphasis should be put on critical infrastructure such as major highways that facilitate economic development and serve as emergency evacuation routes, it should not be done at the expense of forgoing proper design and maintenance of rural roads, be they paved or unpaved.

Design standards and maintenance plans (albeit less stringent than for primary roads) should also be set for rural roads and the agency or municipalities responsible for the network.

Increasing access to international financing to climate-proof infrastructure or mitigate risk. Many SIDS face budget constraints to fund large infrastructure projects due to the small size of their tax base (both a small population and lack of large or international businesses) and lack of natural resources. International financing can help fill this gap, either through loans from development banks such as the Asian Development Bank (ADB) or the Inter-American Development Bank (IDB), or through grants from climate funds such as the Green Climate Fund (GCF), Global Environment Facility or Least Developed Countries Fund or development agencies such as USAID, Australian Department of Foreign Affairs and Trade (DFAT), the UK's Department for International Development (DFID) and GIZ. For example, the GEF-funded Pacific Adaptation to Climate Change (PACC) program had projects aimed at climate-proofing and protecting coastlines in 14 countries in the Pacific (e.g., improving a 7-km section of Kosrae's coastal road in Federated States of Micronesia), and the ADB-funded project in the Cook Islands increased the resiliency of Avatiu Port to damage from large waves and effects of extreme weather. Pooled insurance mechanisms also represent an innovative approach to disaster risk mitigation, including the Pacific Catastrophe Risk Insurance pilot program through the World Bank and the Caribbean Catastrophe Risk Insurance Facility.

REFERENCES

Airports Authority of Jamaica. (2015). “Annual Report 2015–2016.” Retrieved from http://www.airportsauthorityjamaica.aero/pdf/AAJ_Annual_Report_2015-16.pdf.

Bindoff, N.L., J. Willebrand, V. Artale, A, Cazenave, J. Gregory, S. Gulev, K. Hanawa, C. Le Quéré, S. Levitus, Y. Nojiri, C.K. Shum, L.D. Talley and A. Unnikrishnan. (2007). Observations: Oceanic Climate Change and Sea Level. In: Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change [Solomon, S., D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M. Tignor and H.L. Miller (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

Brabb E., (1993). Proposal for worldwide landslide hazard maps. Proceedings of 7th International Conference and field workshop on landslide in Czech and Slovak Republics; pp. 15–27.

Burgess, C.P., M.A. Taylor, T. Stephenson, A. Mandal, L. Powell, (2015). A macro-scale flood risk model for Jamaica with impact of climate variability. Natural Hazards 78(1), pp. 231–256.

Climate Studies Group, Mona (CSGM), (2012). State of the Jamaican Climate 2012: Information for Resilience Building (Full Report). Produced for the Planning Institute of Jamaica (PIOJ), Kingston Jamaica.

Climate Studies Group, Mona (CSGM), (2017). State of the Jamaican Climate 2015: Information for Resilience Building (Full Report). Produced for the Planning Institute of Jamaica (PIOJ), Kingston Jamaica.

Desinventar – http://www.desinventar.net/DesInventar/profiletab.jsp?countrycode=jam

Hay, C.C., E. Morrow, R.E. Kopp and J.X. Mitrovica, (2015). Probabilistic reanalysis of twentieth-century sea-level rise. Nature 517: 481–484.

IPCC, (2007). Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. [Solomon, S., D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M. Tignor and H.L. Miller (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, 996pp.

Ministry of Finance. (2016). “2016–2017 Jamaica Budget.” Retrieved from http://www.mof.gov.jm/downloads/budgets/eoe/Estimates_of_Expenditure_2016-2017.pdf.

Ministry of Transport and Mining. (2017a). “Integrated Strategic Business Plan 2017/2018–2019/2020.” Retrieved from http://www.mtw.gov.jm/index.php/downloads/send/6-2017-2018-plans/6-2017-2020-strategic-business-plan.

Ministry of Transport and Mining. (2017b). “Operational Plan 2017–2018.” Retrieved from http://www.mtw.gov.jm/index.php/downloads/send/6-2017-2018-plans/5-2017-2018-operational-plan.

Ministry of Transport and Works. (2007). “National Transport Policy.” Retrieved from http://www.oas.org/en/sedi/dsd/Biodiversity/Sustainable_Cities/Sustainable_Communities/Events/SC%20Course%20Jamaica%202016/Module%20III/National%20Transport%20Policy-%20Jamaica.pdf.

Ministry of Transport, Works and Housing. (2015). “Preliminary Evaluation: National Transport Policy (2007), National Transport Policy Review Working Group (NTPRWG).”

Ministry of Water, Land, Environment and Climate Change. (2013). “Climate Change Policy Framework for Jamaica.” Retrieved from http://www.japarliament.gov.jm/attachments/440_Climate%20Change.pdf.

Neufville, Zadie. (2012). “Working to Cope with Climate Change, Jamaica Calculates Costs.” Inter Press Service News Agency. Retrieved from http://www.ipsnews.net/2012/04/working-to-cope-with-climate-change-jamaica-calculates-costs/

Planning Institute of Jamaica (PIOJ). (2009a). “Vision 2030 Jamaica – National Development Plan.” Retrieved from http://www.vision2030.gov.jm/Portals/0/NDP/Vision%202030%20Jamaica%20NDP%20Full%20No%20Cover%20(web).pdf.

PIOJ. (2009b). “Vision 2030 Transport Sector Plan.” Retrieved from http://www.vision2030.gov.jm/Portals/0/Sector_Plan/Microsoft%20Word%20-%20Vision%202030%20Jamaica%20-%20Final%20Draft%20Transport%20Sector%20Plan%20_S%C3%A2%E2%82%AC%C2%A6.pdf.

PIOJ. (2011). “Assessing the Costs of Disasters on Jamaica’s Infrastructure: Evidence from the Damage and Loss Assessment.”

PIOJ. (2015). “Vision 2030 Medium Term Socio-Economic Policy Framework 2015–2018.” Retrieved from http://www.vision2030.gov.jm/Portals/0/MTF/MTF%202015%20-%202018%20-%20Final%20Draft%20-%20December%2031,%202015%20-%20Rev%202.pdf.

Pinnock, Fritz H., Ajagunna, Ibrahim A. (2012). “The Caribbean Maritime Transportation Sector: Achieving Sustainability Through Efficiency.” Centre for International Governance Innovation

Port Authority of Jamaica (PAJ). (2017). “Statistical Publication, July 2017.” Retrieved from http://www.portjam.com/docs/MonthlyStatisticalReport.pdf.

Simpson, M.C., Gössling, S., Scott, D., Hall, M., & Gladin, E., (2008). “Climate change adaptation and mitigation in the tourism sector: Frameworks, tools and practices.” Paris: UNEP.

Tindigarukayo, Jimmy Kazaara, (2014). “The Impact of Rural-Urban Influx on Jamaican Society.” International Journal of Humanities and Social Science. Retrieved from: http://www.ijhssnet.com/journals/Vol_4_No_9_1_July_2014/5.pdf

United Nations Conference on Trade and Development (UNCTAD). (2014). “Small island developing states: Challenges in transport and trade logistics.” Retrieved from http://unctad.org/meetings/en/SessionalDocuments/cimem7d8_en.pdf.

United Nations Economic and Social Commission for Asia and the Pacific (UNESCAP). (2016). “Transport connectivity for least developed countries, landlocked developing countries and small island developing states.” Retrieved from http://www.unescap.org/sites/default/files/pre-ods/MCT3_6E.pdf.

World Economic Forum. (2016). “The Global Competitiveness Report 2016–2017.” Retrieved from https://www.weforum.org/reports/the-global-competitiveness-report-2016-2017-1.

ANNEX A: DATA LIST OF SPATIAL INFORMATION COMPILED AND UTILIZED FOR THIS ASSESMENT

TYPE	OVERVIEW	SHAPEFILE NAME	DATA ORIGINATOR
Transportation Assets	railways	JAM_rails	Ministry of Transport and Mining
	roads overall	JAM_roads	National Works Agency
	Main Roads Condition survey	MainRoadsCondition2011	National Works Agency
	bridge inventory	Bridges	National Works Agency
	ports	Ports	Ministry of Transport and Mining
	main JUTC routes	Premium outbound, portmore outbound, rockford outbound, Twcikenham	JUTC
	airports	Airports	Ministry of Transport and Mining
Environmental Factors	climate	ja_geoclimate	Geology and Mines
	hydrogelology	ja_hydrogeology	
	soils	Jamaica_soil_classification	
	elevation	SRTM	NASA
Hydrology and Floodplains	watersheds	watersheds	Water Resources Authority
	rivers	rivers	
	flood-prone places from WRA	flood_prone_places	
	flood-prone road sections	wra_flood_prone_main_Roads	
	location of landslides and floods	disaster_locations	
	Black River	uppermorass_10yr_flood	
		uppermorass_25yr_flood	
		uppermorass_50yr_flood	
		uppermorass_100yr_flood	
	Hope River	hope_river_100yrboundary	
	Manchional River	25_yrFlood	
		100_yrFlood	
	Morant River	25_yrFlood	
		100_yrFlood	
		Morant_25_river_surge	
		Morant_50_river_surge	
		Morant_100_river_surge	
	Manch River	Manch_25_river_surge	
		Manch_50_river_surge	
		Manch_100_river_surge	
	Nightengale_Gove	bushypark_10yrFlood	

		bushypark_25yrFlood	
		bushypark_50yrFlood	
		bushypark_100yrFlood	
	Rio Cobre	rio_cobre_10yr	
		rio_cobre_25yr	
		rio_cobre_50yr	
		rio_cobre_100yr	
	Rio Grande	rio_grande_10yr	
		rio_grande_25yr	
		rio_grande_50yr	
		rio_grande_100yr	
	Rio Minho	10_yrFlood	
		25_yrFlood	
		50_yrFlood	
		100_yrFlood	
	Yallahs	yallahs_flood Bounadry 2001	
		Gully_network	
Administrative boundaries	Parish Boundaries	admin1	DIVA GIS
	Municipalities	admin2	

ANNEX B: TRANSPORT POLICIES, PLANS, REPORTS AND STUDIES

The NTP does not have an action plan or similar implementation strategy, and the TSP does not have a transport-specific MTF, but the MTM does operationalize aspects of both the NTP and TSP through its four-year integrated strategic business plans, which lay out medium-term priorities and targets for the ministries and all portfolio entities, as well as assess performance during the previous period. The business plan is then further broken down into two-year operational plans, which list actions to achieve medium-term priorities as well as indicators to measure progress (MTM 2017a; MTM 2017b). An overview of these policies and plans is presented below, along with a summary of relevant disaster preparedness plans, agency reports and studies.

TYPE	OVERVIEW
National Policies and Plans	
National Transport Policy (2007)	A comprehensive policy document that covers all modes of transport in Jamaica: air, water (both maritime and inland), roads, railways, public transport, nontraditional modes of transport, general infrastructure and maintenance. The policy addresses the roles of government, the private sector and the numerous authorities operating in the sector. It seeks to identify issues faced by the GOJ in the transport sector and changes necessary in the regulatory structure.
Vision 2030 Jamaica: Transport Sector Plan 2009-2030	One of 31 sectoral plans that make up a comprehensive long-term national development plan focused on local economic development. Sets out a strategic vision and planning framework for the sector as well as an M&E framework. Culminates in an action plan to implement more than 250 activities.
Vision 2030 Medium Term Socio-Economic Policy Framework 2015–2018	Vision 2030 is implemented through a series of Medium Term Socio-Economic Policy Frameworks (MTFs), which identify the priority outcomes, strategies and actions for each three-year period from 2009 to 2030. Transportation is specifically addressed in National Outcome # 9 - Strong Economic Infrastructure.
MTM Integrated Strategic Business Plan 2017/2018–2019/2020	Lays out the MTM's medium-term priority policies, programs and projects, strategies to achieve the desired results, financial and human resources needed to achieve results, along with a procurement plan, and M&E plan. The business plan also includes subplans for all portfolio agencies and departments under the MTM.
MTM Operational Plan 2017–2018	Operationalizes the strategic business plan by listing shorter-term action items to achieve the business plan's strategic objectives. Lists strategy, output and performance indicators for each item, as well as quarterly tasks/milestones to achieve the action item.
Climate Change Policy Framework for Jamaica (2015)	Framework document to create an institutional mechanism and structures to facilitate the development, coordination and implementation of policies, sectoral plans, strategies and legislation to address the impacts of climate change. Also focuses on mainstreaming climate change considerations into national policies and development planning.

TYPE	OVERVIEW
Disaster Preparedness, Prevention and Response	
National Disaster Action Plan (1997)	Provides detailed administrative and operational information and instructions for disaster preparedness, operations and training. Also details the responsibilities of government agencies and government officers, including the makeup and functions of the National Emergency Operations Centre.
National Hazard Risk Reduction Policy for Jamaica (2005)	Provides a framework for integrating hazard mitigation into policies, programs and plans at the national and community levels. Defines the broad goals and guiding principles for hazard risk reduction to inform the development of national and sectoral hazard mitigation plans.
Transport Sector Hazard Mitigation Strategy	Currently under development by NWA; intended to be a mitigation strategy to limit the adverse impact of natural, environmental or technological disasters on the country's road transport network.
Transport Sector Disaster Management Contingency Plan	Currently under development by NWA; intended to be a disaster response strategy to maintain the continuing functioning of the country's main road network following natural disasters or catastrophic events.
Reports	
Airports Authority of Jamaica Annual Report 2015–2016	Provides fiscal year report on passenger and cargo movement, airport operations, commercial development and financial performance. Also provides detailed audited financial statement for the year.
National Works Agency Annual Report 2009–2010	Provides fiscal year report on key performance indicators, priority program and project achievements, road and bridge maintenance and status, studies and tests conducted, and human resources development. Also provides detailed audited financial statement for the year.
Port Authority of Jamaica Annual Report 2015–2016	Provides fiscal year report on cargo and cruise ship movement, port operations, financial performance, commercial development and corporate governance. Also provides detailed audited financial statement for the year.
Transportation Authority Annual Report 2014–2015	Provides fiscal year report on corporate governance, major program highlights, financial performance and key performance indicators. Also provides detailed audited financial statement for the year.
Studies	
Master Drainage Plan	A countrywide drainage plan to relieve flooding problems within identified problem areas. Plan is currently finalized but not yet implemented.
Assessment of the Socio-Economic and Environmental Impact of Natural Disasters	Studies conducted by PIOJ on impacts of numerous storms, including Hurricane Ivan, Hurricane Dennis, Hurricane Emily, Hurricane Wilma, Hurricane Dean, Tropical Storm Gustav and Hurricane Sandy.
Assessment of the Impact of Floods and Landslides on the Jamaican Transport Infrastructure	An assessment commissioned by the World Bank to conduct flood and landslide modeling and assess the effect on road infrastructure, communities and the economy.
Frequency analysis, infilling and trends for extreme precipitation for Jamaica (1895–2100)	A study conducted by UWI Mona faculty to update intensity duration frequency (IDF) curves for Jamaica.

ANNEX C: GUIDANCE DOCUMENTS AND TOOLS TO ASSESS CLIMATE RISKS TO THE TRANSPORT SECTOR

NAME	ORG	YEAR	PURPOSE	STEPS	SUBSECTORS
Guidance Documents					
Climate Risk Screening & Management Tool – Infrastructure, Construction and Energy Annex	USAID	2017	• Climate risk screening; • Climate risk management	• Climate Risks to Infrastructure, Construction, and Energy • Adaptive Capacity Related to Infrastructure, Construction, and Energy • Opportunities Related to Infrastructure, Construction, and Energy • Climate Risk Management Options for Infrastructure, Construction, and Energy	Transportation (general)
Incorporating Climate Change Adaptation in Infrastructure Planning and Design	USAID	2015	• Climate risk assessment • Climate risk management	• Establish the Context • Vulnerability Assessment • Risk Assessment • Develop an Adaptation Strategy • Implementation	• Roads • Bridges
Risk Management for Roads in a Changing Climate: A Guidebook to the RIMAROCC Method	European Union-CEDR	2010	• Climate risk assessment • Climate risk management	• Context Analysis • Risk Identification • Risk Analysis • Risk Evaluation • Risk Mitigation • Implementation of Action Plan • Monitoring, Review & Capitalisation	Road network
Climate proofing ADB investment in the transport sector: initial experience	ADB	2014	• Best practice guidance	n/a	• Roads • Bridges • Ports • Urban transportation
Guidelines for Climate Proofing Investment in the Transport Sector: Road Infrastructure Projects	ADB	2011	• Climate risk screening • Climate risk assessment	• Project Screening and Scoping • Impact Assessment • Vulnerability Assessment	Roads

NAME	ORG	YEAR	PURPOSE	STEPS	SUBSECTORS
			• Climate risk management	• Adaptation Assessment Implementation Arrangements • Monitoring and Evaluation	
International Climate Change Adaptation Framework for Road Infrastructure	World Road Association	2015	• Climate risk assessment • Climate risk management	• Identifying scope, variables, risk & data • Assessing and prioritizing risk • Developing and selecting adaptation responses • Integrating findings into decision making processes	Roads
Moving Toward Climate-Resilient Transport	World Bank	2015	Best practice guidance	n/a	Transportation (general)
Climate and Disaster Resilient Transport in Small Island Developing States: A Call for Action	World Bank	2017	Best practice guidance	n/a	Transportation (general)
Risk-Based Adaptation Frameworks for Climate Change Planning in the Transportation Sector: A Synthesis of Practice	Transportation Research Board (TRB)	2013	Best practice guidance	n/a	Transportation (general)
Climate Change & Extreme Weather Vulnerability Assessment Framework	U.S. Federal Highway Administration (FHA)	2012	• Climate risk assessment • Climate risk management	• Define scope • Develop climate inputs • Develop information on asset sensitivity to climate • Incorporate likelihood and risk • Identify & rate vulnerabilities • Assess asset criticality • Collect & integrate data on assets • Integrate into decision making	Roads
Climate Change Adaptation Planning: Risk Assessment for Airports	TRB/FAA	2015	• Climate risk assessment • Climate risk management	• Assess baseline climate and projected climate changes • Identify critical assets and operations • Inventory asset and operational vulnerabilities • Prioritize risks and incorporate into stand alone or mainstreamed documents	Airports

NAME	ORG	YEAR	PURPOSE	STEPS	SUBSECTORS
Climate change adaptation guidelines for ports	National Climate Change Adaptation Research Facility	2013	• Climate risk assessment • Climate risk management	• Establish the port context • Identify current vulnerabilities and future risks • Analyse and evaluate risks • Identify and prioritise adaptation options • Monitoring and evaluation	Ports
Tools					
Climate Risk Screening & Management Tool	USAID	2017	Climate risk screening		
Airport Climate Risk Operational Screening (ACROS) tool	TRB	2015	Climate risk screening		
Sensitivity Matrix for Modes of Transportation	FHA	2012	Climate risk screening		
Climate & Disaster Risk Screening Tools – Roads Projects	World Bank	2017	Climate risk screening		
Aware	Acclimatise	2017	Climate risk screening		
SimCLIM	CLIM Systems	2017	• Climate modeling • Climate risk assessment		
Caribbean Climate Online Risk and Adaptation tool (CCORAL)	Caribbean Community Climate Change Centre	2013	Climate risk screening		

U.S. Agency for International Development
1300 Pennsylvania Avenue, NW
Washington, DC 20523
Tel: (202) 712-0000
Fax: (202) 216-3524
www.usaid.gov