Climate Change Impacts on Coastal Transportation Infrastructure in the Caribbean: Enhancing the Adaptive Capacity of Small Island Developing States (SIDS)

JAMAICA: A case study

EXECUTIVE SUMMARY*

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Executive Summary

Jamaica, and other Small Island Developing States (SIDS) in the Caribbean, are especially vulnerable to climate change. This is due to:

- The location of the Caribbean – within the "hurricane alley" of the Atlantic;
- The geographic nature of the islands – typically characterised by small land masses with mountainous inland areas and narrow coastal plains, combined with large population concentrations and infrastructure located in these narrow coastal areas;
- A limited economic base and dependency on natural resources – this results in a very limited financial, technical and institutional capacity for adaptation.

Because of this heightened vulnerability [as further detailed in Chapters 1 and 2 of this report], development of climate change adaptation strategies and policies are of paramount importance to Jamaica at this time in its planning framework. No longer can Jamaica, or any of the other Caribbean SIDS, afford to ignore the looming impacts of climate change on their respective nations.

An examination of the cost of the impacts of climate change on Jamaica was examined in Chapter 2 of the report. The analysis revealed that the current cumulative loss of GDP due to damage associated with natural disasters was estimated to be in the order of $120 billion (roughly 7% of GDP). This is a significant number, which is even more grave given the already slow growth and fragility of Jamaica's economy. When this is coupled with potential climate change induced impacts, such as an increase in the number of extreme hurricanes, the figure is even more worrisome as it is likely to rise. Estimates indicate that it could reach as high as 56 per cent of GDP by 2025 if climate predictions are accurate.

Transportation Sector – Overview and Project Scope

The transportation sector is crucial to Jamaica's economic development; any major disruptions can seriously affect the economic flow and operations of the country. This is because the transport sector acts as a conduit, linking production and service areas to the end users. This link is especially vital in small islands such as Jamaica, where the country's population, by virtue of existing on an island, is cut off geographically from neighbours and trading partners in the Caribbean and North and South America. To address this need, Jamaica has developed a multi-modal transportation system comprising of air, land (road and rail), and maritime transportation. Of all these modes, the United Nations Conference on Trade and Development (UNCTAD) has focused on the ports and airports sectors as being critically important for development. UNCTAD, in recognizing this dependency of SIDS on their port and airport infrastructure, has noted:

> *"access to well-functioning and reliable transportation systems, in particular maritime and air transport systems, is vital [for SIDS]. Seaports and airports are the lifelines sustaining the survival of these States, especially since they are highly dependent on transport-intensive imports for much of their consumption needs, for example food and energy. While maritime transport accounts for nearly 80 per cent of world merchandise trade by volume, this share is higher for SIDS. Although maritime transport is the predominant mode used to carry cargo and freight, air transport is relied upon primarily for passenger and tourist transport and domestic inter-island shipping and mobility."* – UNCTAD Trade & Development Commission. Multi-Year Meeting on Transport, Trade Logistics and Trade Facilitation. Third session. Geneva. November 24–26 2014. Item 3 :- Small island developing States: Challenges in transport and trade logistics. (TD/B/C.I/MEM.7/8)

Ports and airports are therefore critical to Jamaica's economy. They are required to provide necessary food imports into the country, as Jamaica cannot produce enough to feed its people and meet other vital consumer needs, such as oil and gas to power its electricity producing plants and cars, among other things. Additionally, ports and airports are gateways to bring persons to the island for tourism, which is a major foreign exchange earner. It is noted (World Travel & Tourism Council – Jamaica Economic Impact 2015) that the direct contribution of the travel and tourism sector to the island's GDP in 2015 was 8.5%, and this was projected to increase to 11.6% by 2025. When the wider effects from investment, the supply chain and induced income impacts are factored in, these numbers rise to 28% and 37.5% respectively, further underscoring the importance of the transportation sector to the Jamaican economy.

Project Objective and Outline

The criticality and importance of the transportation sector in Jamaica is undeniable, as is the particular vulnerability of those same transportation facilities along the coastline. It is therefore crucial that climate change impacts for these facilities be properly understood, and that adaptation strategies and a comprehensive procedure for their strategic implementation be developed in tandem. In recognizing this need, the United Nations launched a capacity building project on "Climate change impacts on coastal transport infrastructure in the Caribbean: Enhancing the adaptive capacity of Small Island Developing States (SIDS)", which is being implemented by the United Nations Conference on Trade and Development (UNCTAD).

The underlying purpose of this initiative, which draws on UNCTAD's earlier relevant work in the field, is to strengthen the capacity of policy makers, transport planners and transport infrastructure managers in SIDS to (a) understand the full range of climate change impacts on coastal transport infrastructure, in particular seaports and airports; and (b) take appropriate adaptation response measures. This report represents the case study for Jamaica. In support of the objectives of the project, the following steps will be undertaken within the body of this report.

1. In Chapter 2, Jamaica as a nation is described for the general reader in terms of its geography, its population, its economy and its social issues. It is felt that this is a necessary component of framing the overall project within a context specific to Jamaica.
2. A thorough review of the State of Jamaica's climate is then undertaken in Chapter 3 to develop an understanding of the current climate conditions in the island, the climate trends as they have existed up to this point, and the future climate projections based on current climatic modelling.
3. Four key transportation facilities (SIA, NMIA, HFCP, KCT) have been selected and are detailed in Chapter 4, to ascertain the criticality of each to the nation. The facilities themselves will be studied to understand their operations and throughput. This defines for the project the criticality of the facilities to the country and forms a basis to hypothesize what could result from a disruption in services due to climate change.
4. In Chapter 5 the facility vulnerability to climate stressors is assessed taking into account the methodology (which was developed in tandem with this report) of determining facility operational thresholds. This is done in an attempt to quantify the amount of disruptions and the costs associated with each particular climate stressor.
5. Potential Adaptation Strategies are then presented on a facility basis as well as on a national level for a more general sense.

Jamaica's Climate

Current Climate Conditions

Analysis of historical data collected on various meteorological parameters governing Jamaica's climate suggests the following:

- Surface temperature in Jamaica is largely controlled by the variation of solar insolation. Average annual temperatures range from 24°C in the winter months to 27°C in the summer months.
- The rainfall pattern is bimodal with early rainfall peaking in May and late season rainfall peaking in October. For all seasons, the maximum rainfall is located in the parish of Portland, close to the border with St. Thomas. The main drivers of the rainfall pattern are the North Atlantic High (NAH) Pressure system, sea surface temperatures, easterly waves, and the Trade Winds.
- The data suggests that Jamaica receives an estimated average of 1825 kWH/m^2 per year of direct solar radiation. The south receives marginally more radiation than the north and the far eastern tip of Jamaica receives more than anywhere else. The annual variation suggests that for the given locations radiation peaks around June.
- Winds are strongest in Portland and St. Thomas, Manchester and St. Elizabeth. The strongest influence are the prevailing winds from the East or North East.
- Data paucity hampers the in-depth analysis of other meteorological variables, particularly analysis of their spatial variation.
- Relative humidity does not vary significantly throughout the year. For morning hours, the average humidity at the airport stations is higher and ranges from 72-80%. In the afternoon it is lower (59-65%).
- Sunshine hours vary little throughout the year, ranging between 7 and 9 hours per day. The average evaporation at Manley International Airport is 7.23 mm/day and 5.50 mm/day at Sangster International Airport.
- There appears to have been a lull in hurricane activity near Jamaica between 1952 and 1973 and much increased activity since 2001.

Historical Climate Trends

Analysis of historical climate data also reveal certain trends which are summarized following:

- There is an upward (linear) trend in temperatures which are consistent with global rates. Minimum temperatures are increasing faster than maximum temperatures. Mean temperatures are increasing at a rate of 0.16°C/decade.
- There is significant year-to-year variability in rainfall due to the influence of various phenomena (El Niño etc.) which results in no clear trend and an insignificant upward trend. The intensity and occurrence of extreme rainfall events have been increasing between 1940 – 2010.
- There is a regional increase in sea level rise of 0.18 ±0.01 mm/year between 1950 and 2010 which is consistent with the global mean, although there is a higher rate of increase in the later years: up to 3.2 mm/year between 1993 and 2010.

- There has been a dramatic increase in frequency of Atlantic hurricanes since 1995. There has also been an increase in category 4 and 5 hurricanes; rainfall intensity associated peak wind intensities and mean rainfall for the same period.

Climate Projections

Some of the work conducted by the Climate Studies Group, Mona, University of the West Indies (UWI-Mona) has been in predicting future climate under various Regional Climate Models (RCM) which are similar to Global Climate Models (GCM) but scaled to suitably fit the Caribbean and the island of Jamaica. Key projections are summarized following:

- Temperatures increase across all seasons of the year, irrespective of scenario, through the end of the century. The mean temperature increase (in °C) from the GCMs will be 0.75-1.04°C by the 2030s and 0.87-1.74°C by the 2050s. However, RCMs suggest higher magnitude increases for the downscaled grid boxes. Mean daily maximum temperature each month at the Norman Manley International Airport (NMIA) station is expected to increase by 0.8-1.3°C by early to mid-century. The annual frequency of warm days in any given month at the NMIA station may increase by 4-19 days by mid-century.
- GCM's suggest that mid 2030's will be up to 4% drier while the 2050's will be up to 10% drier, while by the end of the century the county as a whole may be up to 21% drier for the most severe scenario. Similarly, RCM projections reflect the onset of a drying trend from the mid-2030's, which continues through to the end of the century. However, the decreases are higher for the grid boxes in the RCM than for the GCM projections for the entire country. There is some spatial variation across the country with the south and east showing greater decreases than the north and west.
- For Jamaica, projected sea level rise (SLR) for the north coast is 0.43-0.67m by the end of the century with a maximum rise of 1.05m. SLR rates are similar for the south coast.
- There seems to be a shift towards stronger storms by the end of the century: maximum wind speed increases of +2 to +11% and rainfall rates increasing +20% to +30% for the hurricane's core. Although there is no statistically significant increase in the frequency of all hurricanes, it is predicted that there will be an 80% increase in the frequency of Saffir-Simpson category 4 and 5 Atlantic hurricanes over the next 80 years using the A1B scenario.

Climate Projections effect on Transport

Of the climate projections highlighted above, the temperatures and sea level rise are of the greatest immediate concern. Extremely hot temperatures cause excessive strain on HVAC systems, which affect operations and functionality of the facilities. Further, these extreme temperatures can affect asphalt both on the linking roadways and on the airport tarmacs. Sea level rise is also a grave concern as all the transport facilities under this study are located in low-lying coastal areas subject to inundation by rising waters. Increasing and stronger storms are also concerning as they cause large disruptions in the service operations of both the airports and seaports and can also cause significant damage to the facilities and equipment.

Criticality of Transport Facilities

The four transport facilities selected for analysis within this project are the two international airports, the largest cargo handling port in the island and the port with the most cruise ship arrivals:

° The Sangster International Airport

° The Norman Manley International Airport

° The Historic Falmouth Cruise Port

° The Kingston Container Terminal

The Sangster International Airport (SIA)

The importance of the SIA as the gateway to Jamaica's north coast cannot be overstated as the bulk of tourists visiting the island arrive through this airport. According to the airport's website: *Of the approximately 1.7 million annual visitors to Jamaica, 72% use SIA as their primary airport.* The Airports Authority of Jamaica (AAJ) also shows that 72% of visitors to the island came through the SIA in the financial year 2013/14. The AAJ data further indicates that this percentage share of the passengers entering the island has been on the rise since the 2008/09 financial year. This not only shows that the SIA is the most important airport in the island for visiting passenger traffic, but it also indicates that it is becoming more important as the share of the total national traffic is growing. Although the SIA does not heavily compete in the freight movement: cargo and mail, the movement of cargo and mail is increasing at a faster rate than the passenger movement. Regardless of the rate of increase, the data available clearly indicates that SIA features a large throughput of passengers and cargo that has steadily increased over the past 6 years. Further, because of its location on the north coast, close to hotels and tourist attractions the airport serves as a critical tourist gateway into the island, without which arriving passengers would have to travel long hours from NMIA to reach their north coast destinations.

The Norman Manley International Airport (NMIA)

As the "premier gateway to the nation's capital", NMIA plays a critical role in the economic development of Jamaica. The airport caters to over 1.5 million total passengers per year on average and handles over 9 million kilos of the island's airfreight (roughly 70% of total air freight traffic to the island). NMIA tends to provide air service primarily for visiting friends and relatives (VFR) and business travellers, rather than pleasure-seeking tourists. Surveys have indicated that over a million Jamaican-born persons live outside of Jamaica in the United States (75.5%), the United Kingdom (13.5%) and Canada (11%). The VFR traffic at NMIA reflects the demographic characteristics of this diaspora. NMIA is a draw for business travellers because of the proximity to Kingston. The city plays a central role in Jamaica's economy as the administrative capital and commercial and financial hub. The city is also home to several multinational organizations with regional headquarters, head offices of banks and consultancies, universities and sites of archaeological and historical interest. The criticality of air traffic access to the island's capital for the facilitation of business cannot be overstated.

Airport Comparison

The SIA and the NMIA are Jamaica's only two international airports; with similar histories and similar challenges they have a lot in common. Both international airports have existed in their respective locations in some form for over 60 years. Both airports currently occupy large extents of land (between 350 – 400 acres in each case) and feature all necessary elements of a functioning international airport. Throughout their histories, upgrades on both airports has been an almost ongoing process, and plans for improvements continue, with both airports having significant capital improvement programmes including the lengthening of their runways (when funds become available).

However, there are distinct differences between the two airports. Reports issued by the Airports Authority of Jamaica (AAJ) indicated that between the financial years 2008/09 to 2013/14, the

percentage share of total passenger traffic to the island controlled by the SIA ranged from a low of 66.5% to a maximum of 72% with an average percentage share of 69%. NMIA contributed the remaining 31% on average over the period to total passenger traffic. The data regarding freight performance for the same period as recorded by the AAJ, shows that the NMIA has a higher market share in this field than SIA averaging 71% of total market share over the period and SIA controlling only 29%. The information is also found in the tables below.

The key points and trends revealed from the AAJ data can be summarized as follows:

- The SIA is steadily increasing its percentage share in both the freight market and the passenger market. Conversely the NMIA is losing percentage share in both markets.
- The SIA and the NMIA are dominant in two clearly distinct areas – the SIA has consistently controlled more than two thirds of the island's passenger traffic, while the NMIA has controlled over 70% of the freight traffic in the island for all years of record save one.
- The SIA and the NMIA differ in terms of the makeup of their passengers – the NMIA caters primarily to Jamaicans living abroad and to business travellers, while the SIA is the gateway to the north coast predominantly utilised by tourists vacationing in the island.

This analysis clearly highlights the complementarity of the two assets, which are both vital to the island in different ways. However, because the strengths of the facilities are so vastly different it raises questions about each facility's readiness to absorb the other's load in the event of a closure of either. For instance, in the event of a failure of SIA, NMIA would have to manage those passengers coming into the island, which are roughly 4 times its usual load (over the period of a year). It is unlikely that NMIA could adequately cope with the surge in passenger traffic in this eventuality; and conversely, it is also unlikely that SIA could manage the surge in freight traffic should NMIA close for any reason. This again reinforces the criticality of each airport in the management of passengers and freight entering the island.

The Historic Falmouth Cruise Port (HFCP)

Because of its excellent location and its ability to host larger cruise ship vessels, the HFCP is a critical player in the island's cruise ship industry. Additionally, the number of calls has continuously increased since the port's opening in 2011, which bodes well for anticipated growth.

Data obtained from Port Authority of Jamaica (PAJ) publications revealed that since it's opening in 2011 the Falmouth Pier has consistently had more passengers arriving on its docks than any of the other cruise ship piers in Jamaica. This is partly because it is able to dock larger ships with larger passenger capacities, but is also related to the popularity of the HFCP. It is likely also a function of the fact that the port lies between Montego Bay and Ocho Rios, allowing visitors a greater range of attraction options. The data also shows that the HFCP facility is responsible for approximately half (48% on average) of the total cruise ship passenger arrivals to the island. This elucidates the criticality and importance of the HFCP to the island's cruise ship industry. Damage of the port facility causing non-functionality for whatever reason would thus have massive effects on Jamaica's 'stop-over' tourism trade. Total cruise ship arrivals account for a significant part of total tourist arrivals into the island; in 2014, that percentage was 41%. This highlights the relative importance of cruise ship tourism in the island's overall tourism economy. As the cruise ship port with the most arrivals and calls, the data further underscores the importance of the HFCP to the island's economy.

Even locally the presence of the port is a significant economic contributor. Figures received from The Falmouth Jamaica Land Co. Ltd. revealed that approximately nine hundred (900) staff are employed within the 'plaza' of the pier i.e. within the shops and restaurants etc. This figure does not include tour operators etc. which are outside companies using the pier for excursion pickups,

and so the overall number of persons who depend on the pier for their livelihood is even higher than stated above. In the small town of Falmouth, with a population under 9,000 persons, this is a very important employment centre (roughly 10% of the population) to the people of the town.

The Kingston Container Terminal (KCT)[1]

Data extracted from the database of the Port Authority of Jamaica (PAJ) on the KCT for the past five (5) years: 2011 – 2015 revealed that roughly 1500 vessels visited the KCT each year over the period. Of this amount, the vast majority (approximately 96%) were cargo vessels. The data showed that close to a million metric tonnes of cargo are brought into the island on an annual basis through this port alone. Other documents revealed data related to the 2008-2009 shipping season. During that period: *"the KCT received 2470 vessel calls and handled a total of almost 16.3 million metric tons of cargo. Fees produced by the KCT… during the 2008-2009 shipping season, generated a net income of $8.5 billion for KCT."* [– World Port Source]. It is worth noting that the bulk of the KCT business is transhipment and not domestic importation. *"Of the total amount handled by the port in the 2008-2009 shipping season, about 1.4 million TEUs (86%) were transhipments. Domestic containerized cargo represented 12% of the total 1.7 million."* [– World Port Source]

The transhipment services to the region – the Caribbean, North, Central and South American markets, are a vital component of the KCT business. The Economic Commission for Latin America and the Caribbean (ECLAC) updates every year its ranking of container port throughput, which shows the cargo volume in containers in 120 ports of the region, based on data obtained directly from port authorities and terminal operators. In 2015, the regional activity grew 1.7%, with a total volume of approximately 48 million TEU. ECLAC ranked the KCT as 8th in Latin America and the Caribbean.

The critical importance of the port is thus multi-fold:

- It controls the largest share of the country's imports and exports.
- It is a major contributor to the region's (Latin America and Caribbean) transhipment activities.
- It is a major revenue earner as well as a large employer of persons in the island, and thus contributor to the island's economy, through direct earnings and taxes.

The domestic cargo market should also not be underestimated as large amounts of produce and commodities are brought into the island through the port. Through the KCT and other ports, Jamaica mainly imports oil and ethanol (to satisfy the island's energy needs); wheat and rice (as the primary food imports); as well as lye, electronic appliances, vehicles and metals, all of which are inputs for manufacturing, agriculture and local businesses. Should operations at the KCT be forced to cease for any reason such as a natural disaster, Jamaica's economy and its people would be severely affected.

Vulnerability of Transport Facilities

The extensive studies reported in Chapter 3 of this report indicate clearly that: Climate projections specific to the island indicate climate change will likely occur. Key projections of climatic changes for the island of Jamaica along with their likely effects are summarized below:

[1] Throughout the document, Kingston Container Terminal refers to the port facility whereas Kingston Freeport Terminal Limited (KFT or KFTL) will refer to the current (since 2015) managing company of the facility.

Table Error! No text of specified style in document.**.1 Forecasted changes in climate and their effects on transport facilities**

Parameter	Change	Period	Effect
Higher Temperatures	Increase by 0.87-1.74°C	2050s	- Strain on HVAC systems - Weaken asphalt - Strain on personnel working outdoors
More Warm Days	Increase by 4-19 days	2050s	
More Droughts	10% drier	2050s	- Limits water supply and related functionality - Detracts tourists
Higher Sea Level	Increase by 0.43-0.67m	2100s	- Increased risk of inundation of facility runways, container bays and access roads
More Intense Storms	Wind Speed: +2 to +11% Rainfall: +20% to +30%	2100s	- More incidents of higher category storms - More likely to have facility shutdown due to storms.

Of all the climate changes which will occur, the climate stressor that is perhaps of most concern to facility managers is the threat of more intense hurricanes. The wave action; storm surge; and flooding linked to hurricanes has in the past resulted in large disruptions in the service operations of both the airports and seaports and has also caused significant damage to the facilities and equipment. The effects of climate change on these parameters will increase their damaging effects which is an alarming thought.

All the transportation facilities in this study border the sea, and KCT is almost completely surrounded by water. Therefore, the vulnerability of the sites to sea level rise, or inundation of the facility and access roads because of storm surge, is quite clear.

Possible Adaptation Strategies

The analysis so far suggests some actions that can be taken by the facilities to safeguard against the impending climate changes which could include:

Facility	Potential Adaptation Strategy	Effect
SIA	- Raise Runway - Extend Runway	- combat SLR and storm surges - combat warmer temperatures affecting lift
NMIA	- Extend Runway - Raise low-lying areas	- combat warmer temperatures affecting lift - combat SLR and storm surges
HFCP	- Combine efforts with local government to improve infrastructure in Falmouth	- improve resilience of access roads - improve tourist experience
KCT	- Invest in better reinforcement for cranes - Deploy booms in Hunts Bay	- combat higher wind speeds - control debris outflow

All of the improvement strategies recommended will decrease the vulnerability of the facilities in question. However, to make really effective change, especially for the seaports, coordination with agencies outside of the facility will be required. Additionally, national level strategies are also

required for cohesive and long-term planning, especially for those issues being affected on a larger scale.

In this context, with a view to the development of effective adaptation measures, it is important to note that the Jamaican Government, in 2015, has adopted a comprehensive and cross-cutting Climate Change Policy Framework for Jamaica which expressly recognizes the importance of climate change adaptation for seaports and airports.