COP26 Futures We Want – Jamaica Country Profile

The purpose of this draft country profile is to provide an evidence base to inform the production of Net Zero Future visions. A consolidated version of material contained here was used as stimulus for in-country workshops and creative translational approaches that developed a plausible vision for each country. This document provides a selection of relevant evidence for the sectors and themes identified through the scoping exercise.

Part A: Executive Summary

This country profile for Jamaica has been developed in collaboration with in-country academic experts - Professor Michael A. Taylor, Doctor David C. Smith, and Rajne Reynolds (University of the West Indies) - and with reference to a wide range of available literature, including local media, government reports, and academic papers. It sets out a summary of the current socioeconomic conditions in Jamaica, the predicted impacts of climate change, and discusses a range of possible options for adaptation and mitigation, whilst also delivering key goals for ongoing sustainable development.

As a small island developing state (SIDS) located within the tropics, Jamaica's location and environmental conditions make it physically vulnerable to climate impacts, whilst an historically poorly diversified economy, and remaining poverty and security issues, mean that it lacks resilience and capacity to recover from or adapt to these. Climate change impacts including increased temperatures, reduced rainfall, rising sea levels, and increased occurrence of intense storms are already being felt, and have brought damage to coastal infrastructure and ecosystems, water shortages, health impacts, and agricultural losses. Climate change impacts – already affecting daily life – are predicted to worsen by 2030, and if the world goes beyond 1.5 degrees of warming, compared to a late 20th century baseline, consequences for life in Jamaica and other Caribbean states will be very severe.

Jamaica's priority is therefore to rapidly develop strategies to adapt its economy and way of life to the new climate conditions, and to provide greater resilience and ability to recover from climate effects. This is also coupled with a desire for continued socioeconomic development towards the Sustainable Development Goals, and the need for finding an equitable approach to this both within-country, and as part of global efforts to tackle climate change. Climate mitigation strategies that are compatible with Jamaica's critical needs to adapt and develop, are being developed as far as possible, despite Jamaica's emissions being low compared to more developed countries.

Delivery of climate compatible development can be achieved by improving ecological, economic, and social resilience. Restoring and strengthening both the natural and built environment, adding diversity within the economy, and capacity within Jamaica's people offers great potential for climate change adaptation and also sustainable development. Key approaches for delivering both sets of benefits could include nature-based solutions including restoration of coastal and upland habitats, as well as investments in research and development within agriculture, strengthening of

governance and authorities, capacity building to allow economic diversification, and development of new infrastructure with climate-smart designs.

This profile is structured in five main sections: (1) Country context, which covers the economic and development context of Jamaica, and its current greenhouse gas emissions; (2) Physical climate change, Jamaica's risk profile, vulnerability and discussion of impacts it will cause, including interactions between physical, social and economic features; (3) Adaptation, and solutions and opportunities for adaptation; (4) Development compatible emissions, and solutions and opportunities for reducing emissions; and (5) Development compatible transitions, including discussion of how to tie together all the necessary approaches in a just way, including risks, co-benefits, trade-offs, and the timescale over which action needs to happen. From section (3) onwards we bring in examples from seven priority sectors and three cross-cutting themes that were identified in discussion with the team of in-country academic experts as being of particular importance to consider within the Jamaica context. These are: (1) Land use, agriculture, and forestry; (2) Energy and electricity generation; (3) Infrastructure and health of ecosystem services; (4) Transport; (5) Tourism; and (6) Health and wellbeing. Within these, three cross-cutting themes that were critical to success across all areas were also identified: (1) Water; (2) Loss and damage; and (3) Risk.

Part B: Expert Committee Inputs

1. Country Context

1.a Economic Context

1.a.i Sectors that contribute most to the country's GDP

In the decades immediately following Jamaica gaining independence in 1962, mining, manufacturing and construction, and tourism industries grew rapidly, and have remained important, despite suffering impacts from economic downturns, natural disasters, and external shocks during the intervening decades [1]. In addition to these key industries, there has also been a rise in financial services, telecommunications, entertainment, and distribution sectors in recent decades [2].

The Statistical Institute of Jamaica reports on the status of the following key sectors: (1) agriculture, forestry and fishing; (2) mining and quarrying; (3) manufacturing; (4) electricity and water supply; (5) construction; (6) wholesale and retail trade; repairs; installation of machinery and equipment; (7) hotels and restaurants; (8) transport, storage and communication; (9) finance and insurance services; (10) real estate, renting and business activities; (11) producers of government services; and (12) other services [3]. In 2019/2020, the largest sectors in terms of contribution to GDP were wholesale and retail (15.7% of GDP), government services (10.5%), finance (9.0%), and real estate (8.9%). The traditionally important manufacturing and agriculture sectors each contributed about 7% of GDP, and mining only 1.6% [4] (Figure 1).

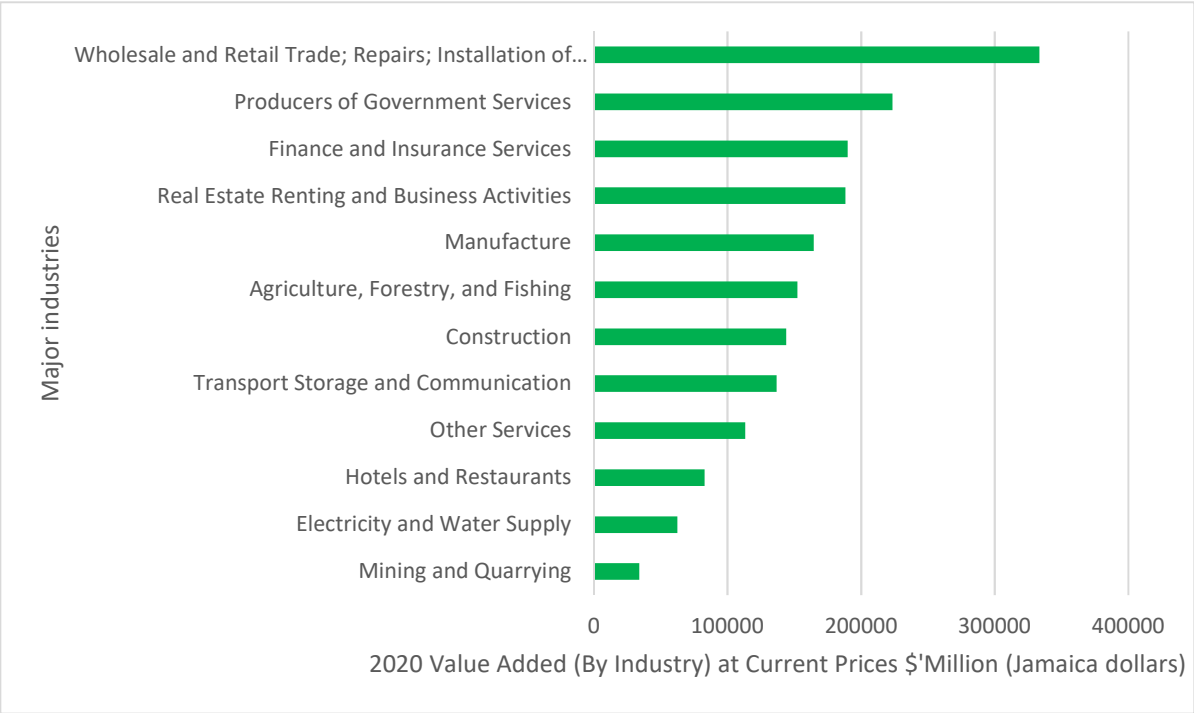

Figure 1- *Value added by each industry at current prices (website accessed June 2021) for the fiscal year 2020 (April 2019-April 2020). The full industry name for 'Wholesale and Retail Trade; Repairs' is 'Wholesale & Retail Trade; Repairs; Installation of Machinery & Equipment'. Values are in Jamaican dollars (on 27/10/21 1 JMD = 0.0065 USD). The plot was constructed using data from [5].*

Although hotels and restaurants are specifically listed and alone contributed 3.9% of GDP in 2019/2020 [6], and it is estimated that in 2019 tourism directly generated 9.8% of Jamaica's GDP [7], these figures do not fully demonstrate the importance of the tourism industry. It is likely that tourism also makes substantial indirect contributions to many of the other listed sectors, and it has been reported that in 2018/2019 tourism actually supported >30% of Jamaica's GDP, having seen rapid growth year on year since the 2000s [8]. Jamaica has a score of 38.5 out of a maximum of 100 on the 'Tourism Dependency Index' – a metric that is calculated using average values for the total contribution of tourism to export receipts, GDP and employment within the country (2014-2018), and indicates the level of importance of tourism to the economy of a country, with 100 representing total dependence. This score means that Jamaica ranks 17th out of 166 countries globally in terms of their dependence on tourism to support their economy [9]. The vast majority of revenue from the tourism industry is generated from inbound tourists from overseas rather than domestic tourists [10].

In terms of employment of the labour force, the key sectors (>7% of the workforce employed, in January 2021) were: wholesale and retail (20.1%); agriculture (14.7%); construction (10%); arts and entertainment (9.3%); real estate (8.4%); education, health and social care (8.1%); and hotels and restaurants (7.9%) [11]. Financial and insurance services, information and communications, electricity and water, and mining each employed under 2% of the labour force [12].

1.a.ii Sectors that represent growth areas for the country economically (in absolute terms, but also as a proportion of GDP)

In past decades Jamaica has had one of the slowest growing economies of developing countries across the world, and its economy was often regarded to be underperforming [13]. However, more recently, the economy has been strengthening, and showed a 7th consecutive year of growth in 2019/20 [14]. In 2019/20, growth compared to the previous financial year was achieved through a 1.5% increase in the services industry, which outweighed a 0.6% decline in goods producing industries. Growth sectors included manufacturing (+1.8%); energy, electricity and water (+1.3%); transport (+0.9%); finance and insurance (+3.3%); hotels and restaurants (+5.0%); wholesale and retail (+0.9%); and agriculture (+0.5%), whilst declines were seen in construction (-0.5%) and mining and quarrying (-11.5%) [15]. Factors that affected this included a mixture of internal policies such as the development of programmes to choose crops and livestock more strategically, and changing rates of new infrastructure projects; as well as both increases and decreases in external markets including tourist arrivals and demands for exports [16].

However, the COVID-19 pandemic caused unprecedented changes in the global economy, and led to substantial declines in Jamaica's service industry in 2020 (overall 11.5% decline, Oct-Dec 2020 compared to Oct-Dec 2019), primarily as a result of loss of the tourism industry. It is estimated that the tourism industry suffered a contraction of US$4.4 billion, reducing the real economy GDP by 6.3% between 2019 and 2020 [17]. Jamaica's agriculture, forestry and fishing also declined by 6.1% because of heavy rainfall, and manufacturing declined by 3.4% owing to lower demand for goods. However, mining and quarrying increased by 6% in response to increased external demand, and construction increased by 6.2% as a result of civil engineering activity on the island [18]. Therefore, with so much recent uncertainty, it is currently unclear which sectors represent long term growth areas for the country.
The long term trend in economic underperformance, coupled with the heavy and unpredictable impacts of COVID-19, weather conditions, and external factors on several industries over just the recent few years underline the importance of continuing to diversify the economy as far as possible to help provide resilience. Jamaica's National Development Plan 'Vision 2030' listed agriculture, manufacturing, mining and quarrying, construction, creative industries, sport, information and communications technology, services, and tourism as the industries that they hoped would become internationally competitive by 2030 [19].

1.a.iii. Major trade-flows (goods and services) in and out of the country today

Jamaica is a net importer of goods, importing a total of US$5.91 billion and exporting US$1.85 billion-worth of goods in 2019. The most imported goods in 2019 were: refined petroleum (14.1%, $836M); cars (5.62%, $332M); crude petroleum (4.02%, $238M); and petroleum gas (3.31%, $195M), plus a wide range of other products (Figure 2A). The majority of these imports came from the United States (43.3%, $2.56B), China (10.7%, $530M), Japan (4.4%, $260M), Trinidad and Tobago (2.8%, $166M) and Turkey (2.77%, $164M). Exports in 2019 were dominated by a few key products: aluminium oxide (52.1%, $966M); refined petroleum (14.2%, $363M); aluminium ore (4.83%, $89.5M); and hard liquor (4.68%, $86.7M), along with smaller quantities of a range of others (Figure 2B). Jamaica's major goods export markets in 2019 were the United States (32%, $594M), the Netherlands (10.8%, $201M), Germany (9.35%, $173M), Canada (7.21%, £134M), and Iceland (6.5%, $120M) [20].

Jamaica is a net exporter of services, exporting a total of US$3.83 billion and importing US$2.47 billion-worth of services in 2018. Service exports in 2018 were overwhelmingly dominated by personal travel services (tourism) ($3.1B), with transportation ($224M), other business services ($223M), computer and information services ($128M) and personal, cultural and recreational services ($105M) playing a much smaller role in comparison. Service imports in 2018 showed slightly more of a mix, being dominated by transportation ($905M) and other business services ($809M), and then personal travel ($242M), insurance services ($138M) and construction services ($101M) to a lesser extent [21].

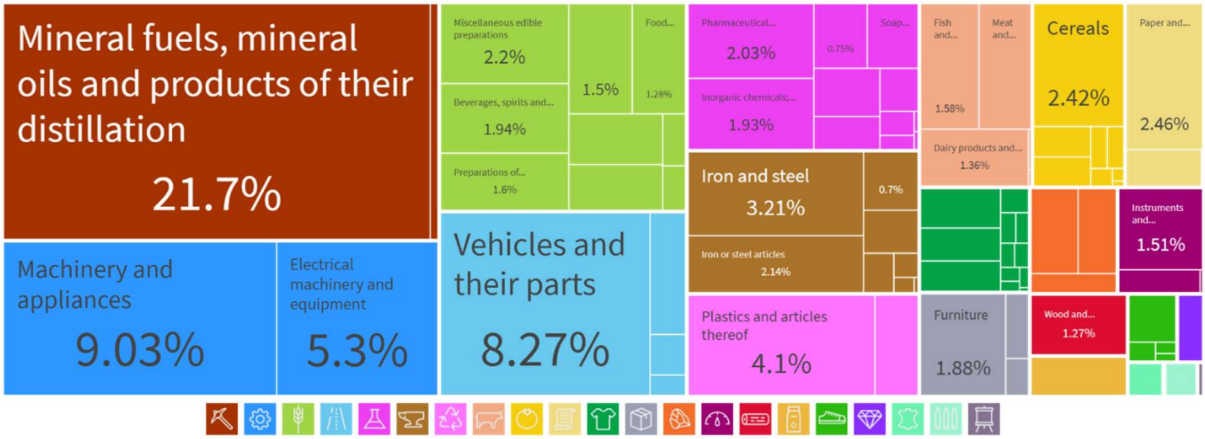

***Figure 2A**- Imports into Jamaica 2018. Reproduced from [22].*

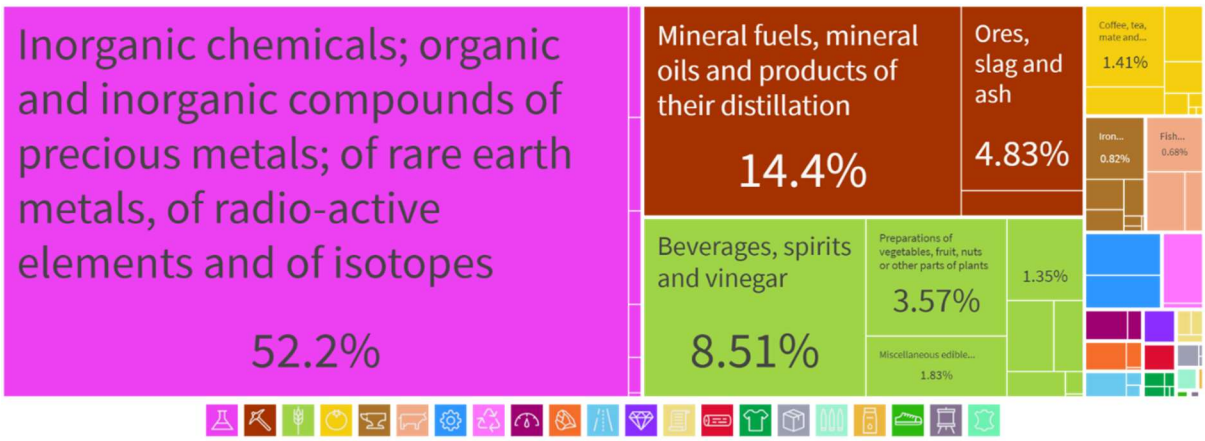

***Figure 2B**- Exports from Jamaica 2018. Reproduced from [23].*

1.b Development Context

1.b.i What are the key development indices for this country

In 2019, Jamaica had a Human Development Score of 0.734, which placed it as a high human development level country and gave it a global ranking of 101st out of 189 countries on the Human Development Index [24]. In terms of progress towards achieving the Sustainable Development Goals (SDGs), Jamaica achieved a score of 68.7 out of 100, and was ranked 84 out of 193 countries [25].

Although Jamaica has not yet achieved any of the SDGs and there are 'major challenges' or 'significant challenges' for achieving many of them, it is on track to achieve 'Decent Work and Economic Growth' and many individual health, education, and wellbeing metrics are improving [26]. These include good levels or recent improvements in child mortality rates; literacy rates; electricity and clean fuel access; and high-quality university education [27]. However, there are 'major challenges' remaining in achieving 'Zero Hunger', 'Reduced Inequalities', and protecting 'Life Below Water', and 'significant challenges' remaining for achieving gender equality and several other SDGs. Key challenges include increasing incidence of obesity and non-communicable diseases related to unhealthy lifestyles such as diabetes and cardiovascular disease; decreasing education enrolment and completion rates; high murder rate; poor quality of trade and transport related infrastructure; low levels of spending on research, development, health and education; poor marine and terrestrial environmental and species protection; and poor management of some waste materials [28].

A 2019 within-country assessment of 75 indicators measuring progress towards the country's key 'Vision 2030' [29] development targets, found that there was mixed performance. Between 2009 and 2018/19, 32% of targets for the period had been met or exceeded, and a further 32% had shown improvement beyond the 2007 baseline. However, 28% had either shown no progress or were at a worse level than 2007, whilst 8% could not be measured [30]. Key areas of improvement were in development of human capital, improved macroeconomic stability, reduced unemployment, increase in the use of renewable and alternative energy, improved government effectiveness, infrastructural development, and economic growth in some sectors, particularly tourism, agriculture, and mining and quarrying. However, areas where there were losses included crime rates, rates of chronic diseases, and environmental stability. Although improvement had been made, poverty levels were still considered to be at undesirable levels [31].

It should be noted that the impacts of the recent COVID-19 pandemic on the status of development indices have not yet been assessed.

1.b.ii What are the priorities and barriers to enabling the country's sustainable, inclusive and resilient growth?

In common with many small island developing states (SIDS - as recognised by the United Nations since 1992), decision making and capacity for economic growth in Jamaica are heavily influenced by the nation's small size, its remoteness from global market centres, lack of economic diversity and therefore vulnerability to economic shocks and debt, and vulnerability to natural hazards and environmental changes [32]. Difficulties such as the small size of domestic markets, high fixed costs and reliance on the public sector, limited opportunities for developing the private sector, a narrow resource base, lack of capacity for economies of scale, as well as vulnerability to price fluctuations and economic volatility are likely to constrain the ability of SIDS, including Jamaica, to develop their economies [33]. Environmental constraints such as quality and quantity of freshwater, fragile natural environments, and lack of resilience to natural hazards may also limit the ability to follow traditional economic growth pathways, but make the need for sustainable and resilient growth even more critical [34].

In addition to environmental constraints, Jamaica's progress over recent decades has been hampered by serious social limitations including high levels of outward migration; poor education performance; high youth unemployment; gender inequality; weak institutions; high rates of crime and violence; and a high perception of corruption in public and private sectors [35]. However, following a range of government led initiatives, with a focus on social provision, education, health, and security, many social indicators have shown improvements [36.] For example, unemployment in 2019 was at its lowest point ever (7.7%), with youth unemployment falling from 24.2 to 20.6% between 2018 and 2019; school enrolment levels are currently high; and life expectancy is at 74.2 years [37.] However, rising rates of non-communicable diseases related to unhealthy lifestyle habits, including cancer, cardiovascular disease, diabetes, and chronic lower respiratory disease, and increasing rates of infectious diseases such as dengue, as the climate is already starting to change, are emerging problems which are putting the country's health service under strain [38, 39, 40] . In addition, injuries from violence, road traffic crashes, and suicide attempts also place a substantial burden on the health service, with a cost of JM$12.6 billion per year (2017 analysis, (on 27/10/21 1 JMD = 0.0065 USD).) [41]. Crime and violence rates are still high, with Jamaica having one of the world's highest *per capita* homicide rates [42]. As well as health impacts of injuries, The National Security Policy indicated that crime and the fear of crime has adversely affected investment, capital formation and business development [43, 44].

Jamaica ranked 80th out of 141 countries on the Global Competitiveness Index (GCI) 2019 (which assesses efficiency [45]), 74th out of 180 countries on Transparency International's Corruption Percentages Index (CPI) 2019 (a measure of accountability and transparency of governance [46, 19]), and 49th out of 128 countries in the Rule of Law index [47]. These scores have shown improvements over recent years, but there are still substantial improvements that could be made to improve trust and effectiveness. Jamaica's Logistics Performance Index (LPI) score, which is a measure of its efficiency in trade, shipments, customs checks, competence and quality of logistics, and timeliness of shipping ranged from 2.2 to 2.9 (with 1 being low, and 5 being high) between 2007 and 2016. Although several other countries in the Caribbean including The Bahamas, Cuba, Guyana and Haiti recorded similar scores over these years, several of these - Guyana and Cuba in particular - showed steady improvement in score over time, whereas Jamaica's scores fluctuated [48, 49].

There is limited institutional capacity and trust, individual capacity, or financial or technical support to be able to enact policy changes [50]. Research and technological development are also limited. This means that historically there has been a lack of legislative or regulatory support for climate change considerations, and limited integration of environmental considerations into policies and strategies, which could make transition to policies for sustainability difficult. However, in recent years there has been an increase in the number of policies that consider these issues [51].

Jamaica hopes to achieve developed country status by 2030 by implementing a development programme that focuses on delivering a high quality of life and world class standards of education, healthcare, nutrition, basic amenities, social order, and access to environment goods and services for all its citizens [52]. This development vision for 2030 has a major focus on sustainable prosperity, and ensuring that current

needs are not being met at the expense of the ability of future generations to meet their needs [53].

1.c Development compatible greenhouse gas emissions (GHGs)

1.c.i Country's current GHG emissions profile

Jamaica accounts for 0.02% of global consumption-based CO_2 emissions [54] and has set targets to cut these still further (see 'Development compatible emissions: Solutions & Opportunities'). Jamaica's GHG emissions (measured in carbon-dioxide equivalent, CO_2e or GHGe) were 9.44 Mt in 1990, increased steadily to a peak of 14.09 Mt in 2006, and then fell sharply back towards 1990 levels from 2009 onwards, where they have since remained (9.6 Mt in 2016 - the last year for which data are available) (Figure 3 [55]). Per capita CO_2 emissions followed a similar trend between 1990 (3.1 tonnes per capita per year) and 2018 (2.8 t), but with a peak in 2000 (3.9 t) [56]. It is estimated that CO_2 emissions make up the majority of greenhouse gas emissions in Jamaica (approximately 65% of total emissions in 2012), with N_2O being the second major contributor (approximately 30% of total emissions in 2012 in terms of CO_2 equivalents). CH_4 and HFC also contributed small amounts (~4% and ~0.4% respectively) [57]. Land Use, Land Use Change and Forestry (LULUCF) are a small net GHG sink, which were estimated to have drawn down approximately 7% of the total GHG emissions in 2012 overall, once LULUCF emissions and storage was calculated [58].

In 2018, Jamaica's *per capita* emissions ranked 89th out of 193 countries listed [59]. Jamaica's 2018 *per capita* CO_2 emissions are equal to the Latin America and Caribbean average of 2.8 tonnes *per capita*, slightly lower than the SIDS average of 3.2, somewhat lower than the High Human Development category country average of 5.2, and substantially lower than the Very High Human Development category average of 10.4 [60, 61] (Figure 3). While emissions are decreasing over time, reducing CO_2 emissions arising from energy consumption and imported goods and services remain a SDG challenge [62].

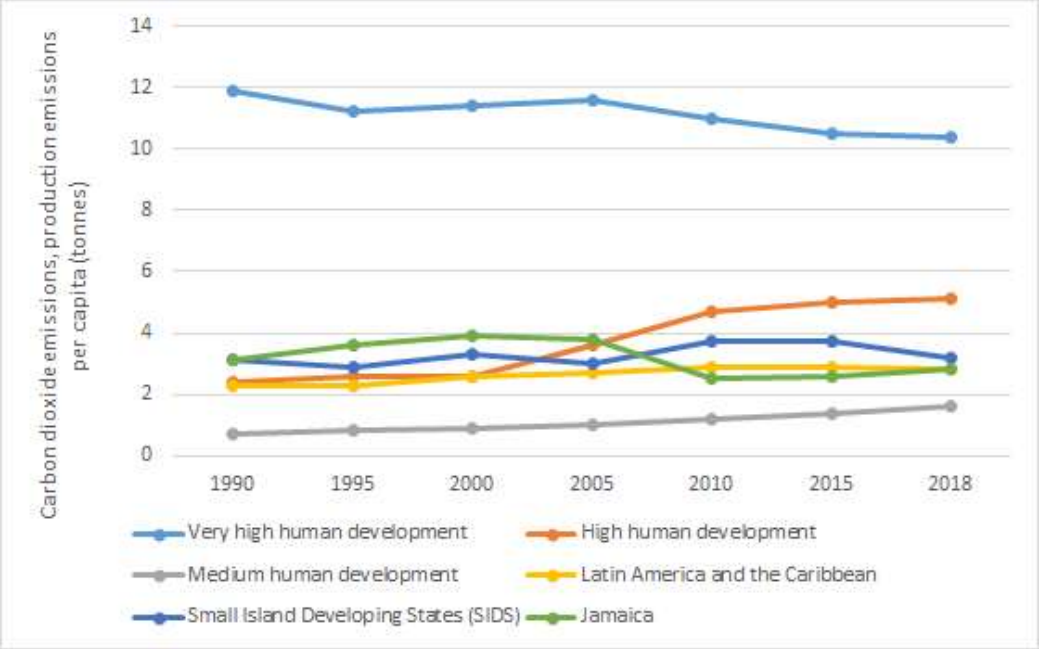

Figure 3- Per capita *carbon dioxide emissions (in tonnes) 1990-2016 for Jamaica, in comparison with the averages across all Small Island Developing States (SIDS), all Latin American and Caribbean counties combined, and all Very High, High, and Medium Human Development countries (as defined by the United Nations Development Programme, UNDP). Carbon dioxide emissions values used are territorial emissions, i.e., all carbon dioxide emissions that are produced as a consequence of human activities (use of coal, oil and gas for combustion and industrial processes, gas flaring and cement manufacture) within the country in which they physically occur. Emissions totals are divided by midyear population to give* per capita *values. Values are shown at intervals of 5 years apart from 2015-2018, because 2018 data are the latest available. Plotted using data from [63], originally from [64].*

1.c.ii Sector-specific GHG emissions from the sectors which are key for development in this country

In 2016, Jamaica's largest greenhouse gas emitting sectors (in terms of carbon-dioxide equivalent, CO_2e or GHGe) were electricity and heat generation (2.7 Mt), manufacturing and construction (2.4 Mt), and transport (1.8 Mt), with all other sectors (agriculture, industry, waste, buildings, other fuel combustion, land-use change and forestry) releasing a combined total of 3.51 Mt (Figure 4) [65].

CO_2 emissions in Jamaica in 2006-2012 (most recent published data available) were primarily from fuel combustion to generate electricity (22% in 2012), fuel combustion within the bauxite mining industry (12% in 2012), and use for road transport (14% in 2012). N_2O emissions were nearly all from the agricultural sector (98% in 2012), whilst CH_4 emissions were generated predominantly by landfill sites (54% in 2012) and also from animal farming (20% in 2012). HFC's were from refrigeration and air conditioning equipment [66]. Fluctuations in emissions year to year are driven mostly by variations in livestock numbers, and in changes in the level of activity within the mining industry. For example, the economic downturn in 2008-2009 led to decreased mining [67], and also manufacturing and construction (Figure 4), therefore lower emissions from these sectors.

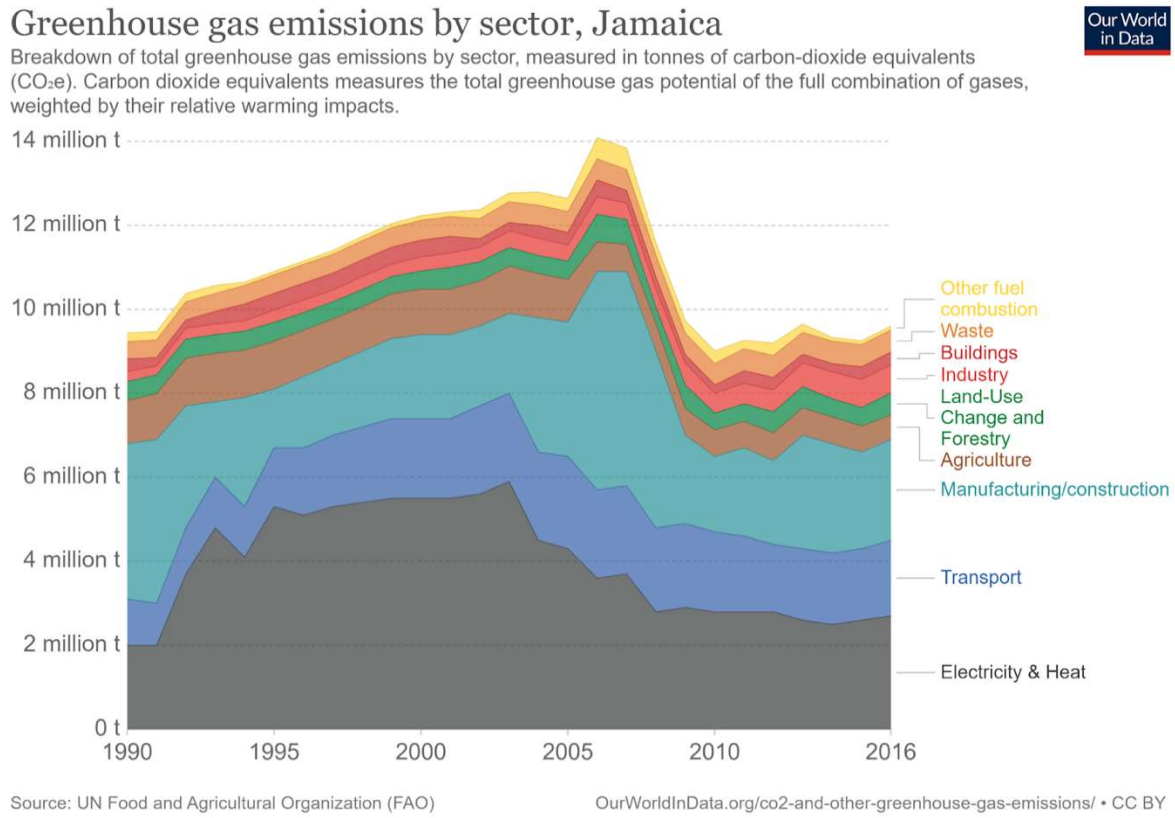

Figure 4- *Greenhouse gas emissions by economic sector, Jamaica (1990-2016). Graph reproduced from [68].*

2. <u>Physical climate change – risks, adaptation and opportunities</u>

2.a Physical climate risk profile

2.a.i, 2.a.ii, 2a.iii. Physical climate risks that the country is already facing, and predictions for 2050 and 2100

Jamaica will face four main sets of impacts as a result of climate change (the implications of which are discussed further in 'Examples of the impacts of climate change across a range of sectors'). These key impacts are: (1) increases in temperature; (2) highly variable rainfall patterns (including intense rainfall events and prolonged droughts); (3) rising sea levels; and (4) increases in intensity of hurricanes and storms [69].

Increases in temperature: Between 1961 and 2010, average annual temperature in Jamaica increased by 0.16°C per decade, whilst sea surface temperatures increased by 0.7°C per decade between 1960 and 2006 [70,71]. The State of the Jamaica Climate 2020 report (in prep.) shows the same rate of increase up to 2019 (Michael Taylor, pers. comm.) By the 2050s, it is projected that there will be a 0.85-1.8°C increase in temperature, and a 0.82-3.09°C increase for 2081-2100 (compared to a 1986-2005 baseline, and calculated across RCP2.6, RCP4.5, RCP6.0, and RCP8.5 scenarios [72].

Highly variable rainfall patterns: There is typically interannual variation in rainfall, in part due to the modulating influence of El Niño Southern Oscillation (ENSO) events, and there has been a mix of wetter and drier decades since the 1960s [73.] There are also differences in rainfall totals across Jamaica's four rainfall zones [74]. Between 1940 and 2010 there was an increase in the occurrence of extreme rainfall events. It is projected that from the 2020s onwards there will be less rainfall than average, with the 2050s up to 10% drier, and 2100 perhaps up to 21% drier than current, as a result of changes in summer rainfall [75]. It is projected that the south and east of Jamaica will show greater decreases in rainfall than the north and the west. There is limited evidence and low agreement on the cause of this Caribbean drying trend, though it is likely that it will continue in coming decades[76].

Rising sea levels: Sea levels in the Caribbean have risen by between 0.18 mm per year between 1950 and 2010, but by up to 3.2 mm per year between 1993 and 2010. At Port Royal on the southeast of Jamaica the increase has been about 1.66 mm per year. It is projected that sea level rise on the north coast of Jamaica will be 0.58-0.87 m by the end of the century, and up to 1.04 m for the south coast [77].

Increases in intensity of hurricanes and storms: There has been an increase in frequency of intense Atlantic hurricanes since 1995, and in particular those that are category 4 and 5 [78, 79]. While the frequency of hurricanes is not projected to increase[80], it is projected that by the end of the century there will be stronger storms, with maximum wind speeds 2-11% higher, and rainfall rates 20-30% higher in the core of the hurricane, and an 80% increase in the frequency of category 4 and 5 hurricanes [81, 82], coupled with rising sea levels and storm surge potential [83].

Vulnerability to climate impacts

Including: 2.b. Sectoral and socioeconomic impacts of physical climate risks; 2.b.i Economic sectors listed in section 1.a. which are most exposed/vulnerable to physical climate risks; 2.b.iii Demographic and ethnographic groups most at risk from climatic changes; 2.b.iv Broader risks to sustainable development within the country/region that arise from physical climate change

Across a range of approaches, Jamaica was consistently ranked as one of the Caribbean countries that will be most vulnerable to climate change impacts over the coming decades [84]. Across the broader Environmental Vulnerability Index (EVI) - which is based on 50 indicators that consider vulnerability to climate change, biodiversity, water, agriculture and fisheries, human health aspects, desertification, and exposure to natural disasters, Jamaica was ranked as 'extremely vulnerable' [85] . It was also classified as high vulnerability and medium resilience by Briguglio's resilience/vulnerability framework because of its high dependence on a limited number of exports and degree of economic openness [86]. Like many other SIDS, Jamaica is extremely vulnerable to external shocks including climate change impacts, owing to its high dependency on natural resources, limited range of economic sectors, narrow range of exports, and dependence on imports [87]. Its small land area, mountainous interior, narrow coastal plain, and high exposure to hurricanes also create substantial additional vulnerability [88].

Jamaica's environmental constraints mean that the vast majority of Jamaica's infrastructure and settlements (90% of the country's GDP generation, including much of the tourism, transport, and energy and water supply infrastructure) are along the coastline, making them vulnerable to sea level rise and increased storm damage [89, 90]. Inland areas are mountainous (approximately 80% of the island is hilly, with >50% having slopes greater than 20°), are prone to soil erosion [91], and are vulnerable to the impacts of temperature and rainfall changes, and storm damage [92, 93]. Coastal ecosystems such as coral reefs, mangroves and fisheries are already severely degraded as a result of overfishing but are also threatened by sea level rise and ocean warming, with impacts on fish stocks due to ecosystem degradation and increased storms, already being seen on the island [94]. A rise of global temperature of 1.5°C is likely to result in 70-90% of tropical coral reefs disappearing while a rise of 2°C is projected to cause >99% loss [95, 96] . This would have profound deleterious effects on the coastal environment and the fishing and tourism industries it supports. Jamaica depends on groundwater supplies for 90% of its water demands [97] , making it highly vulnerable to the impacts of increased temperatures leading to higher evaporation, reduced rainfall causing drought, and increased sea levels and storm surges causing incursion of sea water [98]. Availability of water within streams in Jamaica is also likely to be heavily reduced by climate change [99].

As a tropical nation with already high annual temperatures, Jamaica's population is likely to face substantial health risks due to the negative socioeconomic impacts of climate change [100]. For example, over the coming decades, it is likely that there will be substantial loss of working hours because of increased heat. At temperatures between 33 and 34°C, a worker working at moderate intensity is 50% less able to work than at temperatures below 24°C [101, 102, 103, 104]. There will also be increased incidence of deadly heat [105], heat stroke [106], infectious disease [107], and adverse mental health impacts [108] leading to increased absence from work, greater healthcare burdens, and negative social implications. Increased temperature has also been shown to reduce learning capability [109], therefore potentially creating additional socioeconomic problems for future generations. Additional energy and water demand to help keep people cool and hydrated in hot weather will also place extra strain on water and energy supplies, which are likely to already be heavily stretched by drought, and infrastructure damage [110].

Jamaica's socioeconomic status as a still developing nation means that its economy and labour market is not yet very diverse, is heavily focused on resource-based industries, and very dependent on just a few key industries. Many industries are poorly developed or have suffered from underinvestment. For example, the agricultural sector is already weakened by a lack of technical and financial support in recent years [111], whilst other sectors such as micro and small enterprises are weak because they have only recently been developed. The country also has very limited financial reserves [112]. This means that Jamaica's economy has little resilience to climate change impacts. As an island nation, Jamaica's transport sector is particularly critical to economic development, linking all production and services to end users, and underpinning all other industries. Jamaica has a mix of land transport (road and rail), and air and seaports which are of critical importance for development because they allow food and fuel imports, exports and facilitate cruise shipping. The air and seaports are at risk from rising temperature because this places strain on functionality of

transport systems, weakens asphalt, and limits the time that personnel can work outdoors; increased droughts limit water supplies and may discourage tourists from visiting; risk from sea level rise is because seaports are centred in low-lying coastal areas and both airport runways are less than 3 m elevation and adjacent to or partially surrounded by the sea [113]. Ports are therefore at high risk of inundation; and more extreme storms are likely to cause damage and greater shutdowns of facilities [114, 115].

On top of the broader context of Jamaica's socioeconomic vulnerability, there are also likely to be particular demographic and ethnographic groups that are even more at risk than others from the effects of climate change. Although poverty rates are improving (with a 6.7% reduction in poverty levels 2017-2018 [116]), significant portions of the population are living below the poverty line (12.6% in 2018 [117]), and are disadvantaged by poor education performance, unemployment, poor access to healthcare and social security provision, and high incidence of crime and violence. Climate change impacts will endanger livelihoods and homes, increase the risk of conflicts within communities, and may cause impacts on cultural practices [118]. There is therefore substantial risk that - owing to their current circumstances and locations - already disadvantaged groups could be most directly affected by climate change impacts, the knock-on consequences of climate change impacts could affect them most strongly, or they could lose out as others benefit from a transition towards greater resilience and development. For example, it has been shown that a lack of wind-resistant building materials in homes for construction of walls, most likely because of existing poverty, results in substantial increases in poverty after a hurricane [119].

Groups that are particularly vulnerable, marginalised, and likely to be suffering from poverty are at high risk of being displaced or heavily affected by climate change impacts. Women are vulnerable because they play the major role as caregivers and so typically earn less, have lower social status and power in decision-making, suffer inequality in land tenure, and are less represented in the labour market compared to men [120, 121, 122, 123] . As such, households headed by women tend to be poorer [124], and have reduced access to financing [125], particularly those within the agricultural sector [126]. Across the agricultural sector more broadly, small scale farmers within the hilly interior of the country [127] and fishermen, are also highly vulnerable to climate change impacts because they are dependent on nature for their income [128] and are typically surviving on low incomes. For example, a study of smallholder coffee growers in the Blue Mountains of Jamaica found that there was high vulnerability to having low harvests as a result of climate variability interacting with effects of plant diseases and changing market conditions, and that their ability to cope was limited by their lack of resources, reduced public investment in smallholders, and unequal market relations [129]. Within these vulnerable communities it is also likely that some people are more vulnerable than others as a result of differences in social and economic capital [130, 131]. This has been found to be the case in fishing communities in Old Harbour Bay, showing the need for targeted approaches to climate change adaptation strategies, to ensure that they are reaching the people who are most in need [132]. Members of Maroon communities (a traditionally independent social grouping, who still live on communal lands [133]), are also at high risk of being displaced from their land.

Regardless of socioeconomic situation, all children, pregnant women, the elderly, people with pre-existing medical conditions, and those who are socially isolated, are

likely to be particularly vulnerable to heat stress [134, 135]. The productivity of those working in the agricultural and construction industries is likely to be more heavily affected by rising temperature than those working in other sectors [136]. Climate change risks in terms of annual percentage loss in value are estimated to be variable across the country meaning that people living in some areas of the country will be more at risk of climate change impacts than others [137].

Examples of the impacts of climate change across a range of sectors

Including: 2.b.ii Examples of how these sectors may be impacted by climate change including any material impacts on trade flows.

The changes in temperature, rainfall, sea level, and occurrence of extreme events that have occurred over the last few decades are already causing serious impacts to Jamaica, across a range of key sectors. Freshwater resources, the health of terrestrial ecosystems, human health, infrastructure, beaches, and coastal ecosystems have been particularly heavily affected, with consequences that affect all economic sectors. Many of these impacts are predicted to worsen over the coming decades, whilst a range of additional impacts are also likely to emerge.

Examples of climate change impacts that have already been seen in Jamaica, and are predicted to worsen over coming decades include:

- Damage to coastal and marine resources including erosion of beaches, and destruction of coastal habitats by storms [138, 139].
- Sargassum seaweed blooms have begun to cover beaches in many parts of the Caribbean, including Jamaica, potentially as a result of rising sea surface temperatures. They discolour water, beaches, and release a bad smell, and so threaten the appeal of the island's beaches to tourists as well as threatening fisheries [140].
- Reductions in tourist visits because of increasing rates of intense hurricanes. From 2003-2008 data from across the Caribbean, it was estimated that average hurricane strikes decrease tourist arrivals by about 2% within the month of the strike, whilst the most severe hurricanes decrease numbers by 20%. However, there was no evidence of longer term effects [141].
- Impacts on water resources including changes in availability, saltwater intrusion, greater sedimentation in reservoirs and damage to water resource infrastructure because of extreme weather events [142].
- Livestock in Jamaica have been found to be experiencing heat stress during some periods of the year, and it is predicted that this will be year-round if average temperatures rise by 1.5°C above a 1961-1990 baseline [143] . There could also be large-scale loss of cattle, decreased birth weight and birth number of livestock, reduced milk quality, and lower quality meat in chickens [144].
- It is estimated that between 1994 and 2010, major climate events caused JM$14.4 billion of damage and loss within the agricultural sector [145]. In 2012 alone, farmers lost JM$140 million's worth of crops as a result of damage from the Beet Army Worm – a pest that thrives under high temperatures (on 27/10/21 1 JMD = 0.0065 USD)[146].
- Damage to human settlements and infrastructure caused by extreme weather events have already occurred and are likely to become more common [147].

- It is predicted that rates of chikungunya, dengue and other vector-borne diseases (such as malaria, and yellow fever) will increase with temperature increases as this shortens the incubation period of viruses within the mosquito vectors [148]. Jamaica experienced a severe outbreak of chikungunya in 2014 which affected 60% of the population and had an estimated economic loss of JM$30 million [149]. An outbreak of dengue in 2019 required activation of the national disaster mechanism to help bring it under control [150].
- From 2001 to 2020 extreme weather-related events caused a total of US$1.9 billion in damage and loss according to Planning Institute of Jamaica (PIOJ) reports [151]. This averages to US$94 million *per annum* or 26% of the Government's capital budget [152].
- Ocean acidification poses a risk to Jamaica's coral reefs, with loss of beach width due to coral reef degradation leading to a possible decline in tourism of 9000 – 18000 visitors annually[153].

Examples of projected additional future impacts include:

- Additional loss of coastal ecosystems including coral bleaching and sea grass decline as a result of warming temperatures and beach erosion and degraded wetlands as a result of sea level rise [154].
- The tourism industry will be heavily affected by damage to infrastructure, beach erosion, increased heat stress for people, higher cooling costs, and loss of ecotourism sites and biodiversity [155]. For example, a 2011 study that focused on three key tourism areas in Jamaica (Negril, Montego Bay, and Ocho Rios) estimated that coastal erosion alone could reduce tourist visits by between 9,000 and 18,000 per year over 10 years, at a cost of between US$11-23 million per year [156]. Studies on the beach at Negril, a major tourist resort, indicated that by 2060 a combination of accelerated sea level rise (due to climate change) and the degradation of seagrass meadows and coral reefs could lead to a total loss of sand along 35% of the beach during a storm that is currently characterised as a 1 in 50-year event [157].
- Jamaica's Sangster International Airport runway is highly vulnerable to inundation and would be flooded if there was a storm surge flood that is currently characterised as a 1 in 25-year event [158]. With this level of vulnerability and worsening rates of extreme events, it is therefore likely that the airport will soon be severely affected.
- Agricultural production will be affected by increasing temperatures, droughts, rainfall variability, and greater storm intensity leading to crop losses, erosion, reductions in soil fertility, flooding, landslides and new pests and diseases [159, 160]. It is predicted that a +1.5°C temperature increase (compared to 1970-2000 baseline) will severely reduce the range of crops that Jamaica's farmers can successfully grow therefore causing substantial social and economic impacts, whilst anything >1.5°C would severely imperil the sustainability of Jamaica's agricultural industry [161]. High value crops such as coffee, citrus, sugarcane and banana are likely to be particularly vulnerable to extreme climate events [162].
- Additional human health impacts including greater incidence of waterborne diseases such as leptospirosis (as a result of sanitation problems caused by climate impacts on infrastructure), heat stress (as a result of rising temperatures), and severe loss of worker productivity are likely to emerge and become increasingly widespread [163,164]. Increasing temperatures and humidity

are expected to increase respiratory problems, including acute asthma, bronchitis, and allergies [165]. High temperatures are likely to cause reproductive problems including reduced sperm counts in men, and increased rates of embryo deaths and deformities as a result of heat exposure in pregnant women [166]. There is also a greater risk of malnutrition because of agricultural and fisheries failures and breakdown of import supply chains [167], higher risk of accidental deaths from extreme events [168], as well as predicted declines in mental health and overall wellbeing [169].

- There are concerns about future freshwater availability as a result of drought, and also contamination from extreme weather events such as storms, heavy rainfall, and coastal flooding [170].
- Increasing demand for energy for air conditioning and fans, but potentially decreased capacity of the energy sector to generate electricity as a result of damage to coastal infrastructure, and reduced efficiency of solar power generation at high temperature [171].
- Insurance and banking sectors will be heavily affected by the changing risks of weather-related catastrophes, as they will have a reduced ability to calculate risks reliably and meet claims when they arise. Lack of insurance cover and ability of industry to underwrite risk will have serious implications for a developing economy that also has high vulnerability to climate impacts, like Jamaica [172].
- Risks of climate impacts reducing school attendance and learning capacity because of infrastructure damage, health impacts, or need for children to help with tasks at home if families are struggling with impacts [173].
- Breakdowns in security as a result of damages and increased pressure on resources, and reduced ability of authorities to cope [174].
- It is estimated that costs will reach as high as 56% of GDP by 2025 with potential climate change induced impacts included [175].

Interactions between risks, vulnerabilities, and impacts

Including: 2.a.iv. How might different physical, sociological and economic risks and vulnerabilities interact? (correlated and cascading risks, multiple interacting risks, interconnectivity between these different physical climate risks)

The severity, and multifaceted nature of the climate change impacts that Jamaica is facing, coupled with its high environmental, economic, and social vulnerability as a Small Island Developing State, means that a wide range of sectoral and socioeconomic impacts are likely to be, and are already being, felt (Figure 5 [176]). Rather than impacts being discrete and separate across different sectors of the economy or social groups, the interconnectedness, and lack of environmental, economic, and social resilience within the small island developing context of Jamaica means that everything is intertwined, with climate changes having impacts across multiple sectors [177].

Examples of interactions between different risks and vulnerabilities, resulting in cascading impacts, are already being seen in some regions of the island. Negril in Jamaica's northwest corner is an example of an area that is already showing effects

of ecosystems collapsing under the strain of impacts from tourism and climate change. Its coastline is suffering from high rates of erosion caused by heightened waves, whilst loss of wetland systems and poor sewerage systems have led to decreased water quality [178]. Despite the establishment of marine protected areas to manage the coastal ecosystems that support tourism, the industry continues to contribute to degradation and damage of coastal ecosystems and insufficient funds are allocated to ecosystem management [179]. A multifaceted response, including stronger enforcement of legislation by the government, greater corporate environmental responsibility from hotels to ensure sustainable tourism, and increased capacity building and community participation are needed to help ensure a more successful balance is struck, especially as climate change impacts become increasingly severe.

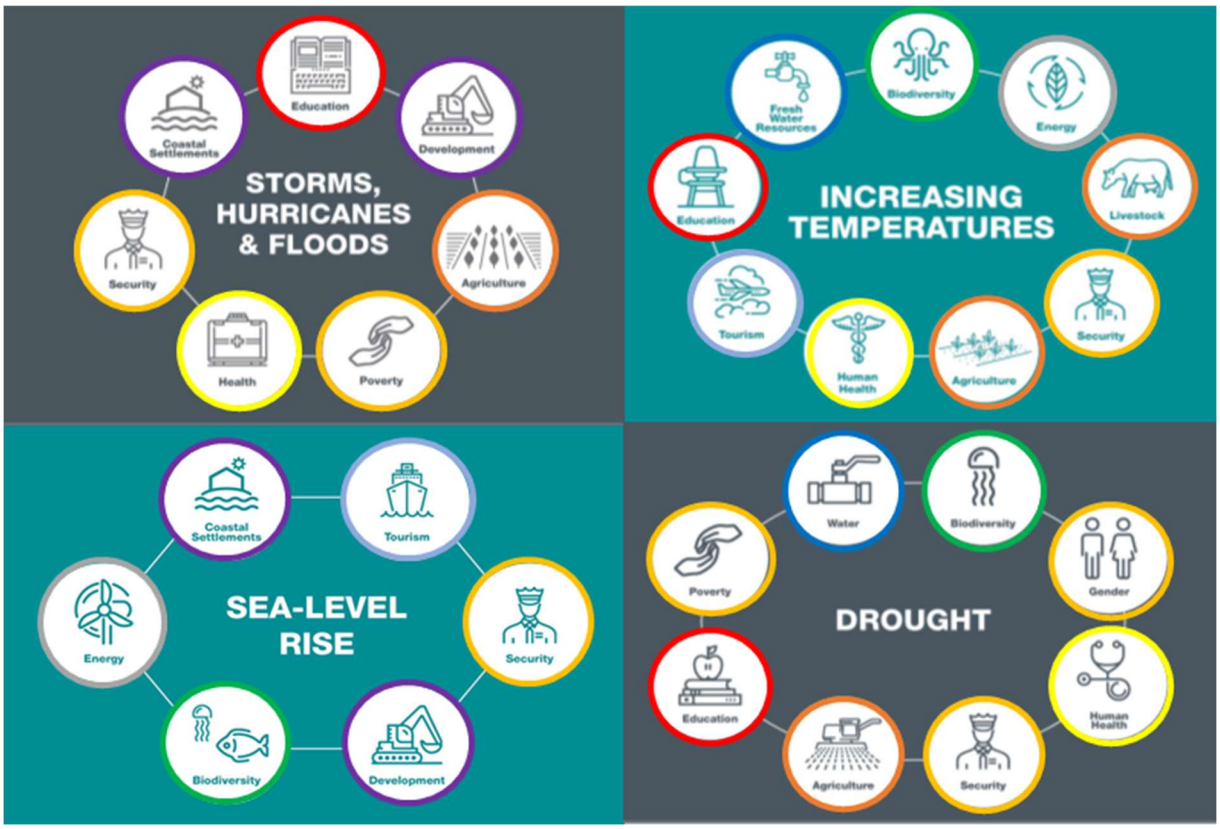

Figure 5 *- Schematic diagram to illustrate the multiple impacts of climate change, across multiple environmental, economic, and social sectors. Linkages between sectors, and matched or similar coloured outlines around sector icons, illustrate linkages between them. Modified from [180].*

2.c Adaptation: Solutions & Opportunities

Sectoral impacts included from this point forwards in the document - 3.c.i Sectors most likely to be impacted, including material impacts on trade-flows, and considering both risks and opportunities; 3.c.ii Examples of how these sectors may be impacted by a net zero transition, including any material impacts on trade flows.

To help explore possible options for interconnected adaptation and net zero solutions, we will concentrate our discussion on solutions that focus on a set of priority sectors

and cross-cutting themes. These sectors have been identified by the Jamaica expert committee members as being of key importance for maintaining and developing the environmental, economic, and social structure that Jamaica will need for a successful net zero and climate change resilient future coupled with continued development. These are:

(1) Land use, agriculture, and forestry
(2) Energy and electricity generation
(3) Infrastructure and health of ecosystem services
(4) Transport
(5) Tourism
(6) Health and wellbeing

Within these, three cross-cutting themes that were critical to success across all areas were also identified: (1) Water; (2) Loss and damage; and (3) Risk. Our discussion from this point forwards will therefore consider strategies that contribute to reinforcing and developing these sectors.

Country specific adaptation and resilience to climate change impacts – priorities, solutions, and emerging sectors

Including: 2.c.i Country specific adaptation and resilience priorities against anticipated levels of climate change impacts; 2.c.ii Current/future solutions which have the potential to satisfy this country's adaptation needs, including transformation; 2.c.iv Locally specific emerging sectors that might be of future importance for adaptation

Jamaica has developed a range of plans and initiatives to increase its resilience and ability to adapt to the temperature, rainfall, sea level rise, and storm event climate change impacts that it will face over the coming decades. These include strategies such as government-led changes to infrastructure and policy including guidelines on rainwater harvesting, forest management and conservation, and water sector strategies [181]; development of plans such as the Comprehensive Disaster Management Strategy [182] to deal with extreme events more effectively; and NGO and community led initiatives [183]. These approaches include a range of technological, infrastructure, social, and nature-based solutions to help safeguard the key environmental, economic, and social sectors and requirements.

Approaches to safeguard key coastal infrastructure - and therefore much of the key energy, transport, tourism and settlement infrastructure that is housed there - include construction of sea defences such as groynes, protective dunes, and stone or 'riprap' revetment structures [184]. Maintenance and restoration of coastal ecosystems including coral reefs, sea grass beds, and mangroves along Jamaica's coastline offer a particularly promising and cost-effective option to protect coastal areas. Coral reefs reduce wave energy and therefore rates of beach erosion, whilst sea grasses play a critical role in creating and maintaining beach sand [185]. The storm protection value that mangroves can provide in Jamaica is estimated to be worth an average of US$2,500 per ha annually, increasing to >US$5000 per ha in more populated areas [186]. For example, during Hurricane Dean in 2007, presence of mangroves around Mitchell Town lowered water levels by 0.3-0.6m, keeping the village safe from flooding [187]. Although 770 ha of mangroves were lost from Jamaica's coastlines between 1996 and

2016, over 70% of these are potentially restorable [188]. Costs of mangrove restoration projects in Jamaica, and globally, are generally much cheaper than engineering alternatives [189].

Protecting forests in upper watersheds provides the benefits of protecting water supplies, reducing the flood hazard and protecting biological diversity, which in the case of endemic species and neotropical migrant birds provides global benefits. This is the aim of the Integrated Management of the Yallahs and Hope River Watershed Management Areas (Yallahs-Hope) Project in Jamaica [190]. This is a payment for ecosystem services (PES) watershed protection project being implemented by the National Environment and Planning Agency (NEPA), Rural Agricultural Development Authority (RADA), and Forestry Department which aims to protect parts of the Blue Mountains, one of the global 'Centres of Plant Biodiversity' [191] and a World Heritage site, as well as improving water supply for residents in the western part of the island [192, 193].

A key component for safeguarding Jamaica's transport and tourism sectors is to maintain the functioning of its two international airports, its cruise ship ports, and cargo ship terminals. To combat the risks of sea level rise induced flooding, increased rates of storm damage, and warmer temperatures affecting aeroplane lift, the runways of Jamaica's two international airports could be raised or extended [194]. Resilience to storm and flood damage of access roads near the cruise ship ports could be improved, whilst reinforcement of cranes and deployment of booms could help to counter the effects of higher wind speeds and debris overflow at the country's container terminal [195]. Switching to more resilient or more cheaply and easily repairable types of infrastructure, including renewable energy generation rather than fossil fuel power stations, can also help minimise impacts.

In addition to making changes to infrastructure to help protect against the damaging impacts of severe hurricanes and sea level rise, steps could be taken to help improve ability to cope with the after-effects. These could include the government setting up a national relief fund, largely funded by taxation from key industries such as tourism that serve to benefit from speedy recovery [196]. There could also be options for insurance schemes across the Caribbean, such as the Caribbean Catastrophe Risk Insurance Facility [197]. Jamaica has recently established an agreement with the Inter-American Development Bank (IDB) for a Contingent Credit Facility up to US$285 million to help provide this necessary buffer [198]. Investments in social provision, capacity building, healthcare and education, that will help to improve the adaptability of the population, will also help the country to develop greater resilience in the longer term. Barbados, meanwhile, has sought to protect its fiscal recovery following major disasters by inserting natural disaster clauses into sovereign bonds. When an independent organisation, such as the WHO or metereological agency, declares

Loss of work days caused by heavy rainfall could be alleviated by improvements to travel infrastructure, including steps to prevent roads flooding; increasing diversification of the economy towards more communications-based industries that have the potential to be carried out remotely; and to develop greater broadband provision to help support home working [199] and online schooling.

To protect agriculture against hurricane damage, techniques such as transplanting of plants, cutting trenches, spraying, early harvesting and storing, and plant bracing can be used to protect crops, whilst long term relocation of farm plots and scaling down of production could be considered [200]. In areas where soil will not get waterlogged, hurricane damage to crops could be minimised by switching to crops that grow underground (e.g. yams and potatoes), rather than growing above ground crops that are highly susceptible to storm damage [201]. Options for coping with drought could include growing different crops, harvesting rainwater, improving water storage structures, mulching to help with water conservation, reduced tillage practices to reduce run-off, and drip irrigation [202]. Flood adaptations could include using raised beds, and checking dams and drains, whilst contouring planting and using hedgerow alley-cropping could help minimize impacts of landslides [203]. Attempts could be made to protect livestock from heat stress by developing early warning systems, providing better training for farmers, lowering the stocking density, increasing ventilation of animal housing or providing sprinkler systems, providing shade in pasture or practicing night grazing, and developing more heat resistant breeds [204]. Community engagement strategies that encourage adaptation planning, and that draw on local knowledge, take into account local perceptions, and historical context, are likely to be crucial in developing effective resilience strategies [205, 206].

Social adaptations are also likely to be key for help small-scale fishermen to adapt to climate changes. A recent review of studies from around the world suggested six key social strategies for improving climate change adaptation: (1) minimising risks associated with fishing schedules; (2) increasing social cohesion and support networks; (3) improving local knowledge about climate changes; (4) learning new alternative skills; (5) getting involved in planning of adaptation strategies; and (6) providing credit facilities [207]. These strategies would give fishermen the knowledge they need to understand impacts and options for adaptation, as well as the financial and social support to be able to enact changes. This model of providing both information and resources to allow adaptation to climate change has the potential to be tailored to the Jamaican fishing context (similar ideas discussed in [208]), as well as for a wider range of at-risk communities. There is evidence that several communities are adopting some or all of these principles to build local resilience, though there still remains a need for greater roll-out across all sectors and areas [209].

In addition to the existing ‘Jamaica Moves’ health initiative [210] that aims to reverse Jamaica’s soaring rates of non-communicable diseases that relate to unhealthy lifestyles, and therefore improve the resilience of the population and healthcare system to health stressors, there have been a series of recent recommendations for necessary actions to safeguard against the health impacts of climate change specifically. These include: (1) finalising and implementing a health and climate change strategy plan that ensures that health priorities are identified, adaptation options considered, budget allocated, and monitoring protocols put in place; (2) developing this further with greater consideration of health vulnerability, impacts and adaptive capacity; (3) strengthening risk surveillance and meteorological early warning systems, so that the country’s healthcare system can be more prepared for impacts; (4) finding ways to increase access to international climate change finance to support health adaptation; and (5) building climate-resilient and environmentally sustainable healthcare facilities, so that healthcare provision can be maintained [211].

In order to maximise the adaptation benefits, climate change strategy should be developed in an integrated way across sectors, and regions, and according to risk profiles and prioritisation plans. Actions such as the National Adaptation Plan (NAP) Approach are already underway and involve the development of 12 sector strategies and action plans, which each include monitoring and evaluation frameworks and investment plans in order to help get ideas off the ground, and for them to work as effectively as possible [212].

3.d. Development compatible emissions: Solutions & Opportunities

Including: 3.d.i Current/future solutions that can enable development-compatible emissions reduction in this country (in line with the SDGs); 3.d.ii Locally specific emerging sectors that might be of future importance for development compatible mitigation.

Along with other low-carbon emitting SIDS, Jamaica places more focus on adaptation measures and building resilience than on reducing emissions. However, the government is also committed to following a 'no regrets' approach which includes mitigation measures in its policies [213]. Key policies and initiatives to help with this include The National Energy Policy 2009-2030 as part of the nation's 2030 Vision [214], and a draft National Carbon Emissions Trading Policy which makes commitments to participate in the Clean Development Mechanism and Kyoto Protocol, and establishes the guidelines under which Jamaica would participate in carbon trading [215]. Jamaica has committed to the Paris Agreement, and has increased its mitigation component within its Nationally Determined Contributions (NDC) [216]. Jamaica's targets are for a 25.4% reduction in emissions relative to business-as-usual emissions in 2030 without international support (unconditional), or a 28.5% reduction conditional upon international support [217].

Jamaica's 2030 Vision policies aim to modernise its energy sector in terms of both conserving energy and producing it, in order to increase affordability, reliability and sustainability. This will be achieved by developing new sources of energy including renewables, alternative energy sources, and natural gas, and promoting and improving energy efficiency and conservation practices in government, businesses, and homes, and increasing the efficiency of electricity generating plants and distribution systems [218]. Jamaica currently depends on imported oil for the majority of its energy needs, and particularly within the transport, bauxite and aluminium, and electricity generation sectors [219]. The Government's 2018 Integrated Resource Plan sets out a scenario where 31% of electricity generation in 2030 is from renewables (solar, hydro, wind power, and bioethanol), rising to 49% by 2037 [220]. Progress has already been made with the commissioning of the Caribbean's largest solar farm in western Jamaica [221, 222], windfarms in the parish of Manchester, and implementation of island-wide energy efficiency and water efficiency projects [223]. Generation of electricity from sugarcane bagasse is also thought to be feasible [224]. The UWI has built a Net-Zero energy building using 100% local expertise in design and construction. This multiple use facility is built to withstand meteorological hazards, has a water management system, and through a combination of solar power and smart systems generates more energy than it consumes and also saves water [225]. The building serves as a demonstration project and a prototype and can be replicated using skills,

techniques, and expertise that exist on the island [226]. In addition to large-scale infrastructure projects and a shift to renewables, there is also a recognised need for the Jamaican public to be more conscious of energy efficiency, and making energy savings in their choices of home design, household appliances, vehicles, and personal commodities [227], but as far as we are aware, there are not yet clear plans in place for how this might be achieved.
A recent study shows that it should be possible for Jamaica to transition towards 100% renewable power by 2055 [228]. This would probably need to be done following a two phased approach, because battery capability is not yet sufficient to allow an immediate transition without there being fluctuations in power availability. In the first phase (2020-2030) the study said it should be possible to integrate 30% renewable energy into the system. In the second phase (2030-2055), production by renewables could be developed further, under the expectation that long term power storage, such as battery technology, will have improved sufficiently to allow no need for new fossil fuel plants to be built between 2020 and 2055 [229]. However, it is uncertain to what extent unpredictable climate change impacts could affect the ability to deliver these renewable energy sources, e.g. hydroelectric capacity could potentially be limited by droughts.

Jamaica could reduce emissions from forestry and land use change by preserving and enhancing these stocks [230]. Across the energy and forestry sectors combined, the government hopes to be able to achieve between 25% and 28% emissions reductions by 2030 through emissions reductions in the energy sector and taking into account land use management [231]. Current plans to reduce emissions from the transport sector are focused on a transition to electric vehicles. The aim is that at least 10% of Jamaica's vehicles are electric by 2030 [232], and development of electric car charging stations is already underway across the island [233, 234]. There are also rural-urban transport plans being developed, including plans to increase bus routes and for revitalisation of the rail system [235], which could potentially be developed further to decrease reliance on cars. Cities could also be re-engineered to make them more walkable to allow people to make more active and sustainable transport choices. This has been proposed as an option that would improve public health in Jamaica [236], but it is unclear to what extent this is a current policy of the Ministry of Transport as it does not appear in its current strategic plan [237].

Further emissions reduction and broader environmental approaches that are already being implemented include bans on many types of single-use plastic bags, straws, and of polystyrene foam for use in the food and drinks industry from 2019/2020. There is also a Plastic Waste Minimisation project underway, and initiatives are in place to improve waste management and therefore reduce emissions from this sector [238].

Carbon sequestration benefits could be provided by nature-based adaptation strategies such as mangrove maintenance and restoration, and upland watershed protection and reforestation. The current annual carbon sequestration of Jamaica's 9715 ha of mangroves is estimated to be 13.7 million tonnes of CO_2 equivalent, which was estimated to be worth ~US$180 million in a 2019 World Bank report [239]. It is estimated that the Yallahs-Hope Project will give emissions reductions of over 550,000 t CO_2 equivalent within four years, as well as providing multiple co-benefits for water provision, biodiversity, and livelihoods [240].

3. Development compatible transition – risks, mitigation and opportunities

Just Transition – What are the priorities for enabling a just transition to a climate change-resilient Jamaica, and the socioeconomic and sustainable development risks of a net zero transition?

Including: 3.a. and 3b. Socioeconomic and sustainable development risks of a net zero transition, and ensuring a just transition; 3.a.i How different demographic and ethnographic groups would be impacted by a net zero transition; 3.a.ii Risks to broader sustainable development within the country/region that could arise; 3.b.i What are the priorities for enabling a just transition in this country?; 3.b.ii What are some examples of future opportunities that could enable a just transition in this country, including adaptation to transition risks?

Jamaica's primary climate focus is on developing adaptation strategies for the climate impacts it is facing now and additional impacts that it will face soon, and to also mitigate as far as possible. This must all be achieved hand in hand with continued efforts to bring sustainable development to its people. In its 'Vision 2030' document, Jamaica lays out four key goals: (1) Jamaicans are empowered to achieve their fullest potential; (2) The Jamaican society is secure, cohesive and just; (3) Jamaica's economy is prosperous; and (4) Jamaica has a healthy natural environment [241]. Jamaica has historically faced environmental, economic, and societal barriers that have made these goals difficult to achieve, and there is a substantial risk that climate change impacts might extend these barriers even further. However, if a just transition to a more climate-change-resilient Jamaica can be achieved, it will also help to provide the key sectors, infrastructure, and conditions necessary to underpin these goals.

A just transition will need to ensure that disadvantaged groups in Jamaica (see 'Vulnerability to climate impacts' section) are not further disadvantaged by transition policies. From work conducted in relation to climate change in the Jamaican agricultural context, there is recognition that the way in which climate change issues are framed and discussed affects the likelihood of them being able to deliver a range of benefits, including social justice [242]. Of three common frameworks for addressing climate change - adaptation, resilience, and vulnerability - the vulnerability perspective was the only one in which climate justice issues were intrinsic, with there being a risk that they were missed out when looking at the problem through a different lens [243]. Climate schemes, such as REDD+, in which people receive payments for positive action such as maintaining trees can present a substantial risk of people either being left behind or exploited if they are not well designed. In particular, it can be difficult to distribute benefits fairly and effectively, and over the long term when multiple groups are involved; local people may have decision making about their land taken away from them; institutions may not be strong; and there may be powerful lobbies at play that favour deforestation [244].

Thinking more broadly beyond Jamaica's borders, and the position in which the nation sits in the wider push towards a 'net zero transition', it is likely that the policy decisions made by other countries could bring substantial risks for Jamaica. Along with other members of the Alliance of Small Island States (AOSIS), Jamaica has lobbied strongly

that global warming must be limited to 1.5°C in comparison to pre-industrial levels, in order to avoid catastrophic levels of impact, and stay within the realm where it is possible for adaptations to be made [245]. In order to achieve this, it is critical that net zero policies are pursued globally in order to cut emissions. If there is insufficient action to achieve this, then Jamaica will be severely affected by climate impacts and may not be able to adapt. However, inappropriately chosen actions led by other countries could also have substantial impacts on vulnerable countries such as Jamaica. For example, if countries choose climate mitigation policies such as carbon taxes, limits on air travel, and taxes on air cargo, countries such as Jamaica that are heavily dependent on tourism and imports of goods will be severely affected, and their ability to adapt to the climate impacts already being faced, whilst continuing to reach SDGs, could be severely compromised.

3.e Likely co-benefits and trade-offs of the solutions and opportunities identified, including, where relevant, in the context of the Sustainable Development Goals?

To achieve its goals, the National Development Plan intends to improve healthcare provision, improve education environments, improve social protection for vulnerable people, develop sport and culture, improving the accountability of institutions, law enforcement, and government, and to develop a prosperous economy [246]. Key plans for developing the economy include stabilising the macroeconomy, promoting a business environment, creating strong economic infrastructure, and ensuring energy security and efficiency [247]. This will be done through a raft of government-led initiatives including developing a fair tax system, ensuring strong and stable institutions and prices, promoting investments, making labour markets more efficient, improving land transport, improving shipping in order to become a trade hub, expanding broadband connection, ensuring safe water supplies and sanitation, and promoting science and technology [248]. The initiatives focus on a range of strategies for improving the efficiency of key existing industries such as agriculture, manufacturing, mining and quarrying, tourism, and construction; developing and supporting newer industries including culture, sport, and communications [249]. The Plan also highlights a desire to manage natural environments and resources more effectively including a transition towards industries and technologies that do not harm the environment, improved regulation of environmental matters, eco-system based adaptation; as well as a desire to develop plans for sustainable urban and rural development [250].

Many of the key requirements for climate change adaptation and resilience - including environmental protection, infrastructure development, economic diversification, improved economic efficiency, and development of healthcare and education - also provide many of the environmental, economic, and social provisions that Jamaica wants to develop to improve quality of life for its population and to work towards meeting the Sustainable Development Goals. Areas of particular promise for delivering co-benefits include:

- Nature-based solutions (e.g. mangrove protection, improving forest protection and watershed management and reforesting the uplands) which can simultaneously improve the environment, deliver ecosystem services, and carbon sequestration, whilst also providing climate protection.

- Investments in agriculture (e.g. upscaling community-based strategies, research into crop improvements, development of new technologies, agroecological approaches) can bring improved livelihoods for the rural poor, greater self-sufficiency in food production, and improvements to the environment whilst also bringing climate change adaptation [251].
- Strengthening of governance and authorities (e.g. tax system, policing, environmental agencies) which can simultaneously bring economic and social improvements whilst also allowing more coordinated climate responses.
- Capacity building to allow economic diversification (e.g. widespread access to broadband, improved education and training, greater investment in research and development) that can simultaneously improve wealth and opportunities, but also economic resilience to climate change impacts.
- Resilient, low carbon infrastructure development (e.g. development and protection of roads and coastal structures including, airports and seaports, improving housing stock, increasing efficiency and sources of energy production, water harvesting and storage) to simultaneously develop the economy and living conditions for people, whilst also providing resilience to climate change damages.

Potential trade-offs include the risk of increasing Jamaica's carbon footprint because of economic development. However, Jamaica's emissions are extremely low, and if nature-based and service-based options are pursued, it is unlikely that this would increase substantially. A greater risk is that of unequal delivery of transition benefits across Jamaica's population, with some groups getting 'left behind' as other areas of the country develop - an issue that could cause serious risk to life in the face of increasing climate change impacts. There could also be risks of land-use conflicts with nature-based solutions or infrastructure developments. Although there has been conflict about expansion of mining activities in Jamaica within an ecologically and culturally important site [252], we are not aware of any disagreements that have arisen so far surrounding sustainable infrastructure. However, there were some initial negative perceptions of Marine Protected Areas (MPAs) by local fishing communities in Bluefields, Jamaica, because they felt marginalised in decision making [253]. To ensure that delivery of benefits is equitable, systems to improve the strength and transparency of institutions must be developed, while consultation and collaboration across sectors, and planning of all projects should include engagement with a wide range of stakeholder groups.

3.c Sectoral and socioeconomic impacts of a development compatible transition under each of the following transition pathways

- **Steady, orderly, persistent transition pathway**
- **Late, disorderly transition pathway**

It is projected that under current emissions global temperature will be 1.5°C above the historic baseline by the 2030s, with already severe impacts for ecosystems, economies, and health [254, 255]. Limiting warming to this level rather than continuing towards 2.0°C will be critical for substantial proportions of ecosystems globally to be maintained, and to avoid severe impacts for human health and economies [256, 257]. For the Caribbean in particular, it is thought that the 1.5°C level of warming is the limit for

viability, and thus, there is an emphatic “1.5 to Stay Alive” call to the world to not let global warming go beyond this level [258]. At this point, there will already be significant climatic change in the Caribbean, including longer warm and hot spells, and moderate to extreme drought for ~16% of the time [259]. Coral reefs will experience unprecedented climates after ~2030 and are highly vulnerable to small changes in temperature [260] . Going even further beyond this to a 2.0°C increase in global temperature would lead to much hotter and drier conditions across the whole region, with potentially devastating consequences for Caribbean people. This critical 1.5°C point may now be less than a decade away [261].

Following a ‘Late, disorderly transition pathway’ and leaving it very late to make climate change adaptations would lead to substantial risk that the environment, economy, and social stability that Jamaica needs if it is to maintain or improve its development status and the wellbeing of its citizens will not be attained. In comparison, following a ‘Steady, orderly, persistent transition pathway’ in which immediate steps are taken to protect and improve the environment, diversify and strengthen the economy, protect and develop infrastructure, prioritise health and wellbeing, and – critically – that integrates climate policies and plans across all sectors, would support the delivery of strong climate change resilience, socioeconomic development, and the wider Sustainable Development Goals.

4. Definitions of key terms

Mitigation The lessening of the potential adverse impacts of physical hazards through actions that reduce hazard, exposure, and vulnerability.

Adaptation The process of adjustment to actual or expected climate and its effects, in order to moderate harm or exploit beneficial opportunities.

Resilience The ability of a system and its component parts to anticipate, absorb, accommodate or re- cover from the effects of a hazardous event in a timely and efficient manner while retaining the same basic structure and ways of functioning, the capacity for self-organization and the capacity to adapt to stress and change.

Vulnerability The degree to which a system is susceptible to, or unable to cope with, adverse effects of climate change, including climate variability and extremes.

Risk The potential for consequences where something of value is at stake and where the outcome is uncertain, recognizing the diversity of values. Risk is often represented as probability or likelihood of occurrence of hazardous events or trends multiplied by the impacts if these events or trends occur.

5. Acknowledgements

This country profile was written by Dr Sarah Luke (Department of Zoology, University of Cambridge, UK), with input from in-country academic experts Professor Michael Taylor (The University of the West Indies, Jamaica), Dr David Smith (The University of the West Indies, Jamaica) and Mr Rajne Reynolds (The University of the West Indies, Jamaica) in the context of the BEIS COP26 Futures We Want project. The production of the document was supported by project teams at Cambridge Zero (University of Cambridge) and Deloitte. The authors thank Dr Richard Jones at the Met Office and Dr Hugh Sealy (The University of the West Indies), for their reviews which significantly improved the quality of this manuscript.

6. References

[1] The Planning Institute of Jamaica (PIOJ). Vision 2030 Jamaica: National Development Plan.; 2009. http://www.vision2030.gov.jm/National-Development-Plan

[2] The Planning Institute of Jamaica (PIOJ). *Vision 2030 Jamaica: National Development Plan*.; 2009. http://www.vision2030.gov.jm/National-Development-Plan

[3] Statistical Institute of Jamaica. Statin Digital Publications. Published 2021. https://statinja.gov.jm/PubReleases.aspx

[4] Statistical Institute of Jamaica. *Quarterly Gross Domestic Product, October-December 2020*.; 2020. https://statinja.gov.jm/NationalAccounting/Quarterly/NewQuarterlyGDP.aspx

[5] Statistical Institute of Jamaica. *Quarterly Gross Domestic Product, October-December 2020*.; 2020. https://statinja.gov.jm/NationalAccounting/Quarterly/NewQuarterlyGDP.aspx

[6] Statistical Institute of Jamaica. *Quarterly Gross Domestic Product, October-December 2020*.; 2020. https://statinja.gov.jm/NationalAccounting/Quarterly/NewQuarterlyGDP.aspx

[7] Statistical Institute of Jamaica. Tourism Direct Gross Domestic Product at Current Market Prices, $'Million. Published 2021. Accessed June 6, 2021. https://statinja.gov.jm/NationalAccounting/Annual/NewAnnualGDP.aspx

[8] Jamaica Observer. 'Tourism is the key to the Caribbean's economic recovery', published October 14, 2020. Accessed June 29, 2021. https://www.jamaicaobserver.com/business-observer/tourism-is-the-key-to-the-caribbean-s-economic-recovery_205299

[9] Mooney H, Zegarra MA. *Extreme Outlier: The Pandemic's Unprecedented Shock to Tourism in Latin America and the Caribbean*. Inter-American Development Bank; 2020. doi:10.18235/0002470

[10] Statistical Institute of Jamaica. Tourism Direct Gross Domestic Product at Current Market Prices, $'Million. Published 2021. Accessed June 6, 2021. https://statinja.gov.jm/NationalAccounting/Annual/NewAnnualGDP.aspx

[11] Statistical Institute of Jamaica. Labour Force by Industry. Published 2021. Accessed June 11, 2021. https://statinja.gov.jm/LabourForce/NewLFS.aspx

[12] Statistical Institute of Jamaica. Labour Force by Industry. Published 2021. Accessed June 11, 2021. https://statinja.gov.jm/LabourForce/NewLFS.aspx

[13] United Nations Conference on Trade and Development. *Climate Change Impacts on Coastal Transportation Infrastructure in the Caribbean: Enhancing the Adaptive Capacity of Small Island Developing States (SIDS) JAMAICA: A Case Study*.; 2017.

[14] The Planning Institute of Jamaica. *Economic and Social Survey Jamaica 2019: Overview*.; 2019. Accessed June 12, 2021. https://www.pioj.gov.jm/product/economic-and-social-survey-jamaica-2019-overview/

[15] The Planning Institute of Jamaica. *Economic and Social Survey Jamaica 2019: Overview*.; 2019. Accessed June 12, 2021. https://www.pioj.gov.jm/product/economic-and-social-survey-jamaica-2019-overview/

[16] The Planning Institute of Jamaica. *Economic and Social Survey Jamaica 2019: Overview*.; 2019. Accessed June 12, 2021. https://www.pioj.gov.jm/product/economic-and-social-survey-jamaica-2019-overview/

[17] World Travel and Tourism Economic Impact Report – Jamaica. Published March 2021. Accessed June 29, 2021. https://wttc.org/Research/Economic-Impact

[18] Review of Economic Performance, January–March 2021. The Planning Institute of Jamaica. Published 2021. Accessed June 11, 2021. http://prod1.pioj.gov.jm/product/review-of-economic-performance-january-march-2021/

[19] The Planning Institute of Jamaica (PIOJ). *Vision 2030 Jamaica: National Development Plan*.; 2009. http://www.vision2030.gov.jm/National-Development-Plan

[20] The Observatory of Economic Complexity. Jamaica trade statistics. Published 2021. https://oec.world/en/profile/country/jam#trade-products

[21] The Observatory of Economic Complexity. Jamaica trade statistics. Published 2021. https://oec.world/en/profile/country/jam#trade-products

[22] The Observatory of Economic Complexity. Jamaica trade statistics. Published 2021. https://oec.world/en/profile/country/jam#trade-products

[23] The Observatory of Economic Complexity. Jamaica trade statistics. Published 2021. https://oec.world/en/profile/country/jam#trade-products

[24] United Nations Development Programme (UNDP). Human Development Reports. Published 2020. Accessed June 12, 2021. http://hdr.undp.org/en/countries/profiles/JAM

[25] Sachs JD, Schmidt-Traub G, Kroll C, Lafortune G, Fuller G, Woelm F. *Sustainable Development Report 2020*. Cambridge University Press; 2020. Accessed June 11, 2021. https://apo.org.au/node/306675

[26] Sachs JD, Schmidt-Traub G, Kroll C, Lafortune G, Fuller G, Woelm F. *Sustainable Development Report 2020*. Cambridge University Press; 2020. Accessed June 11, 2021. https://apo.org.au/node/306675

[27] Sachs JD, Schmidt-Traub G, Kroll C, Lafortune G, Fuller G, Woelm F. *Sustainable Development Report 2020*. Cambridge University Press; 2020. Accessed June 11, 2021. https://apo.org.au/node/306675

[28] Sachs JD, Schmidt-Traub G, Kroll C, Lafortune G, Fuller G, Woelm F. *Sustainable Development Report 2020*. Cambridge University Press; 2020. Accessed June 11, 2021. https://apo.org.au/node/306675

[29] The Planning Institute of Jamaica (PIOJ). *Vision 2030 Jamaica: National Development Plan: The Popular Version*. The Planning Institute of Jamaica (PIOJ); 2010. http://www.vision2030.gov.jm/National-Development-Plan

[30] The Planning Institute of Jamaica. *Economic and Social Survey Jamaica 2019: Overview*.; 2019. Accessed June 12, 2021. https://www.pioj.gov.jm/product/economic-and-social-survey-jamaica-2019-overview/

[31] The Planning Institute of Jamaica. *Economic and Social Survey Jamaica 2019: Overview*.; 2019. Accessed June 12, 2021. https://www.pioj.gov.jm/product/economic-and-social-survey-jamaica-2019-overview/

[32] United Nations. *Global Sustainable Development Report 2019: The Future Is Now –Science for Achieving Sustainable Development*.; 2019. Accessed June 11, 2021. https://www.un.org/development/desa/publications/global-sustainable-development-report-2019.html

[33] United Nations. *Global Sustainable Development Report 2019: The Future Is Now – Science for Achieving Sustainable Development*.; 2019. Accessed June 11, 2021. https://www.un.org/development/desa/publications/global-sustainable-development-report-2019.html

[34] United Nations. *Global Sustainable Development Report 2019: The Future Is Now – Science for Achieving Sustainable Development*.; 2019. Accessed June 11, 2021. https://www.un.org/development/desa/publications/global-sustainable-development-report-2019.html

[35] The Planning Institute of Jamaica (PIOJ). Vision 2030 Jamaica: National Development Plan.; 2009. http://www.vision2030.gov.jm/National-Development-Plan

[36] The Planning Institute of Jamaica. Economic and Social Survey Jamaica 2019: Overview.; 2019. Accessed June 12, 2021. https://www.pioj.gov.jm/product/economic-and-social-survey-jamaica-2019-overview/

[37] The Planning Institute of Jamaica. Economic and Social Survey Jamaica 2019: Overview.; 2019. Accessed June 12, 2021. https://www.pioj.gov.jm/product/economic-and-social-survey-jamaica-2019-overview/

[38] Ministry of Health & Wellness, Jamaica. The Non-Communicable Disease and Injury Prevention Unit. Published 2021. https://www.moh.gov.jm/programmes-policies/chronic-non-communicable-diseases/

[39] The Planning Institute of Jamaica. Economic and Social Survey Jamaica 2019: Overview.; 2019. Accessed June 12, 2021. https://www.pioj.gov.jm/product/economic-and-social-survey-jamaica-2019-overview/

[40] Ministry of Health and Wellness, Ministry of Economic Growth & Job Creation - Climate Change Division, Ministry of Finance & Public Service, et al. Health and Climate Change: Country Profile 2021: Jamaica. Accessed June 17, 2021. https://www.who.int/publications-detail-redirect/health-climate-change-country-profile-jamaica

[41] Ministry of Health & Wellness, Jamaica. The Non-Communicable Disease and Injury Prevention Unit. Published 2021. https://www.moh.gov.jm/programmes-policies/chronic-non-communicable-diseases/

[42] The World Bank. World Development Indicators | DataBank. Published 2018. Accessed June 12, 2021. https://databank.worldbank.org/source/world-development-indicators

[43] The World Bank. World Development Indicators | DataBank. Published 2018. Accessed June 12, 2021. https://databank.worldbank.org/source/world-development-indicators

[44] The Government of Jamaica. A New Approach: National Security Policy for Jamaica - Towards a Secure and Prosperous Nation.; 2014. Accessed June 11, 2021. https://japarliament.gov.jm/index.php/publications/ministry-paper-new/2014-ministry-papers/1286-2014-ministry-paper-63-new-approach-national-security-policy-for-jamaica-2013

[45] Schwab K. The Global Competitiveness Report.; 2019. http://www3.weforum.org/docs/WEF_TheGlobalCompetitivenessReport2019.pdf

[46] Transparency International. The Corruption Perceptions Index (CPI). Transparency.org. Published 2019. Accessed June 12, 2021. https://www.transparency.org/en/cpi/2019

[47] WJP Rule of Law Index. Published 2020. Accessed June 21, 2021. https://worldjusticeproject.org//rule-of-law-index/

[48] United Nations Conference on Trade and Development. Climate Change Impacts on Coastal Transportation Infrastructure in the Caribbean: Enhancing the Adaptive Capacity of Small Island Developing States (SIDS) JAMAICA: A Case Study.; 2017.

[49] World Bank. World Bank - Logistics Performance Index. Published 2018. Accessed June 10, 2021. https://lpi.worldbank.org/

[50] The Planning Institute of Jamaica (PIOJ). *Vision 2030 Jamaica: National Development Plan*.; 2009. http://www.vision2030.gov.jm/National-Development-Plan

[51] Government of Jamaica. *Climate Change Policy Framework for Jamaica*.; 2015. https://www.preventionweb.net/english/policies/v.php?id=59577

[52] The Planning Institute of Jamaica (PIOJ). *Vision 2030 Jamaica: National Development Plan*.; 2009. http://www.vision2030.gov.jm/National-Development-Plan

[53] The Planning Institute of Jamaica (PIOJ). *Vision 2030 Jamaica: National Development Plan*.; 2009. http://www.vision2030.gov.jm/National-Development-Plan

[54] Our World Data. Consumption-based CO_2 emissions vs. population share. Our World in Data. Published 2015. Accessed June 12, 2021. https://ourworldindata.org/grapher/consumption-co2-emissions-vs-population

[55] Our World in Data. Published 2021. Accessed June 6, 2021. https://ourworldindata.org/grapher/greenhouse-gas-emissions-by-sector?country=~JAM

[56] United Nations Development Programme. Carbon dioxide emissions, production emissions per capita (tonnes). Human Development Reports. Published 2020. Accessed June 11, 2021. http://hdr.undp.org/en/indicators/195606

[57] Mahlung C, Dore C, Lindo G, et al. *Biennial Update Report of Jamaica, Covering GHG Emissions for 2006- 2012*. United Nations Climate Change; 2014. https://unfccc.int/files/national_reports/non-annex_i_parties/biennial_update_reports/application/pdf/jambur1.pdf

[58] Mahlung C, Dore C, Lindo G, et al. *Biennial Update Report of Jamaica, Covering GHG Emissions for 2006- 2012*. United Nations Climate Change; 2014. https://unfccc.int/files/national_reports/non-annex_i_parties/biennial_update_reports/application/pdf/jambur1.pdf

[59] United Nations Development Programme. Carbon dioxide emissions, production emissions per capita (tonnes). Human Development Reports. Published 2020. Accessed June 11, 2021. http://hdr.undp.org/en/indicators/195606

[60] United Nations Development Programme. Carbon dioxide emissions, production emissions per capita (tonnes). Human Development Reports. Published 2020. Accessed June 11, 2021. http://hdr.undp.org/en/indicators/195606

[61] Global Carbon Project. CO2 Emissions | Global Carbon Atlas. Published 2020. Accessed June 17, 2021. http://www.globalcarbonatlas.org/en/CO2-emissions

[62] Sachs JD, Schmidt-Traub G, Kroll C, Lafortune G, Fuller G, Woelm F. *Sustainable Development Report 2020*. Cambridge University Press; 2020. Accessed June 11, 2021. https://apo.org.au/node/306675

[63] United Nations Development Programme. Carbon dioxide emissions, production emissions per capita (tonnes). Human Development Reports. Published 2020. Accessed June 11, 2021. http://hdr.undp.org/en/indicators/195606

[64] Global Carbon Project. CO2 Emissions | Global Carbon Atlas. Published 2020. Accessed June 17, 2021. http://www.globalcarbonatlas.org/en/CO2-emissions

[65] Our World in Data. Published 2021. Accessed June 6, 2021. https://ourworldindata.org/grapher/greenhouse-gas-emissions-by-sector?country=~JAM

[66] Mahlung C, Dore C, Lindo G, et al. *Biennial Update Report of Jamaica, Covering GHG Emissions for 2006- 2012*. United Nations Climate Change; 2014. https://unfccc.int/files/national_reports/non-annex_i_parties/biennial_update_reports/application/pdf/jambur1.pdf

[67] Mahlung C, Dore C, Lindo G, et al. *Biennial Update Report of Jamaica, Covering GHG Emissions for 2006- 2012*. United Nations Climate Change; 2014. https://unfccc.int/files/national_reports/non-annex_i_parties/biennial_update_reports/application/pdf/jambur1.pdf

[68] Our World in Data. Published 2021. Accessed June 6, 2021. https://ourworldindata.org/grapher/greenhouse-gas-emissions-by-sector?country=~JAM

[69] Climate Studies Group, Mona (CSGM). *State of the Jamaican Climate 2015: Information for Resilience Building (Full Report). Produced for the Planning Institute of Jamaica (PIOJ), Kingston Jamaica.*; 2017. Accessed June 11, 2021. https://www.pioj.gov.jm/product/the-state-of-the-jamaican-climate-2015/

[70] Climate Studies Group, Mona (CSGM). *State of the Jamaican Climate 2015: Information for Resilience Building (Full Report). Produced for the Planning Institute of Jamaica (PIOJ), Kingston Jamaica.*; 2017. Accessed June 11, 2021. https://www.pioj.gov.jm/product/the-state-of-the-jamaican-climate-2015/

[71] USAID Climate Change Integration Support (CCIS). *Climate Risk Profile: Jamaica*.; 2017. Accessed June 11, 2021. https://www.climatelinks.org/resources/climate-risk-profile-jamaica

[72] Climate Studies Group, Mona (CSGM). *State of the Jamaican Climate 2015: Information for Resilience Building (Full Report). Produced for the Planning Institute of Jamaica (PIOJ), Kingston Jamaica.*; 2017. Accessed June 11, 2021. https://www.pioj.gov.jm/product/the-state-of-the-jamaican-climate-2015/

[73] Climate Studies Group, Mona (CSGM). State of the Jamaican Climate 2015: Information for Resilience Building (Full Report). Produced for the Planning Institute of Jamaica (PIOJ), Kingston Jamaica.; 2017. Accessed June 11, 2021. https://www.pioj.gov.jm/product/the-state-of-the-jamaican-climate-2015/

[74] Climate Studies Group, Mona (CSGM). State of the Jamaican Climate 2015: Information for Resilience Building (Full Report). Produced for the Planning Institute of Jamaica (PIOJ), Kingston Jamaica.; 2017. Accessed June 11, 2021. https://www.pioj.gov.jm/product/the-state-of-the-jamaican-climate-2015/

[75] Climate Studies Group, Mona (CSGM). State of the Jamaican Climate 2015: Information for Resilience Building (Full Report). Produced for the Planning Institute of Jamaica (PIOJ), Kingston Jamaica.; 2017. Accessed June 11, 2021. https://www.pioj.gov.jm/product/the-state-of-the-jamaican-climate-2015/

[76] International Panel on Climate Change. AR6 WGI Atlas 2021. Accessed October 27, 2021. https://www.ipcc.ch/report/ar6/wg1/downloads/report/IPCC_AR6_WGI_Atlas.pdf

[77] Climate Studies Group, Mona (CSGM). State of the Jamaican Climate 2015: Information for Resilience Building (Full Report). Produced for the Planning Institute of Jamaica (PIOJ), Kingston Jamaica.; 2017. Accessed June 11, 2021. https://www.pioj.gov.jm/product/the-state-of-the-jamaican-climate-2015/

[78] United Nations Conference on Trade and Development. *Climate Change Impacts on Coastal Transportation Infrastructure in the Caribbean: Enhancing the Adaptive Capacity of Small Island Developing States (SIDS) JAMAICA: A Case Study*.; 2017.

[79] Kossin JP, Knapp KR, Olander TL, Velden CS. Global increase in major tropical cyclone exceedance probability over the past four decades. *Proc Natl Acad Sci*. 2020;117(22):11975-11980.

[80] Climate Studies Group, Mona (CSGM). State of the Jamaican Climate 2015: Information for Resilience Building (Full Report). Produced for the Planning Institute of Jamaica (PIOJ), Kingston Jamaica.; 2017. Accessed June 11, 2021. https://www.pioj.gov.jm/product/the-state-of-the-jamaican-climate-2015/

[81] United Nations Conference on Trade and Development. Climate Change Impacts on Coastal Transportation Infrastructure in the Caribbean: Enhancing the Adaptive Capacity of Small Island Developing States (SIDS) JAMAICA: A Case Study.; 2017.

[82] Government of Jamaica. Climate Change Policy Framework for Jamaica.; 2015. https://www.preventionweb.net/english/policies/v.php?id=59577

[83] Knutson T, Camargo SJ, Chan JCL, et al. Tropical Cyclones and Climate Change Assessment: Part II: Projected Response to Anthropogenic Warming. Bull Am Meteorol Soc. 2020;101(3):E303-E322. doi:10.1175/BAMS-D-18-0194.1

[84] Stennett-Brown RK, Stephenson TS, Taylor MA. Caribbean climate change vulnerability: Lessons from an aggregate index approach. Shaman J, ed. PLOS ONE. 2019;14(7):e0219250. doi:10.1371/journal.pone.0219250

[85] Kaly UL, Pratt CR, Mitchell J. The Environmental Vulnerability Index (EVI) 2004. Vol 384.; 2004:1-323. https://www.sopac.org/sopac/evi/Files/EVI2004TechnicaReport.pdf

[86] Briguglio L. A Vulnerability and Resilience Framework for Small States. In: Building the Resilience for Small States. ; 2014.

[87] Briguglio L. A Vulnerability and Resilience Framework for Small States. In: Building the Resilience for Small States. ; 2014.

[88] United Nations Conference on Trade and Development. Climate Change Impacts on Coastal Transportation Infrastructure in the Caribbean: Enhancing the Adaptive Capacity of Small Island Developing States (SIDS) JAMAICA: A Case Study.; 2017.

[89] United Nations Conference on Trade and Development. Climate Change Impacts on Coastal Transportation Infrastructure in the Caribbean: Enhancing the Adaptive Capacity of Small Island Developing States (SIDS) JAMAICA: A Case Study.; 2017.

[90] USAID Climate Change Integration Support (CCIS). Climate Risk Profile: Jamaica.; 2017. Accessed June 11, 2021. https://www.climatelinks.org/resources/climate-risk-profile-jamaica

[91] Selvaraju R, Food and Agriculture Organization of the United Nations, eds. Climate Change and Agriculture in Jamaica: Agricultural Sector Support Analysis. Food and Agriculture Organization of the United Nations; 2013.

[92] Sachs JD, Schmidt-Traub G, Kroll C, Lafortune G, Fuller G, Woelm F. SustainableDevelopment Report 2020. Cambridge University Press; 2020. Accessed June 11, 2021. https://apo.org.au/node/306675

[93] USAID Climate Change Integration Support (CCIS). Climate Risk Profile: Jamaica.; 2017. Accessed June 11, 2021. https://www.climatelinks.org/resources/climate-risk-profile-jamaica

[94] USAID Climate Change Integration Support (CCIS). Climate Risk Profile: Jamaica.; 2017. Accessed June 11, 2021. https://www.climatelinks.org/resources/climate-risk-profile-jamaica

[95] IPCC. Special Report - Global Warming of 1.5 oC. Published 2018. Accessed June 15, 2021. https://www.ipcc.ch/sr15/

[96] Lenton TM, Rockström J, Gaffney O, et al. Climate tipping points — too risky to bet against. Nature. 2019;575(7784):592-595. doi:10.1038/d41586-019-03595-0

[97] Water Resources Authority (WRA). Water Resources Authority Annual Report 2017/18.; 2018. Accessed June 11, 2021. https://www.wra.gov.jm/about/annual-reports/

[98] USAID Climate Change Integration Support (CCIS). Climate Risk Profile: Jamaica.; 2017. Accessed June 11, 2021. https://www.climatelinks.org/resources/climate-risk-profile-jamaica

[99] Grey OP, Webber DFG, Setegn S, Malesse AM. Estimation of Climate Change Impacts on Water Resources in the Great River Watershed, Jamaica. In: Landscape Dynamics, Soils and Hydrological Processes in Varied Climates. Springer Geography. Springer; 2016.

[100] Watts N, Amann M, Arnell N, et al. The 2020 report of The Lancet Countdown on health and climate change: responding to converging crises. The Lancet. 2021;397(10269):129-170. doi:10.1016/S0140-6736(20)32290-X

[101] Tord Kjellstrom NM. Working on a Warmer Planet: The Effect of Heat Stress on Productivity and Decent Work.; 2019. Accessed June 11, 2021. http://www.ilo.org/global/publications/books/WCMS_711919/lang--en/index.htm

[102] Mora C, Dousset B, Caldwell IR, et al. Global risk of deadly heat. Nat Clim Change. 2017;7(7):501-506. doi:10.1038/nclimate3322

[103] USAID Climate Change Integration Support (CCIS). Climate Risk Profile: Jamaica.; 2017. Accessed June 11, 2021. https://www.climatelinks.org/resources/climate-risk-profile-jamaica

[104] USAID Climate Change Integration Support (CCIS). Climate Risk Profile: Jamaica.; 2017. Accessed June 11, 2021. https://www.climatelinks.org/resources/climate-risk-profile-jamaica

[105] Mora C, Dousset B, Caldwell IR, et al. Global risk of deadly heat. Nat Clim Change. 2017;7(7):501-506. doi:10.1038/nclimate3322

[106] USAID Climate Change Integration Support (CCIS). Climate Risk Profile: Jamaica.; 2017. Accessed June 11, 2021. https://www.climatelinks.org/resources/climate-risk-profile-jamaica

[107] USAID Climate Change Integration Support (CCIS). Climate Risk Profile: Jamaica.; 2017. Accessed June 11, 2021. https://www.climatelinks.org/resources/climate-risk-profile-jamaica

[108] Kelman I, Ayeb-Karlsson S, Rose-Clarke K, et al. A review of mental health and wellbeing under climate change in small island developing states (SIDS). Environ Res Lett. 2021;16(3):033007. doi:10.1088/1748-9326/abe57d

[109] Park RJ, Behrer AP, Goodman J. Learning is inhibited by heat exposure, both internationally and within the United States. Nat Hum Behav. 2021;5(1):19-27. doi:10.1038/s41562-020-00959-9

[110] Climate Studies Group, Mona (CSGM). State of the Jamaican Climate 2015: Information for Resilience Building (Full Report). Produced for the Planning Institute of Jamaica (PIOJ), Kingston Jamaica.; 2017. Accessed June 11, 2021. https://www.pioj.gov.jm/product/the-state-of-the-jamaican-climate-2015/

[111] Rhiney K, Eitzinger A, Farrell AD, Prager SD. Assessing the implications of a 1.5 °C temperature limit for the Jamaican agriculture sector. Reg Environ Change. 2018;18(8):2313-2327. doi:10.1007/s10113-018-1409-4

[112] Government of Jamaica. Climate Change Policy Framework for Jamaica.; 2015. https://www.preventionweb.net/english/policies/v.php?id=59577

[113] Airport Fact Sheet – Norman Manley International Airport. Published 2021. Accessed June 11, 2021. https://nmia.aero/about/airport-fact-sheet/

[114] United Nations Conference on Trade and Development. Climate Change Impacts on Coastal Transportation Infrastructure in the Caribbean: Enhancing the Adaptive Capacity of Small Island Developing States (SIDS) JAMAICA: A Case Study.; 2017.

[115] Monioudi IN, Asariotis R, Becker A, et al. Climate change impacts on critical international transportation assets of Caribbean Small Island Developing States (SIDS): the case of Jamaica and Saint Lucia. Reg Environ Change. 2018;18(8):2211-2225. doi:10.1007/s10113-018-1360-4

[116] Jamaica Survey of Living Conditions (JSLC) 2018: Overview. The Planning Institute of Jamaica (PIOJ), Kingston, Jamaica. 2018. https://www.pioj.gov.jm/product/jamaica-survey-of-living-conditions-jslc-2018-overview/

[117] Jamaica Survey of Living Conditions (JSLC) 2018: Overview. The Planning Institute of Jamaica (PIOJ), Kingston, Jamaica. 2018. https://www.pioj.gov.jm/product/jamaica-survey-of-living-conditions-jslc-2018-overview/

[118] Government of Jamaica. Climate Change Policy Framework for Jamaica.; 2015. https://www.preventionweb.net/english/policies/v.php?id=59577

[119] Poverty and hurricane risk exposure in Jamaica | SpringerLink. doi:10.1057/s10713-021-00063-6

[120] United Nations Development Programme. Enhancing Gender Visibility in Disaster Risk Management and Climate Change in the Caribbean.; 2009. Accessed June 17, 2021. https://www.latinamerica.undp.org/content/rblac/en/home/library/crisis_preventio

n_and_recovery/aumentando-la-visibilidad-de-genero-en-la-gestion-del-riesgo-de-.html

[121] Dunn LL. Gender, Climate Change and Disaster Risk Management.; 2013.

[122] Climate Studies Group, Mona (CSGM). State of the Jamaican Climate 2015: Information for Resilience Building (Full Report). Produced for the Planning Institute of Jamaica (PIOJ), Kingston Jamaica.; 2017. Accessed June 11, 2021. https://www.pioj.gov.jm/product/the-state-of-the-jamaican-climate-2015/

[123] Value for Women. Study of the Impacts of Climate Change on the Women and Men of the Caribbean. Pilot Programme for Climate Resilience Countries.; 2020. https://www.climateinvestmentfunds.org/sites/cif_enc/files/knowledge-documents/study-of-the-impacts-of-climate-change-on-the-women-and-men-in-the-caribbean-pilot-programme-for-climate-resilience-countries.pdf

[124] Ministry of Economic Growth & Job Creation CCD, United Nations Framework Convention on Climate Change (Organization), United Nations Development Programme (UNDP), Global Environment Faculty. Third National Communication of Jamaica to the United Nations Framework Convention on Climate Change Prepared for the Ministry of Economic Growth & Job Creation Climate Change Division .; 2018.

[125] Lee Sharpe C. Building Resilience in Jamaica - Community Experiences at the Intersection of the Food System, Climate Change and Natural Disasters in a Small Island Developing State. Published online 2017. Accessed June 17, 2021. https://www.proquest.com/docview/2002597763/abstract/C820F51CC7DB4D44PQ/1

[126] Bleeker A, Escribano P, Gonzales C, Liberati C, Mawby B. Advancing Gender Equality in Environmental Migration and Disaster Displacement in the Caribbean. CEPAL; 2021. Accessed June 17, 2021. https://www.cepal.org/en/publications/46737-advancing-gender-equality-environmental-migration-and-disaster-displacement

[127] Selvaraju R, Food and Agriculture Organization of the United Nations, eds. Climate Change and Agriculture in Jamaica: Agricultural Sector Support Analysis. Food and Agriculture Organization of the United Nations; 2013.

[128] Shaffril HAM, Abu Samah A, D'Silva JL. Climate change: Social adaptation strategies for fishermen. Mar Policy. 2017;81:256-261. doi:10.1016/j.marpol.2017.03.031

[129] Guido Z, Knudson C, Finan T, Madajewicz M, Rhiney K. Shocks and cherries: The production of vulnerability among smallholder coffee farmers in Jamaica. World Dev. 2020;132:104979. doi:10.1016/j.worlddev.2020.104979

[130] Baptiste AK, Kinlocke R. We are not all the same!: Comparative climate change vulnerabilities among fishers in Old Harbour Bay, Jamaica. Geoforum. 2016;73:47-59. doi:10.1016/j.geoforum.2015.05.006

[131] Campbell D. Environmental change and the livelihood resilience of coffee farmers in Jamaica: A case study of the Cedar Valley farming region. J Rural Stud. 2021;81:220-234. doi:10.1016/j.jrurstud.2020.10.027

[132] Baptiste AK, Kinlocke R. We are not all the same!: Comparative climate change vulnerabilities among fishers in Old Harbour Bay, Jamaica. Geoforum. 2016;73:47-59. doi:10.1016/j.geoforum.2015.05.006

[133] Maroon Settlements In Jamaica. diG Jamaica. Published 2015. Accessed June 9, 2021. http://digjamaica.com/m/blog/maroon-settlements-in-jamaica/

[134] Ministry of Health and Wellness, Ministry of Economic Growth & Job Creation - Climate Change Division, Ministry of Finance & Public Service, et al. Health and Climate Change: Country Profile 2021: Jamaica. Accessed June 17, 2021. https://www.who.int/publications-detail-redirect/health-climate-change-country-profile-jamaica

[135] Government of Jamaica. Climate Change Policy Framework for Jamaica.; 2015. https://www.preventionweb.net/english/policies/v.php?id=59577

[136] Tord Kjellstrom NM. Working on a Warmer Planet: The Effect of Heat Stress on Productivity and Decent Work.; 2019. Accessed June 11, 2021. http://www.ilo.org/global/publications/books/WCMS_711919/lang--en/index.htm

[137] Selvaraju R, Food and Agriculture Organization of the United Nations, eds. Climate Change and Agriculture in Jamaica: Agricultural Sector Support Analysis. Food and Agriculture Organization of the United Nations; 2013.

[138] Government of Jamaica. Climate Change Policy Framework for Jamaica.; 2015. https://www.preventionweb.net/english/policies/v.php?id=59577

[139] United Nations Environment Programme. *Risk and Vulnerability Assessment Methodology Development Project (RiVAMP) - Linking Ecosystems to Risk and Vulnerability Reduction - The Case of Jamaica - Results of the Pilot Assessment*.; 2010. https://postconflict.unep.ch/publications/RiVAMP.pdf

[140] Climate Studies Group, Mona (CSGM). State of the Jamaican Climate 2015: Information for Resilience Building (Full Report). Produced for the Planning Institute of Jamaica (PIOJ), Kingston Jamaica.; 2017. Accessed June 11, 2021. https://www.pioj.gov.jm/product/the-state-of-the-jamaican-climate-2015/

[141] Granvorka C, Strobl E. The Impact of Hurricane Strikes on Tourist Arrivals in the Caribbean. Tour Econ. 2013;19(6):1401-1409. doi:10.5367/te.2013.0238

[142] Government of Jamaica. Climate Change Policy Framework for Jamaica.; 2015. https://www.preventionweb.net/english/policies/v.php?id=59577

[143] Lallo CHO, Cohen J, Rankine D, Taylor M, Cambell J, Stephenson T. Characterizing heat stress on livestock using the temperature humidity index (THI)—prospects for a warmer Caribbean. Reg Environ Change. 2018;18(8):2329-2340. doi:10.1007/s10113-018-1359-x

[144] Climate Studies Group, Mona (CSGM). State of the Jamaican Climate 2015: Information for Resilience Building (Full Report). Produced for the Planning Institute of Jamaica (PIOJ), Kingston Jamaica.; 2017. Accessed June 11, 2021. https://www.pioj.gov.jm/product/the-state-of-the-jamaican-climate-2015/

[145] Selvaraju R, Food and Agriculture Organization of the United Nations, eds. Climate Change and Agriculture in Jamaica: Agricultural Sector Support Analysis. Food and Agriculture Organization of the United Nations; 2013.

[146] Climate Studies Group, Mona (CSGM). State of the Jamaican Climate 2015: Information for Resilience Building (Full Report). Produced for the Planning Institute of Jamaica (PIOJ), Kingston Jamaica.; 2017. Accessed June 11, 2021. https://www.pioj.gov.jm/product/the-state-of-the-jamaican-climate-2015/

[147] Climate Studies Group, Mona (CSGM). State of the Jamaican Climate 2015: Information for Resilience Building (Full Report). Produced for the Planning Institute of Jamaica (PIOJ), Kingston Jamaica.; 2017. Accessed June 11, 2021. https://www.pioj.gov.jm/product/the-state-of-the-jamaican-climate-2015/

[148] Ministry of Health and Wellness, Ministry of Economic Growth & Job Creation - Climate Change Division, Ministry of Finance & Public Service, et al. Health and Climate Change: Country Profile 2021: Jamaica. Accessed June 17, 2021. https://www.who.int/publications-detail-redirect/health-climate-change-country-profile-jamaica

[149] Climate Studies Group, Mona (CSGM). State of the Jamaican Climate 2015: Information for Resilience Building (Full Report). Produced for the Planning Institute of Jamaica (PIOJ), Kingston Jamaica.; 2017. Accessed June 11, 2021. https://www.pioj.gov.jm/product/the-state-of-the-jamaican-climate-2015/

[150] Ministry of Health and Wellness, Ministry of Economic Growth & Job Creation - Climate Change Division, Ministry of Finance & Public Service, et al. Health and Climate Change: Country Profile 2021: Jamaica. Accessed June 17, 2021. https://www.who.int/publications-detail-redirect/health-climate-change-country-profile-jamaica

[151] The Planning Institute of Jamaica (PIOJ). PIOJ reports. Published 2021. Accessed June 15, 2021. https://www.pioj.gov.jm/product-category/reports/?_sft_report_category=sustainable-development

[152] Ministry of Finance & Public Service. Estimates of Expenditure 2021-2022.; 2021. Accessed June 15, 2021. https://mof.gov.jm/documents/documents-publications/document-centre/file/2529-estimates-of-expenditure-2021-2022.html

[153] World Resources Institute. Coastal Capital: Jamaica, The Economic Contribution of Jamaica's Coral Reefs, 2011. Accessed October 27, 2021. http://wriorg.s3.amazonaws.com/s3fs-public/coastal_capital_jamaica_summary_0.pdf

[154] Climate Studies Group, Mona (CSGM). State of the Jamaican Climate 2015: Information for Resilience Building (Full Report). Produced for the Planning Institute of Jamaica (PIOJ), Kingston Jamaica.; 2017. Accessed June 11, 2021. https://www.pioj.gov.jm/product/the-state-of-the-jamaican-climate-2015/

[155] Government of Jamaica. Climate Change Policy Framework for Jamaica.; 2015. https://www.preventionweb.net/english/policies/v.php?id=59577

[156] Kushner B, Edwards P, Burke L, Cooper E. Coral Reefs, Beach Erosion and Impacts to Tourism in Jamaica. Published online 2011:56.

[157] United Nations Environment Programme. Risk and Vulnerability Assessment Methodology Development Project (RiVAMP) - Linking Ecosystems to Risk and Vulnerability Reduction - The Case of Jamaica - Results of the Pilot Assessment.; 2010. https://postconflict.unep.ch/publications/RiVAMP.pdf

[158] Smith Warner International Ltd. Storm Surge Mapping for Montego Bay, Jamaica. Report Prepared by Smith Warner International Ltd., Kingston Jamaica, for the Organization of American States General Secretariat Unit for Sustainable Development and Environment USAID-OAS Caribbean Disaster Mitigation Project.; 1999. Accessed June 11, 2021. https://www.oas.org/cdmp/document/kma/mobay/mobay.htm

[159] Government of Jamaica. Climate Change Policy Framework for Jamaica.; 2015. https://www.preventionweb.net/english/policies/v.php?id=59577

[160] USAID Climate Change Integration Support (CCIS). Climate Risk Profile: Jamaica.; 2017. Accessed June 11, 2021. https://www.climatelinks.org/resources/climate-risk-profile-jamaica

[161] Rhiney K, Eitzinger A, Farrell AD, Prager SD. Assessing the implications of a 1.5 °C temperature limit for the Jamaican agriculture sector. Reg Environ Change. 2018;18(8):2313-2327. doi:10.1007/s10113-018-1409-4

[162] Selvaraju R, Food and Agriculture Organization of the United Nations, eds. Climate Change and Agriculture in Jamaica: Agricultural Sector Support Analysis. Food and Agriculture Organization of the United Nations; 2013.

[163] Ministry of Health and Wellness, Ministry of Economic Growth & Job Creation - Climate Change Division, Ministry of Finance & Public Service, et al. Health and Climate Change: Country Profile 2021: Jamaica. Accessed June 17, 2021. https://www.who.int/publications-detail-redirect/health-climate-change-country-profile-jamaica

[164] Climate Studies Group, Mona (CSGM). State of the Jamaican Climate 2015: Information for Resilience Building (Full Report). Produced for the Planning Institute of Jamaica (PIOJ), Kingston Jamaica.; 2017. Accessed June 11, 2021. https://www.pioj.gov.jm/product/the-state-of-the-jamaican-climate-2015/

[165] Climate Studies Group, Mona (CSGM). State of the Jamaican Climate 2015: Information for Resilience Building (Full Report). Produced for the Planning Institute of Jamaica (PIOJ), Kingston Jamaica.; 2017. Accessed June 11, 2021. https://www.pioj.gov.jm/product/the-state-of-the-jamaican-climate-2015/

[166] Climate Studies Group, Mona (CSGM). State of the Jamaican Climate 2015: Information for Resilience Building (Full Report). Produced for the Planning Institute of Jamaica (PIOJ), Kingston Jamaica.; 2017. Accessed June 11, 2021. https://www.pioj.gov.jm/product/the-state-of-the-jamaican-climate-2015/

[167] Ministry of Health and Wellness, Ministry of Economic Growth & Job Creation - Climate Change Division, Ministry of Finance & Public Service, et al. Health and Climate Change: Country Profile 2021: Jamaica. Accessed June 17, 2021. https://www.who.int/publications-detail-redirect/health-climate-change-country-profile-jamaica

[168] Government of Jamaica. Climate Change Policy Framework for Jamaica.; 2015. https://www.preventionweb.net/english/policies/v.php?id=59577

[169] Kelman I, Ayeb-Karlsson S, Rose-Clarke K, et al. A review of mental health and wellbeing under climate change in small island developing states (SIDS). Environ Res Lett. 2021;16(3):033007. doi:10.1088/1748-9326/abe57d

[170] Climate Studies Group, Mona (CSGM). State of the Jamaican Climate 2015: Information for Resilience Building (Full Report). Produced for the Planning Institute of Jamaica (PIOJ), Kingston Jamaica.; 2017. Accessed June 11, 2021. https://www.pioj.gov.jm/product/the-state-of-the-jamaican-climate-2015/

[171] Climate Studies Group, Mona (CSGM). State of the Jamaican Climate 2015: Information for Resilience Building (Full Report). Produced for the Planning Institute of Jamaica (PIOJ), Kingston Jamaica.; 2017. Accessed June 11, 2021. https://www.pioj.gov.jm/product/the-state-of-the-jamaican-climate-2015/

[172] Climate Studies Group, Mona (CSGM). State of the Jamaican Climate 2015: Information for Resilience Building (Full Report). Produced for the Planning Institute of Jamaica (PIOJ), Kingston Jamaica.; 2017. Accessed June 11, 2021. https://www.pioj.gov.jm/product/the-state-of-the-jamaican-climate-2015/

[173] Climate Studies Group, Mona (CSGM). State of the Jamaican Climate 2015: Information for Resilience Building (Full Report). Produced for the Planning Institute of Jamaica (PIOJ), Kingston Jamaica.; 2017. Accessed June 11, 2021. https://www.pioj.gov.jm/product/the-state-of-the-jamaican-climate-2015/

[174] Climate Studies Group, Mona (CSGM). State of the Jamaican Climate 2015: Information for Resilience Building (Full Report). Produced for the Planning Institute of Jamaica (PIOJ), Kingston Jamaica.; 2017. Accessed June 11, 2021. https://www.pioj.gov.jm/product/the-state-of-the-jamaican-climate-2015/

[175] United Nations Conference on Trade and Development. Climate Change Impacts on Coastal Transportation Infrastructure in the Caribbean: Enhancing the Adaptive Capacity of Small Island Developing States (SIDS) JAMAICA: A Case Study.; 2017.

[176] Climate Studies Group, Mona (CSGM). State of the Jamaican Climate 2015: Information for Resilience Building (Full Report). Produced for the Planning Institute of Jamaica (PIOJ), Kingston Jamaica.; 2017. Accessed June 11, 2021. https://www.pioj.gov.jm/product/the-state-of-the-jamaican-climate-2015/

[177] Climate Studies Group, Mona (CSGM). State of the Jamaican Climate 2015: Information for Resilience Building (Full Report). Produced for the Planning Institute of Jamaica (PIOJ), Kingston Jamaica.; 2017. Accessed June 11, 2021. https://www.pioj.gov.jm/product/the-state-of-the-jamaican-climate-2015/

[178] McDougall C. Erosion and the beaches of Negril. Ocean Coast Manag. 2017;148:204-213. doi:10.1016/j.ocecoaman.2017.08.008

[179] McDougall C. Erosion and the beaches of Negril. Ocean Coast Manag. 2017;148:204-213. doi:10.1016/j.ocecoaman.2017.08.008

[180] Climate Studies Group, Mona (CSGM). State of the Jamaican Climate 2015: Information for Resilience Building (Full Report). Produced for the Planning Institute of Jamaica (PIOJ), Kingston Jamaica.; 2017. Accessed June 11, 2021. https://www.pioj.gov.jm/product/the-state-of-the-jamaican-climate-2015/

[181] Government of Jamaica. Climate Change Policy Framework for Jamaica.; 2015. https://www.preventionweb.net/english/policies/v.php?id=59577

[182] Office of Disaster Preparedness and Emergency Management. Comprehensive Disaster Management (CDM) Strategy. Published 2014. Accessed June 12,

2021. https://www.odpem.org.jm/comprehensive-disaster-management-cdm-strategy/

[183] United Nations Economic Commission for Latin America and the Caribbean. Study on the Vulnerability and Resilience of Caribbean Small Island Developing States (SIDS). CEPAL; 2011. Accessed June 11, 2021. https://www.cepal.org/en/publications/38568-study-vulnerability-and-resilience-caribbean-small-island-developing-states-sids

[184] United Nations Economic Commission for Latin America and the Caribbean. Study on the Vulnerability and Resilience of Caribbean Small Island Developing States (SIDS). CEPAL; 2011. Accessed June 11, 2021. https://www.cepal.org/en/publications/38568-study-vulnerability-and-resilience-caribbean-small-island-developing-states-sids

[185] United Nations Environment Programme. Risk and Vulnerability Assessment Methodology Development Project (RiVAMP) - Linking Ecosystems to Risk and Vulnerability Reduction - The Case of Jamaica - Results of the Pilot Assessment.; 2010. https://postconflict.unep.ch/publications/RiVAMP.pdf

[186] World Bank. Forces of Nature: Coastal Resilience Benefits of Mangroves in Jamaica.; 2019. Accessed June 11, 2021. https://www.worldbank.org/en/region/lac/publication/forces-of-nature-coastal-resilience-benefits-of-mangroves-in-jamaica

[187] World Bank. Forces of Nature: Coastal Resilience Benefits of Mangroves in Jamaica.; 2019. Accessed June 11, 2021. https://www.worldbank.org/en/region/lac/publication/forces-of-nature-coastal-resilience-benefits-of-mangroves-in-jamaica

[188] World Bank. Forces of Nature: Coastal Resilience Benefits of Mangroves in Jamaica.; 2019. Accessed June 11, 2021. https://www.worldbank.org/en/region/lac/publication/forces-of-nature-coastal-resilience-benefits-of-mangroves-in-jamaica

[189] World Bank. Forces of Nature: Coastal Resilience Benefits of Mangroves in Jamaica.; 2019. Accessed June 11, 2021. https://www.worldbank.org/en/region/lac/publication/forces-of-nature-coastal-resilience-benefits-of-mangroves-in-jamaica

[190] Government of Jamaica. Update of Nationally Determined Contribution (NDC) of Jamaica.; 2020. Accessed June 11, 2021. https://www4.unfccc.int/sites/NDCStaging/pages/Party.aspx?party=JAM

[191] WWF and IUCN. Volume 3: The Americas. In: Centres of Plant Diversity: A Guide and Strategy for Their Conservation (1994-1997). Vol 3. ; 1997.

[192] Government of Jamaica. Update of Nationally Determined Contribution (NDC) of Jamaica.; 2020. Accessed June 11, 2021. https://www4.unfccc.int/sites/NDCStaging/pages/Party.aspx?party=JAM

[193] Inter-American Development Bank and Jamaica. Agreement - Integrated Management of the Yallahs-Hope Watershed Management Area | IADB. Published online 2014. Accessed June 11, 2021. https://www.iadb.org/projects/document/EZSHARE-2056220512-560?project=GRT/FM-14607-JA%3BJA-G1001

[194] United Nations Economic Commission for Latin America and the Caribbean. Study on the Vulnerability and Resilience of Caribbean Small Island Developing States (SIDS). CEPAL; 2011. Accessed June 11, 2021. https://www.cepal.org/en/publications/38568-study-vulnerability-and-resilience-caribbean-small-island-developing-states-sids

[195] United Nations Economic Commission for Latin America and the Caribbean. Study on the Vulnerability and Resilience of Caribbean Small Island Developing States (SIDS). CEPAL; 2011. Accessed June 11, 2021. https://www.cepal.org/en/publications/38568-study-vulnerability-and-resilience-caribbean-small-island-developing-states-sids

[196] Granvorka C, Strobl E. The Impact of Hurricane Strikes on Tourist Arrivals in the Caribbean. Tour Econ. 2013;19(6):1401-1409. doi:10.5367/te.2013.0238

[197] Granvorka C, Strobl E. The Impact of Hurricane Strikes on Tourist Arrivals in the Caribbean. Tour Econ. 2013;19(6):1401-1409. doi:10.5367/te.2013.0238

[198] The Planning Institute of Jamaica. Economic and Social Survey Jamaica 2019: Overview.; 2019. Accessed June 12, 2021. https://www.pioj.gov.jm/product/economic-and-social-survey-jamaica-2019-overview/

[199] Spencer N, Urquhart M-A. Extreme Climate and Absence from Work: Evidence from Jamaica. Int J Disaster Risk Sci. 2021;12(2):232-239. doi:10.1007/s13753-020-00327-1

[200] Campbell D, Beckford C. Negotiating Uncertainty: Jamaican Small Farmers' Adaptation and Coping Strategies, Before and After Hurricanes—A Case Study of Hurricane Dean. Sustainability. 2009;1(4):1366-1387. doi:10.3390/su1041366

[201] Spencer N, Polachek S. Hurricane watch: Battening down the effects of the storm on local crop production. Ecol Econ. 2015;120:234-240. doi:10.1016/j.ecolecon.2015.10.006

[202] Selvaraju R, Food and Agriculture Organization of the United Nations, eds. Climate Change and Agriculture in Jamaica: Agricultural Sector Support Analysis. Food and Agriculture Organization of the United Nations; 2013.

[203] Selvaraju R, Food and Agriculture Organization of the United Nations, eds. Climate Change and Agriculture in Jamaica: Agricultural Sector Support Analysis. Food and Agriculture Organization of the United Nations; 2013.

[204] Lallo CHO, Cohen J, Rankine D, Taylor M, Cambell J, Stephenson T. Characterizing heat stress on livestock using the temperature humidity index (THI)—prospects for a warmer Caribbean. Reg Environ Change. 2018;18(8):2329-2340. doi:10.1007/s10113-018-1359-x

[205] Ministry of Economic Growth & Job Creation CCD, United Nations Framework Convention on Climate Change (Organization), United Nations Development Programme (UNDP), Global Environment Faculty. Third National Communication of Jamaica to the United Nations Framework Convention on Climate Change Prepared for the Ministry of Economic Growth & Job Creation Climate Change Division .; 2018.

[206] Gamble DW, Campbell D, Allen TL, et al. Climate Change, Drought, and Jamaican Agriculture: Local Knowledge and the Climate Record. Ann Assoc Am Geogr. 2010;100(4):880-893. doi:10.1080/00045608.2010.497122

[207] Shaffril HAM, Abu Samah A, D'Silva JL. Climate change: Social adaptation strategies for fishermen. Mar Policy. 2017;81:256-261. doi:10.1016/j.marpol.2017.03.031

[208] Baptiste AK, Kinlocke R. We are not all the same!: Comparative climate change vulnerabilities among fishers in Old Harbour Bay, Jamaica. Geoforum. 2016;73:47-59. doi:10.1016/j.geoforum.2015.05.006

[209] Caribbean Coastal Area Management Foundation. Accessed June 22, 2021. https://ccam.org.jm/

[210] Ministry of Health and Wellness. Jamaica Moves. Accessed June 17, 2021. https://www.jamaicamoves.com

[211] Ministry of Health and Wellness, Ministry of Economic Growth & Job Creation - Climate Change Division, Ministry of Finance & Public Service, et al. Health and Climate Change: Country Profile 2021: Jamaica. Accessed June 17, 2021. https://www.who.int/publications-detail-redirect/health-climate-change-country-profile-jamaica

[212] Jamaica National Adaptation Plan (NAP) Approach. https://napglobalnetwork.org/wp-content/uploads/2017/11/jamaica-cop23-nap-global-network-poster.pdf

[213] Government of Jamaica. Climate Change Policy Framework for Jamaica.; 2015. https://www.preventionweb.net/english/policies/v.php?id=59577

[214] The Ministry of Energy and Mining. Jamaica's National Energy Policy 2009-2030.; 2010.

[215] Government of Jamaica. Climate Change Policy Framework for Jamaica.; 2015. https://www.preventionweb.net/english/policies/v.php?id=59577

[216] Government of Jamaica. Update of Nationally Determined Contribution (NDC) of Jamaica.; 2020. Accessed June 11, 2021. https://www4.unfccc.int/sites/NDCStaging/pages/Party.aspx?party=JAM

[217] Government of Jamaica. Update of Nationally Determined Contribution (NDC) of Jamaica.; 2020. Accessed June 11, 2021. https://www4.unfccc.int/sites/NDCStaging/pages/Party.aspx?party=JAM

[218] The Planning Institute of Jamaica (PIOJ). Vision 2030 Jamaica: National Development Plan: The Popular Version. The Planning Institute of Jamaica (PIOJ); 2010. http://www.vision2030.gov.jm/National-Development-Plan

[219] Ministry of Science, Energy & Technology. Jamaica Energy Statistics 2019.; 2019. Accessed June 12, 2021. https://www.mset.gov.jm/documents/jamaica-energy-statistics/

[220] Wray K, Rainford O. 2018 Jamaica Integrated Resource Plan. Published online 2018.

[221] How Angella Rainford Built Jamaica's Largest Solar Farm at 38 Years Old – Soul Career. Accessed June 12, 2021. https://www.soulcareer.com/how-angella-rainford-built-jamaicas-largest-solar-farm-at-38-years-old/

[222] Jamaica's Renewable Energy Transformation: Angella Rainford's Story. Deetken Impact. Published April 22, 2020. Accessed June 12, 2021. https://deetkenimpact.com/blog/jamaicas-energy-transformation-angella-rainfords-story-of-renewable-energy/

[223] Government of Jamaica. Climate Change Policy Framework for Jamaica.; 2015. https://www.preventionweb.net/english/policies/v.php?id=59577

[224] Contreras-Lisperguer R, Batuecas E, Mayo C, Díaz R, Pérez FJ, Springer C. Sustainability assessment of electricity cogeneration from sugarcane bagasse in Jamaica. J Clean Prod. 2018;200:390-401. doi:10.1016/j.jclepro.2018.07.322

[225] LGGE Promoting Energy Efficiency and Renewable Energy in Buildings in Jamaica. Global Environment Facility. Published November 7, 2020. Accessed June 12, 2021. https://www.thegef.org/project/lgge-promoting-energy-efficiency-and-renewable-energy-buildings-jamaica

[226] Leading climate action | Vice-Chancellor's Annual Report to University Council 2019/2020. Accessed June 12, 2021. https://www.uwi.edu/vcreport/ft36.php

[227] Caribbean EC for LA and the. Energy Efficiency Potential in Jamaica: Challenges, Opportunities and Strategies for Implementation. CEPAL; 2011. Accessed June 17, 2021. https://www.cepal.org/en/publications/3855-energy-efficiency-potential-jamaica-challenges-opportunities-and-strategies

[228] Chen AA, Stephens AJ, Koon Koon R, Ashtine M, Mohammed-Koon Koon K. Pathways to climate change mitigation and stable energy by 100% renewable for a small island: Jamaica as an example. Renew Sustain Energy Rev. 2020;121:109671. doi:10.1016/j.rser.2019.109671

[229] Chen AA, Stephens AJ, Koon Koon R, Ashtine M, Mohammed-Koon Koon K. Pathways to climate change mitigation and stable energy by 100% renewable for a small island: Jamaica as an example. Renew Sustain Energy Rev. 2020;121:109671. doi:10.1016/j.rser.2019.109671

[230] Government of Jamaica. Update of Nationally Determined Contribution (NDC) of Jamaica.; 2020. Accessed June 11, 2021. https://www4.unfccc.int/sites/NDCStaging/pages/Party.aspx?party=JAM

[231] Government of Jamaica. Update of Nationally Determined Contribution (NDC) of Jamaica.; 2020. Accessed June 11, 2021. https://www4.unfccc.int/sites/NDCStaging/pages/Party.aspx?party=JAM

[232] JPS Co. Electric Vehicles In Jamaica – An Economical Option. Published December 2020. Accessed June 17, 2021. https://www.jpsco.com/electric-vehicles-in-jamaica-an-economical-option/

[233] Evergo charging stations launched in Jamaica | Auto | Jamaica Gleaner. Accessed June 12, 2021. https://jamaica-gleaner.com/article/auto/20210516/evergo-charging-stations-launched-jamaica

[234] Jamaica Information Service. Several Electric Vehicle Charging Units To Be Installed Islandwide. Published May 11, 2021. Accessed June 17, 2021.

https://jis.gov.jm/features/several-electric-vehicle-charging-units-to-be-installed-islandwide/

[235] Ministry of Transport and Mining. 2019-2020 Plans.; 2019. Accessed June 17, 2021. https://www.mtw.gov.jm/index.php/downloads/category/10-2019-2020-plans

[236] Ministry of Health & Wellness, Jamaica. National Strategic and Action Plan for the Prevention and Control Non-Communicable Diseases (NCDS) in Jamaica. Published 2013. Accessed June 17, 2021. https://www.moh.gov.jm/data/national-strategic-and-action-plan-for-the-prevention-and-control-non-communicable-diseases-ncds-in-jamaica/

[237] Ministry of Transport and Mining. 2019-2020 Plans.; 2019. Accessed June 17, 2021. https://www.mtw.gov.jm/index.php/downloads/category/10-2019-2020-plans

[238] Government of Jamaica. Update of Nationally Determined Contribution (NDC) of Jamaica.; 2020. Accessed June 11, 2021. https://www4.unfccc.int/sites/NDCStaging/pages/Party.aspx?party=JAM

[239] World Bank. Forces of Nature: Coastal Resilience Benefits of Mangroves in Jamaica.; 2019. Accessed June 11, 2021. https://www.worldbank.org/en/region/lac/publication/forces-of-nature-coastal-resilience-benefits-of-mangroves-in-jamaica

[240] Government of Jamaica. Update of Nationally Determined Contribution (NDC) of Jamaica.; 2020. Accessed June 11, 2021. https://www4.unfccc.int/sites/NDCStaging/pages/Party.aspx?party=JAM

[241] The Planning Institute of Jamaica (PIOJ). Vision 2030 Jamaica: National Development Plan: The Popular Version. The Planning Institute of Jamaica (PIOJ); 2010. http://www.vision2030.gov.jm/National-Development-Plan

[242] Popke J, Curtis S, Gamble DW. A social justice framing of climate change discourse and policy: Adaptation, resilience and vulnerability in a Jamaican agricultural landscape. Geoforum. 2016;73:70-80. doi:10.1016/j.geoforum.2014.11.003

[243] Popke J, Curtis S, Gamble DW. A social justice framing of climate change discourse and policy: Adaptation, resilience and vulnerability in a Jamaican agricultural landscape. Geoforum. 2016;73:70-80. doi:10.1016/j.geoforum.2014.11.003

[244] Clements T. Reduced Expectations: the political and institutional challenges of REDD+. Oryx. 2010;44(3):309-310. doi:10.1017/S0030605310000712

[245] Taylor MA, Clarke LA, Centella A, et al. Future Caribbean Climates in a World of Rising Temperatures: The 1.5 vs 2.0 Dilemma. J Clim. 2018;31(7):2907-2926. doi:10.1175/JCLI-D-17-0074.1

[246] The Planning Institute of Jamaica (PIOJ). Vision 2030 Jamaica: National Development Plan: The Popular Version. The Planning Institute of Jamaica (PIOJ); 2010. http://www.vision2030.gov.jm/National-Development-Plan

[247] The Planning Institute of Jamaica (PIOJ). Vision 2030 Jamaica: National Development Plan: The Popular Version. The Planning Institute of Jamaica (PIOJ); 2010. http://www.vision2030.gov.jm/National-Development-Plan

[248] The Planning Institute of Jamaica (PIOJ). Vision 2030 Jamaica: National Development Plan: The Popular Version. The Planning Institute of Jamaica (PIOJ); 2010. http://www.vision2030.gov.jm/National-Development-Plan

[249] The Planning Institute of Jamaica (PIOJ). Vision 2030 Jamaica: National Development Plan: The Popular Version. The Planning Institute of Jamaica (PIOJ); 2010. http://www.vision2030.gov.jm/National-Development-Plan

[250] The Planning Institute of Jamaica (PIOJ). Vision 2030 Jamaica: National Development Plan: The Popular Version. The Planning Institute of Jamaica (PIOJ); 2010. http://www.vision2030.gov.jm/National-Development-Plan

[251] Selvaraju R, Food and Agriculture Organization of the United Nations, eds. Climate Change and Agriculture in Jamaica: Agricultural Sector Support Analysis. Food and Agriculture Organization of the United Nations; 2013.

[252] 'We are ready to fight' - Cockpit Country -residents remain militant in boundary dispute as mining fears linger | News | Jamaica Gleaner. https://jamaica-gleaner.com/article/news/20190724/we-are-ready-fight-cockpit-country-residents-remain-militant-boundary-dispute. Published July 24, 2019. Accessed June 17, 2021.

[253] Chan C, Armitage D, Alexander SM, Campbell D. Examining linkages between ecosystem services and social wellbeing to improve governance for coastal conservation in Jamaica. Ecosyst Serv. 2019;39:100997. doi:10.1016/j.ecoser.2019.100997

[254] Hoegh-Guldberg O, Jacob D, Taylor M, et al. The human imperative of stabilizing global climate change at 1.5°C. Science. 2019;365(6459):eaaw6974. doi:10.1126/science.aaw6974

[255] IPCC. Special Report - Global Warming of 1.5 oC. Published 2018. Accessed June 15, 2021. https://www.ipcc.ch/sr15/

[256] IPCC. Special Report - Global Warming of 1.5 oC. Published 2018. Accessed June 15, 2021. https://www.ipcc.ch/sr15/

[257] Hoegh-Guldberg O, Jacob D, Taylor M, et al. The human imperative of stabilizing global climate change at 1.5°C. Science. 2019;365(6459):eaaw6974. doi:10.1126/science.aaw6974

[258] 1.5 to stay alive - Caribbean Climate Matters. Accessed June 15, 2021. https://1point5.info/en/

[259] Taylor MA, Clarke LA, Centella A, et al. Future Caribbean Climates in a World of Rising Temperatures: The 1.5 vs 2.0 Dilemma. J Clim. 2018;31(7):2907-2926. doi:10.1175/JCLI-D-17-0074.1

[260] Mora C, Frazier AG, Longman RJ, et al. The projected timing of climate departure from recent variability. Nature. 2013;502(7470):183-187. doi:10.1038/nature12540

[261] Taylor MA, Clarke LA, Centella A, et al. Future Caribbean Climates in a World of Rising Temperatures: The 1.5 vs 2.0 Dilemma. J Clim. 2018;31(7):2907-2926. doi:10.1175/JCLI-D-17-0074.1