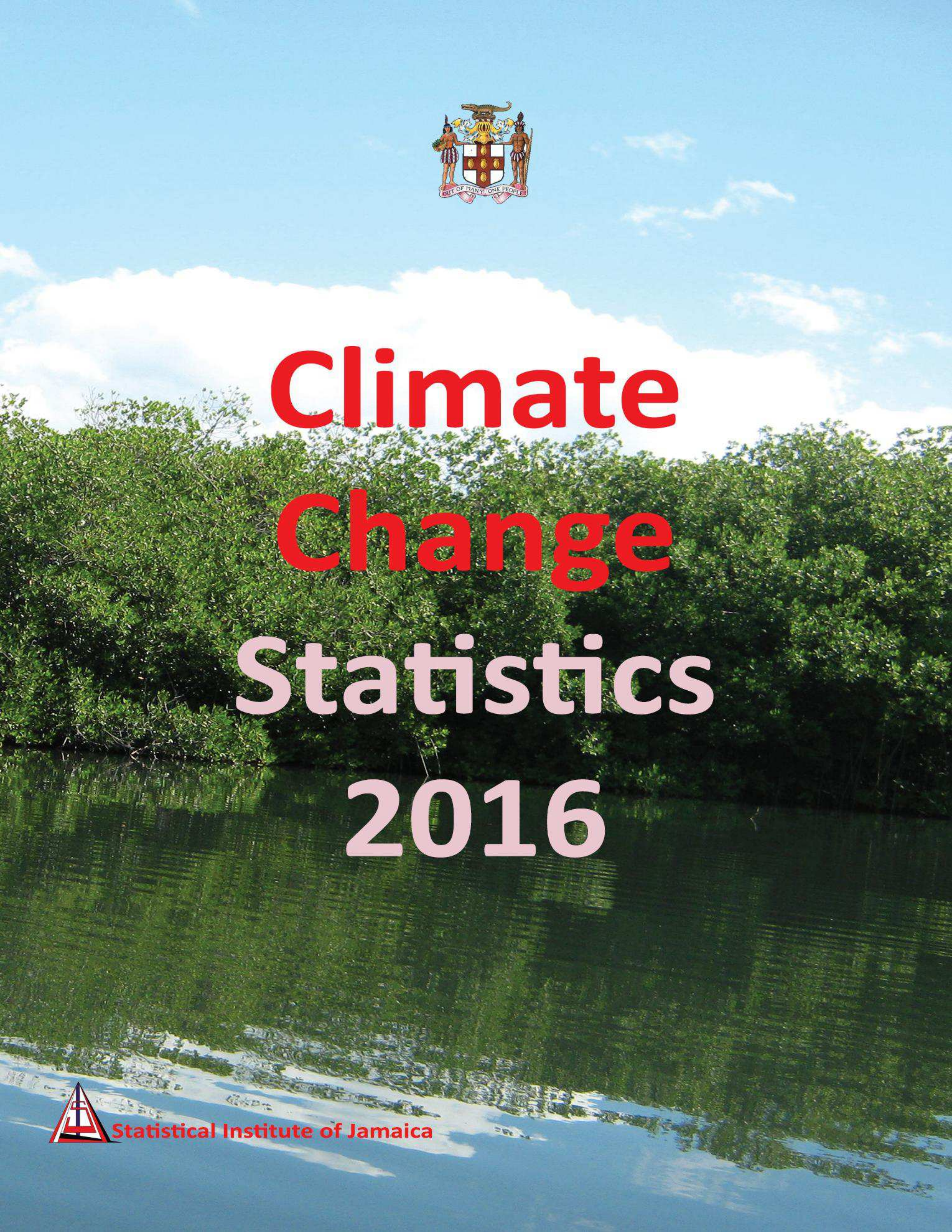

Climate Change Statistics 2016

Statistical Institute of Jamaica

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Cover: Picture of mangroves at Port Royal, Jamaica.

Feedback on the topics and material in this publication is welcome.

This report is available on compact disc and in electronic format as well as a reference in STATIN's library.

Contents

Preface

Climate change is one of the major challenges facing humanity today. This is especially the case for Small Island Developing States (SIDS), such as Jamaica, which are highly vulnerable and are often affected by the impacts of climate change. The Paris Agreement, signed by 175 member states in 2016, is an attempt to mitigate climate change and intensify actions and investments needed for sustainable low-carbon future. The provision of high quality statistics related to climate change are vital to inform policy and in monitoring the achievement of sustainable development. This report, Climate Change Statistics 2016, looks at the primary drivers of climate change; the evidence and impacts of climate change and efforts to mitigate and adapt to climate change. The United Nation's Sustainable Development Goals and the Framework for the Development of Environment Statistics (FDES) include a series of targets, indicators and statistics related to climate change. In this report, however, the tables and graphs presented are mainly based on the statistics and indicators included in the FDES. Included are statistics that are relevant to Jamaica as well as to the global situation.

Unlike some traditional economic and social data, climate change-related statistics, much like other environment statistics, are not as complete or timely. Users of climate change-related statistics will find gaps in time series as well as out-of-date figures. In this first report Climate Change Statistics 2016, the Statistical Institute of Jamaica has gathered all available data on climate-change related statistics and presented them in an easy-to-read format. Efforts will be made to continue to update the data when available, fill the data gaps where possible and make them available on the Institute's website.

Climate Change Statistics 2016 provides data that can be used by policymakers in the planning and implementation of environmentally-sustainable initiatives. Students, teachers and the general public may also utilise the information to enhance their understanding of the impact of climate change and ways in which they can make positive environmental contributions in their daily lives.

This publication was prepared by the staff of the Environment Statistics Unit in the Censuses, Demographic & Social Statistics Division.

Carol Coy

Director General

April 2017

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Notation

–	data nil
…	data negligible
p	preliminary
r	revised

Introduction

Difference between Weather and Climate

Weather is measured in short periods or time spans and refers to changes in the atmosphere at a specific place and time. An example is the weather report on the nightly news which gives a synopsis of recorded changes in the atmosphere for a few hours up to a week, whether it is sunny, windy, cloudy or rainy. **Climate,** in contrast, happens over longer periods of time and is the calculated average state of the weather over seasons, decades or centuries. In short, weather is examined in days and weeks and climate is measured very slowly over time, spanning many years.

Climate change is a long-term shift in weather conditions identified by changes in temperature, precipitation, winds and other indicators. Climate change can involve both changes in average conditions and changes in variability, including, extreme events.[1]

Is the Global Climate Changing?

The earth's climate naturally changes and this is evident throughout history. Scientists have attributed these changes to slight variations in the earth's orbit and the amount of energy from the sun that enters Earth. Other natural changes to climate can be volcanic eruptions and changes in the ocean.

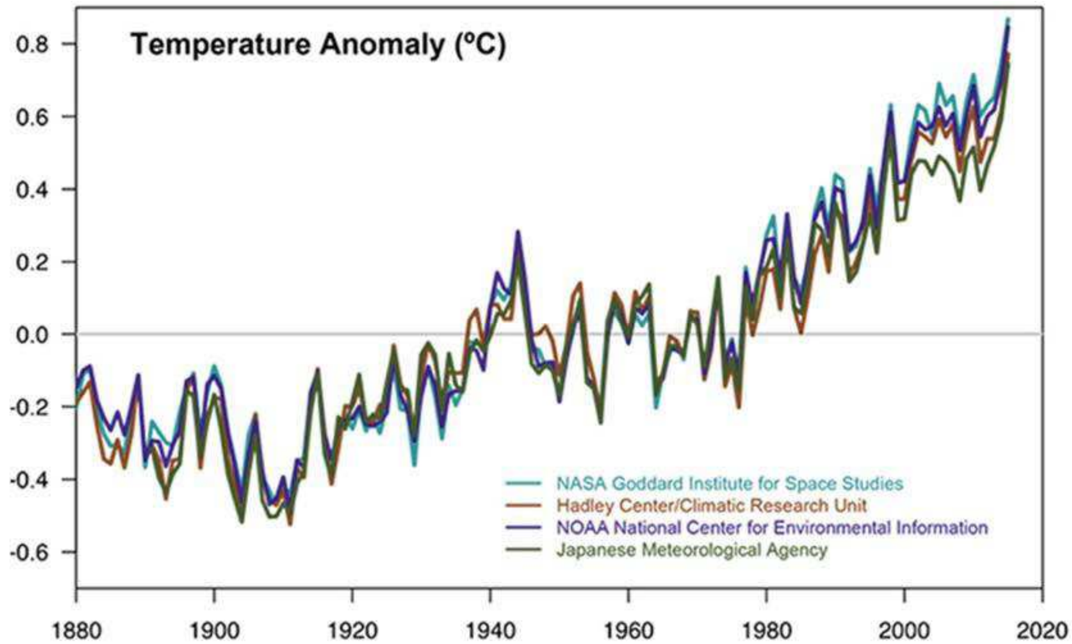
Many persons in the scientific community believe, however, that the world's climate has changed at a faster pace since the advent of the Industrial Revolution that took place from the 18th and 19th centuries. Before the revolution, people used basic hand tools and machines, engaged in farming and worked from home. The revolution saw a departure from this toward the use of heavy specialized machines, construction of factories and mass production. Metals, such as iron ore, were used in the production of steel; fossil fuels, such as coal, was used as energy. It is believed that **human activities** that began at that time and persisted and grew throughout the following centuries resulted in a faster increase of the earth's warming leading to climate change. The burning of fuels such as coal, oil and gas has caused gases that trap heat, e.g., carbon dioxide (CO_2) to enter the air. These gases are called **greenhouse gases** and contribute to **global warming**.

There is a consensus amongst major scientists across the world that, since the early 20th century, the mean annual temperature of the earth has increased by 0.8 °C (National Aeronautics and Space Administration (NASA), Goddard Institute for Space Studies (GISS)). Information leading to this conclusion was also obtained by NASA from NOAA National Climatic Data Center, Met Office Hadley Centre/Climatic Research Unit and the Japanese Meteorological Agency (see figure 1).

The data from NASA show that, with the exception of 1998 which registered an average temperature of 0.64 °C, the ten warmest years have all occurred since 2000 (NASA, [2017]). The warmest years by far were recorded in 2015 and 2016 with increased temperatures of 0.87 °C and 0.99 °C respectively.

[1] www.climatechange.gc.ca

Figure 1
Scientific Consensus: Earth's Climate is Warming



Source: NASA's Goddard Institute for Space Studies NASA/GISS

Climate Process Drivers

Climate process occurs constantly and naturally, it is mainly driven by a large amount of heat and light from the sun stimulating the earth's surface. The amount of light and energy that reaches the earth's atmosphere fluctuates from season to season depending on a few factors, including changes in the Earth's orbit around the sun. These factors that influence seasonal changes are the same factors that are the driving forces behind climate processes.[2]

The average temperature of the earth is regulated by incoming and outgoing energy which determines its energy balance. Any factors that cause a sustained change to either incoming energy or outgoing energy can lead to climate change. Human activities, particularly those since the mid-20th century, have been cited as a significant contributor to the earth's warming. The burning of fossil fuels for heat and energy, deforestation, fertilization of crops, livestock farming and how waste is stored all contribute to greenhouse gas emissions into the atmosphere.

Jamaica, as a signatory to the United Nations Framework Convention on Climate Change (UNFCCC), is mandated to produce biennial reports on the state of its greenhouse gas emissions and efforts to reduce same. The report is termed the Biennial Update Report (BUR) and in 2016 Jamaica submitted its second such report to the UNFCCC: *"Biennial Update Report of Jamaica, Covering GHG Emissions for 2006–2012".*

[2] National Centre for Atmospheric Research/University Corporation for Atmospheric Research-Earth Observing Laboratory (https://www.eol.ucar.edu/discovery/climate-process).

Climate Process Drivers

Several sectors within the Jamaican economy contribute to greenhouse gas emissions. Table 1 highlights various sectors within the economy along with a breakdown of the types of emissions that they are estimated to produce.

Table 1:
List of Categories and Emissions

Sector	CO_2	CH_4	N_2O	HFC	CO	NO_X	NMVOC	SO_2
1 Energy								
Public electricity and heat production	✓	✓	✓	·	✓	✓	✓	✓
Petroleum refining	✓	✓	✓	·	✓	✓	✓	✓
Mining/Bauxite	✓	✓	✓	·	✓	✓	✓	✓
Sugar and other food/drink manufacture	✓	✓	✓	·	✓	✓	✓	✓
Cement	✓	✓	✓	·	✓	✓	✓	✓
Industry, Mobile machinery	✓	✓	✓	·	✓	✓	✓	✓
Industry Other, Stationary	✓	✓	✓	·	✓	✓	✓	✓
Domestic aviation LTO (civil)	✓	✓	✓	·	✓	✓	✓	✓
Road Transport	✓	✓	✓	·	✓	✓	✓	✓
Cars	·	·	·	·	✓	✓	✓	✓
LDVs	·	·	·	·	✓	✓	✓	✓
HGVs	·	·	·	·	✓	✓	✓	✓
Motorcycles	·	·	·	·	✓	✓	✓	✓
Domestic shipping/National Navigation	✓	✓	✓	·	✓	✓	✓	✓
Commercial/institutional: Stationary	✓	✓	✓	·	✓	✓	✓	✓
Commercial/institutional: Mobile	✓	✓	✓	·	✓	✓	✓	✓
Residential: Stationary	✓	✓	✓	·	✓	✓	✓	✓
Agriculture/Forestry/Fishing: Mobile	✓	✓	✓	·	✓	✓	✓	✓
Refinery flaring			✓	·	✓	✓	✓	✓
2 Industrial Processes and Product Use Sector (IPPU)								
Cement	✓	·	·	·	·	·	·	·
Lime	✓	·	·	·	·	·	·	·
HFC consumption	·	·	·		·	·	·	·
Non-Energy Products	✓	·	·	·	·	✓	·	·
Food & Drink	·	·	·	·	·	✓	·	·
3 Solvent Use								
Domestic Solvent Use	·	·	·	·	·	✓	·	·
Coating Applications	·	·	·	·	·	✓	·	·
Dry Cleaning	·	·	·	·	·	✓	·	·

Table 1
List of Categories and Emissions, cont'd

Sector	CO_2	CH_4	N_2O	HFC	CO	NO_X	NMVOC	SO_2
4 Agriculture								
Breeding Swine - Enteric	·	✓	·	·	·	·	·	·
Dairy Cattle – Enteric	·	✓	·	·	·	·	·	·
Goats – Enteric	·	✓	·	·	·	·	·	·
Horses – Enteric	·	✓	·	·	·	·	·	·
Market Swine – Enteric	·	✓	·	·	·	·	·	·
Mules/Asses – Enteric	·	✓	·	·	·	·	·	·
Other Cattle – Enteric	·	✓	·	·	·	·	·	·
Sheep - Enteric	·	✓	·	·	·	·	·	·
Livestock Manure management	·	·	·	·	·	·	✓	·
Breeding Swine	·	✓	✓	·	·	·	·	·
Dairy Cattle	·	✓	✓	·	·	·	·	·
Goats	·	✓	✓	·	·	·	·	·
Horses	·	✓	✓	·	·	·	·	·
Market Swine	·	✓	✓	·	·	·	·	·
Mules/Asses	·	✓	✓	·	·	·	·	·
Other Cattle	·	✓	✓	·	·	·	·	·
Poultry–Chickens (Broilers)	·	✓	✓	·	·	·	·	·
Poultry–Chickens (Layers)	·	✓	✓	·	·	·	·	·
Poultry–Ducks & Geese	·	✓	✓	·	·	·	·	·
Poultry–Turkeys	·	✓	✓	·	·	·	·	·
Rabbit	·	✓	✓	·	·	·	·	·
Sheep	·	✓	✓	·	·	·	·	·
Rice	·	✓		·	·	·	·	·
Crop residues	·	·	✓	·	·	·	·	·
Cultivated Soils	·	·	·	·	·	·	✓	·
Drained/managed organic soils	·	·	✓	·	·	·	·	·
Grazing animals	·	·	✓	·	·	·	·	·
Lime Application	✓	·	·	·	·	·	·	·
NO from managed soils	·	·	·	·	·	✓	·	·
Organic N fertiliser	·	·	✓	·	·	·	·	·
Synthetic N fertiliser	·	·	✓	·	·	·	·	·
Urea Fertiliser Application	✓	·	·	·	·	·	·	·

Table 1 cont'd
List of Categories and Emissions

Sector	CO_2	CH_4	N_2O	HFC	CO	NO_X	NMVOC	SO_2
4 Agriculture (cont'd)								
Field Burning	·	✓	✓	·	✓	✓	·	·
Manure - Atm. Deposition	·	·	✓	·	·	·	·	·
4G Manure - Leaching/runoff	·	·	✓	·	·	·	·	·
4G Soils- Atm. Deposition	·	·	✓	·	·	·	·	·
4G Soils- Leaching/runoff	·	·	✓	·	·	·	·	·
5 Land Use Land Use Change and Forestry (LULUCF)								
Forest Land Remaining Forest Land	✓	·	·	·	·	·	·	·
Land Converted to Forest Land	✓	·	·	·	·	·	·	·
Land Converted to Grassland	✓	·	·	·	·	·	·	·
Land converted to Cropland	✓	·	·	·	·	·	·	·
Land converted to Settlement	✓	·	·	·	·	·	·	·
Other land Remaining other land	✓	·	·	·	·	·	·	·
Land converted to Other Land	✓	·	·	·	·	·	·	·
6 Waste								
Solid waste disposal on land	·	✓	·	·	·	·	✓	·
Domestic wastewater handling	·	✓	✓	·	·	·	·	·
Industrial wastewater handling	·	✓	·	·	·	·	·	·
Waste incineration	✓	✓	✓	·	✓	✓	✓	✓
Biological treatment of waste	·	✓	·	·	·	·	·	·
6D Open burning of waste (backyards)	✓	✓	✓	·	✓	✓	✓	✓
6D Open burning of waste (landfills)	✓	✓	✓	·	✓	✓	✓	✓

Source: Biennial Update Report of Jamaica

Emissions of Greenhouse Gases: Direct GHG Emissions

Carbon Dioxide (CO_2)

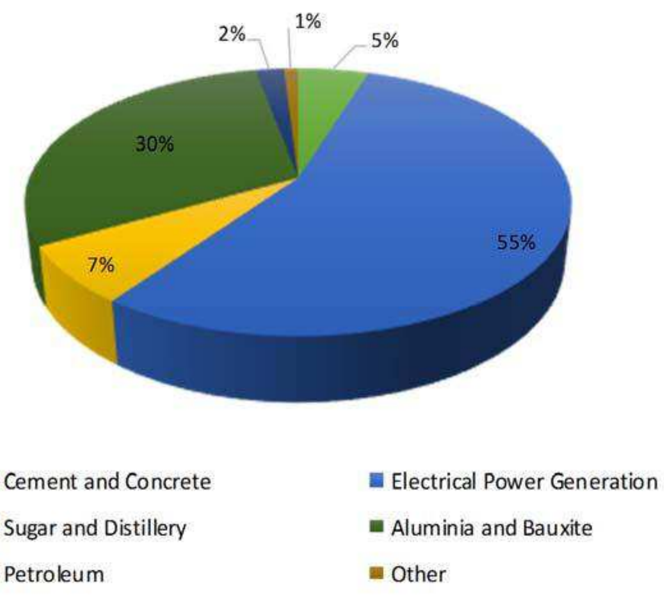
FDES Topic 3.1.1. Emissions of Greenhouse Gases

Carbon dioxide (CO_2) is the primary gas emitted through human activities according to the United States Environmental Protection Agency. Major contributors of CO_2 are the burning of fossil fuels (coal, natural gas and oil) that are used for transportation and energy, deforestation and the storing of waste in landfills. The manufacture of certain commodities such as cement also contribute to carbon dioxide emissions.

Figure 2 highlights the total amount of carbon dioxide emitted by regulated industries in Jamaica in 2013. The data showed that electrical power generation and the alumina and bauxite industries were the two largest contributors of CO_2 emissions with 55.0 and 30.0 per cent respectively.

Figure 2

Total Carbon Dioxide by Regulated Industry: 2013



Source: Biennial Update Report of Jamaica

Methane (CH_4)

Methane is released through the production and transportation of oil and natural gas, the rearing of livestock and other areas within the agriculture sector as well as when waste is broken down in landfills.

Table 2

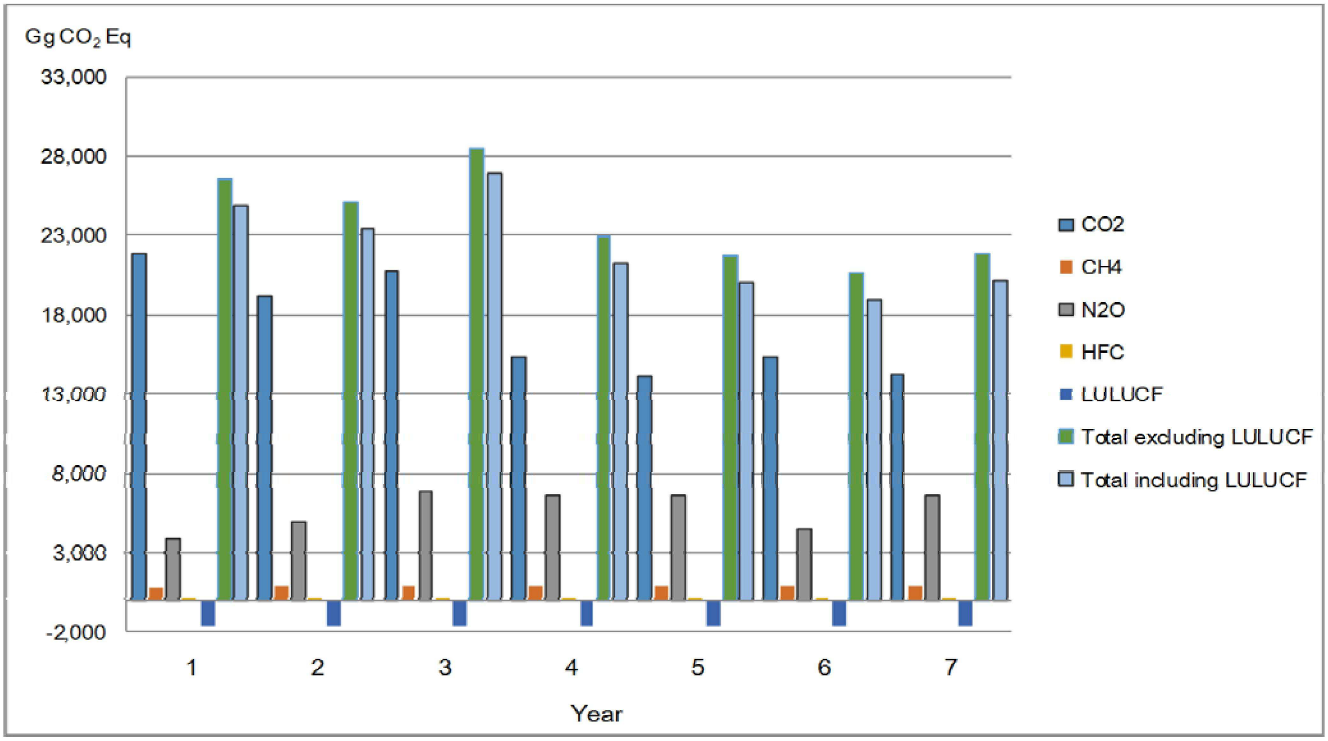
Emissions of Greenhouse Gases in Jamaica: 2006–2012, Gg CO_2 equivalent

Type of Gas	2006	2007	2008	2009	2010	2011	2012
CO_2	21,819	19,187	20,727	15,304	14,113	15,264	14,296
CH_4	818	835	841	857	847	831	852
N_2O	3,870	4,985	6,874	6,662	6,643	4,426	6,594
HFC	87	92	95	95	93	92	89
LULUCF	-1,685	-1,638	-1,631	-1,622	-1,618	-1,616	-1,626
Total excluding LULUCF	**26,595**	**25,100**	**28,537**	**22,919**	**21,696**	**20,614**	**21,831**
Total including LULUCF	**24,910**	**23,462**	**26,906**	**21,298**	**20,078**	**18,998**	**20,205**

Source: Biennial Update Report of Jamaica

LULUCF – Land Use, Land Use Change and Forestry

Figure 3
Emissions of GHG in Jamaica: 2006–2012



Source: Biennial Update Report of Jamaica

Nitrous oxide (N_2O)

Nitrous oxide is produced during the industrial and agricultural industries and in the burning of fossil fuels and waste at landfills.

Fluorinated gases

Hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulphur hexafluoride (SF_6) are referred to as fluorinated gases. These are usually produced during industrial activities. Although they are produced in smaller quantities, due to their potency, they are referred to as high global warming potential (GWP) gases or "high GWP gases".

Emissions of Greenhouse Gases: Indirect GHG Emissions

Sulphur dioxide (SO_2)

Sulphur dioxide is primarily emitted from the burning of sulphur or materials containing sulphur which are then converted into CO_2. Most emissions of SO_2 are from electricity generation as is seen in Table 3. Fuel and diesel oils are both used to produce electricity in Jamaica, with fuel oil generating greater concentrations of SO_2; accounting for 97.0 per cent of the total emissions from public electricity and heat production.[3]

[3] BUR Report of Jamaica, 2006–2012.

Table 3

Emissions of Sulphur Dioxide: 2006–2012, Gg

Source of Emission	2006	2007	2008	2009	2010	2011	2012
Public Electricity and Heat Production	14.28	15.17	14.51	14.87	14.84	14.51	13.11
Mining/Bauxite	2.79	1.80	2.52	0.94	0.75	1.02	0.93
Other Industrial Combustion	1.10	1.47	1.18	1.26	0.75	1.86	1.71
Transport	0.32	0.28	0.27	0.15	0.18	0.15	0.13
Commercial, Residential, Mobile	0.20	0.32	0.14	0.12	0.11	0.11	0.11
Other (Flaring, Non-E Prod Agriculture, Waste)	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Total	**18.71**	**19.05**	**18.63**	**17.34**	**16.65**	**17.66**	**16.00**

Source: Biennial Update Report of Jamaica

Nitrogen oxides (NO_x)

Nitrogen oxides are emitted when fuels are burnt at high temperatures. They are produced from cement kilns, industrial plants and small and large transportation ranging from cars to tractors and boats. The mining/bauxite and transport industries are the largest NO_x producers for the years 2006 to 2012 as seen in Table 4.

Table 4

Emissions of Nitrogen Oxide: 2006–2012, Gg

Source of Emission	2006	2007	2008	2009	2010	2011	2012
Electricity Generation	4.81	5.10	4.91	5.02	4.99	4.92	4.51
Mining/Bauxite	30.49	19.65	27.48	10.25	8.21	11.09	10.11
Other Industrial Combustion	2.46	3.07	4.61	3.07	1.96	2.77	3.26
Transport	18.82	16.72	17.26	16.38	15.48	15.09	14.48
Commercial, Residential (including Agriculture/Forestry/Fishing)	1.99	2.94	1.50	1.26	1.22	1.21	1.23
Agriculture (& Waste)	6.21	7.92	10.81	10.38	10.37	6.99	10.40
Total	**64.77**	**55.4**	**66.57**	**46.36**	**42.23**	**42.06**	**43.98**

Source: Biennial Update Report of Jamaica

Table 5

Emissions of Non-methane Volatile Organic Compounds: 2006–2012, Gg

Source of Emission	2006	2007	2008	2009	2010	2011	2012
Stationary Combustion	3.05	2.61	3.11	2.93	1.58	2.13	2.12
Transport	8.03	7.15	7.4	7.2	6.74	6.61	6.43
Commercial, Residential	1.34	1.37	1.46	1.43	1.42	1.33	1.33
Food & Drink	3.13	3.28	3.11	2.96	2.9	3.09	3.08
Solvent Use	14.25	14.4	14.28	14.19	13.89	14.04	14.01
Other	2.21	2.44	3.04	2.86	2.74	2.2	2.68
Total	**32.01**	**31.24**	**32.38**	**31.57**	**29.26**	**29.41**	**29.65**

Source: Biennial Update Report of Jamaica

Non-methane Volatile Organic Compound (NM-VOCs)

Non-methane volatile organic compounds are emitted from a variety of different sources including the use of solvents and through the production process. NM-VOCs contribute to the formation of ground level or tropospheric ozone which have an adverse impact on human health.[4] Solvent use and transport are the two major contributory sources of NM-VOCs for the period 2006 to 2012 as seen in Table 5.

Consumption of Ozone-depleting Substances

FDES Topic 3.1.2. Consumption of ozone depleting substances

The *Montreal Protocol on Substances that Deplete the Ozone Layer* was entered into force in 1989 and Jamaica ratified the protocol in 1993. The objective of the Protocol is to protect the stratospheric ozone layer by phasing out the production of substances that contribute to ozone depletion and covers substances with a high ozone-depleting potential. These substances include chlorofluorocarbons (CFCs), halons, hydrochlorofluorocarbons (HCFCs), hydrobromofluorocarbons (HBFCs), carbon tetrachloride (CTC), methyl bromide (MB), bromochloromethane (BCM) and trichloroethane (TCA).

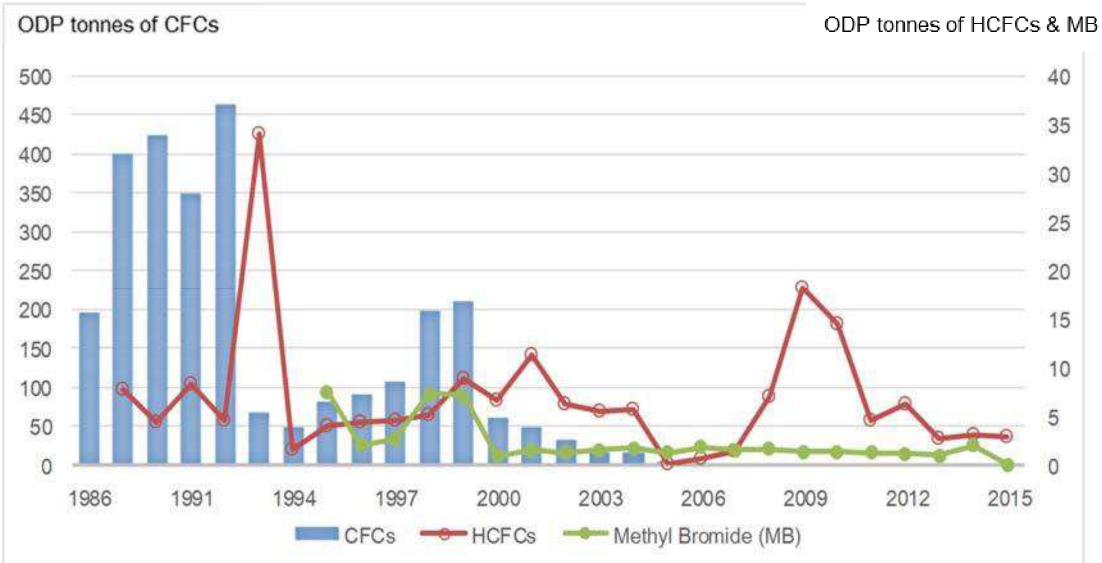
The *Kyoto Protocol to the United Nations Framework Convention on Climate Change*, came into force in 1997 and was ratified by Jamaica in 1999. This Protocol sets binding agreements for 37 industrialised countries and the European Union to reduce greenhouse gas emissions through the reduction of the use of ozone-depleting substances (ODS).

Small-island developing states, such as Jamaica, do not contribute significantly to GHGs. However, as a signatory to the convention and protocol, Jamaica reports on its consumption of ODS which is calculated from imports of products containing ozone-depleting potential (ODP) products. In 1986, imports of ODS products was 196.1 ODP

[4] www.eea.europa.eu

Figure 4

Consumption of Ozone-Depleting Substances: 1986–2015, ODP tonnes



Source: United Nations Ozone Secretariat

ODP – Ozone-depleting potential

tonnes. At that time, only CFCs were being tracked. In 1989, CFCs, halons (which were phased out in 1994) and HCFCs were on the list of substances that were monitored; methyl bromide imports were added in 1995. During the period 1986–2005, the majority of ODS imported into Jamaica were CFCs which were phased out in 2005. In the period 2005–2015, the quantity of ODS imported into Jamaica showed a steady decline from 23.3 to 2.92 ODP tonnes and consisted of HCFCs and methyl bromide which was phased out in 2014 (see Figure 4).

Climate Change Evidence

Physical Conditions: Atmosphere, Climate and Weather

FDES Topic 1.1.1. Atmosphere, climate and weather

Jamaica's economy is largely dependent on agriculture and tourism, two sectors that rely on typical weather pattern or climate. Traditional farmers plant and reap their crops based on the climate. The planting of new crops, is not typically done in the summer months of July as rainfall is less and the temperature is hotter. Irrigation is normally restricted as there is usually a drop in the water table as a result of less rainfall feeding into aquifers, rivers and dams. Planting is normally done in the wetter periods of April to June and August to October as most farmers practice rain-fed agriculture. Consequently, crops planted in this period are cheaper on the market than those planted in the dryer months of December to early April.

Farmers in the 'bread basket' parish of St Elizabeth have cultivated a complex crop schedule over many decades to fit the local climate.[5] The farmers plant quick-growing (three-month) crops from April through June, and this early-season harvest finances their late-season cash crops, which they grow from August through November. The cash crop season also coincides with the main hurricane season, which can bring crippling storms and floods.

The climate also dictates what produce are available at what time. For example, onions are planted at the end of the wetter period going into the dryer months (it is a five-month crop and is typically planted in November to April before the beginning of the May rains). Onions need copious watering at the beginning of the planting cycle, but significantly less as they mature. On the contrary, many orchard crops such as oranges, coffee and cocoa, as well as pineapple and cabbage, are planted in the wetter months.

Climate change evidence from surface air temperature readings collected from stations at Jamaica's two international airports, Norman Manley International Airport (NMIA) and the Donald Sangster International Airport (DSIA) have shown changes in the climate. Jamaica’s surface temperature is largely controlled by the variation in solar insulation, which means the way in which the earth orbits the sun (with its axis tilted at a nearly fixed angle of 23.5° to the plane of its orbit) and this gives rise to variations in temperatures.[6]

Data provided by the CARIBSAVE Risk Atlas[7] showed a mean annual increase in temperature of 0.27 °C per decade over the period 1960–2006. These increases were seen to be most rapid in the June, July, August (JJA) season, at a rate of 0.31 °C per decade. Two major models are used to predict temperature changes in Jamaica, the General Circulation Model (GCM) and the Regional Climate Model (RCM). The GCM tends to map at a larger scale, failing to capture accurately small island states like Jamaica. The RCM maps things on a smaller scale and is, therefore, able to provide a more granular depiction of the country. In using the GCM model to predict future temperature, it was determined that by 2050 there will be an increase of 0.7 °C to 1.8 °C; and 1.0 °C to 3.0 °C by 2080.

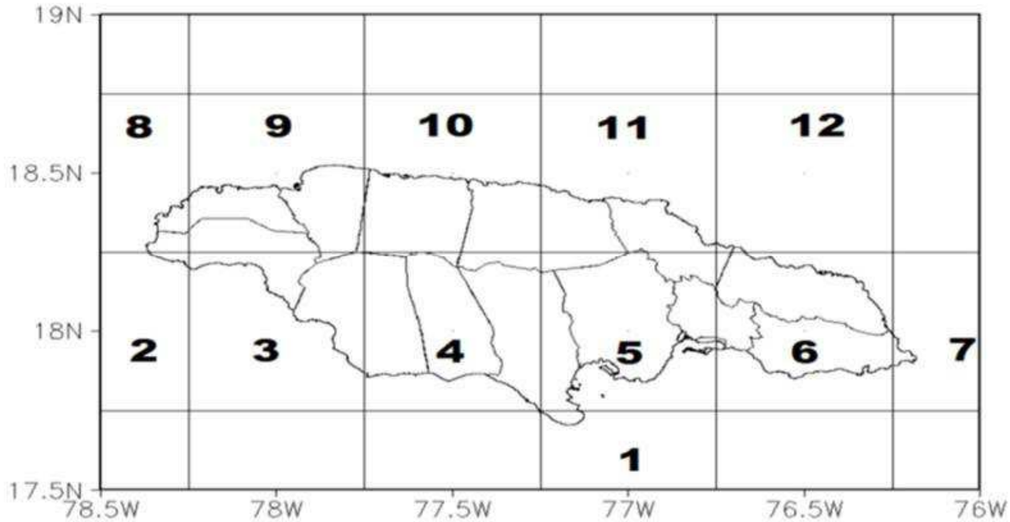
Figure 5 highlights how Jamaica is segmented into twelve grid boxes using a 50 km scale, the prescribed resolution of the PRECIS RCM model. Data is then collected for each grid box and presents the average of all the boxes, easterly or westerly or as a single box. After calculating the annual temperature anomalies for each land or ocean station, scientist then divide the earth up into grid boxes, resembling squares. The average temperature for each box is calculated by combining available data from all stations. Smaller grid boxes give more accurate temperature readings than larger grid boxes, resulting in a more accurate estimate global temperature.

5 Campbell, D, D Barker and D McGregor. 2011. Dealing with drought: Small farmers and environmental hazards in southern St Elizabeth, Jamaica. *Applied Geography* 31(1): 146–158.

6 State of the Jamaican Climate 2012: Information for Resilience Building

7 The CARIBSAVE Climate Change Risk Atlas (CCCRA) Climate Change Risk Profile for Jamaica, March 2012.

Figure 5
PRECIS RCM Grid Box Representation at a Resolution of 50 km over Jamaica

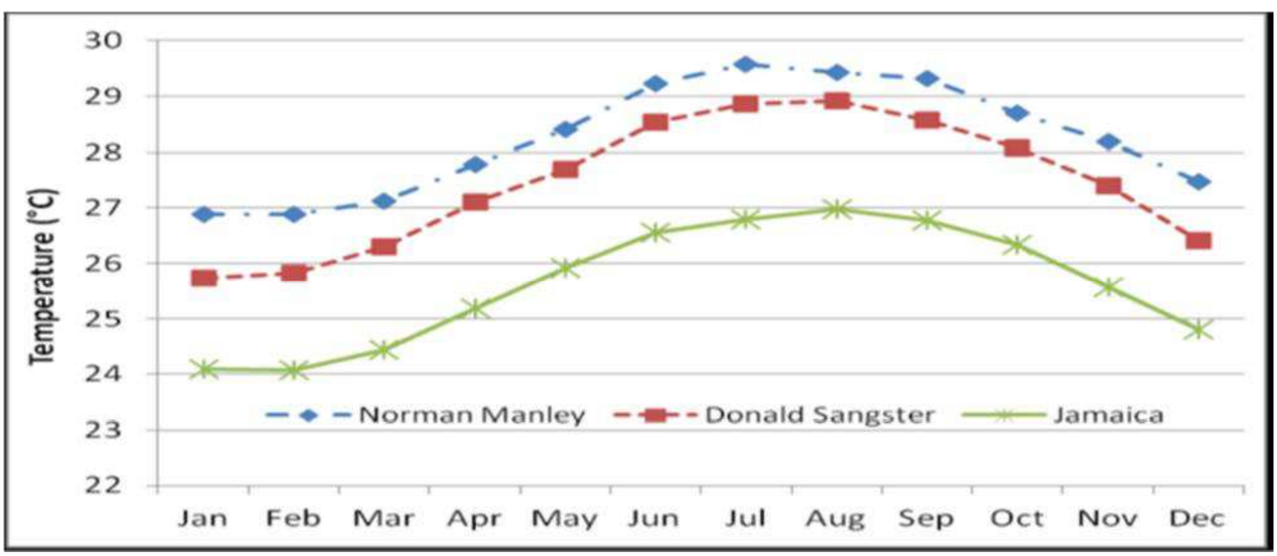


Source: Adopted from State of the Jamaican Climate 2012: Information for Resilience Building

Temperature

The average monthly variation in temperature as recorded by the stations at the two international airports from 1992 to 2008 can be seen in Figure 6. The graph shows cooler months in the northern hemisphere winter and warmer months in the summer. The overall temperature in Jamaica is said to be rising.

Figure 6
Temperature climatology of Jamaica, NMIA and DSIA: 1992–2008



Source: State of the Jamaican Climate 2012

Table 6

Norman Manley: Minimum and Maximum Monthly Temperatures: 2012–2016, °C

	Minimum Temperatures					Maximum Temperatures				
Month	2012	2013	2014	2015	2016	2012	2013	2014	2015	2016
January	22.3	23.4	23.7	23.3	23.5	30.6	31.8	31.0	31.4	30.6
February	23.1	23.2	23.3	23.2	22.9	30.7	31.2	30.7	30.9	30.7
March	22.8	23.4	23.6	23.6	23.8	30.7	30.4	28.9	31.2	31.1
April	24.1	24.7	24.9	24.6	24.6	30.7	31.4	31.3	31.3	31.6
May	25.6	24.9	24.9	25.1	25.1	32.0	32.0	31.7	31.9	32.3
June	26.5	25.3	26.4	26.7	25.9	32.1	32.6	32.7	32.9	32.7
July	25.9	24.9	26.7	25.9	26.7	33.1	32.8	33.0	32.7	33.2
August	25.4	25.7	26.3	26.4	26.7	32.6	33.0	33.2	33.1	33.1
September	25.2	26.2	26.2	26.1	26.2	32.8	32.7	32.8	33.1	33.3
October	25.2	25.7	25.7	25.8	25.7	31.9	31.7	33.0	32.9	32.2
November	24.6	25.0	25.1	24.9	24.7	31.6	32.1	32.1	32.1	31.2
December	23.7	24.0	24.1	24.9	24.3	32.0	31.6	31.3	31.9	31.8

Source: Meteorological Service of Jamaica

Table 6 indicates that slight variations in both minimum day time temperature and maximum night time temperature occurred at the Norman Manley International Airport (NMIA) in Kingston during the years 2012–2016. When analysing the monthly minimum temperature, it was observed that all months, when comparing 2012 and 2016, experienced increased temperature with the exception of February, May and June. Further examination of 2012 and 2016 observed that changes in daytime or maximum temperature increased slightly from 0.1 °C to 0.6 °C. January and February remained unchanged over the period with decreases occurring in December and November.

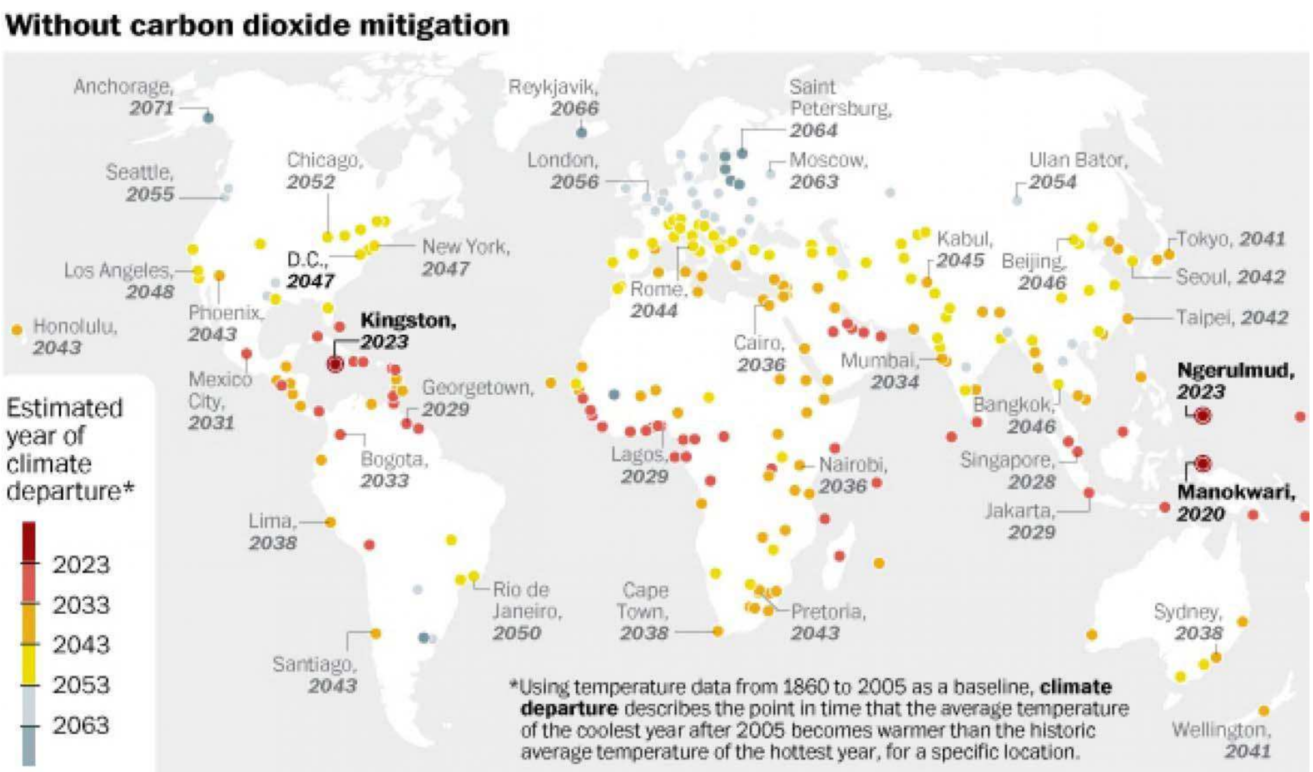
Table 7 shows minimal differences among the minimum and maximum temperatures recorded at the Donald Sangster International Airport (DSIA) between 2012 and 2016. All months experienced increased temperatures with the exception of January and August, which had minimal changes over the period; and February and September which saw slight decreases. Maximum temperatures also recorded miniscule changes across the reporting period. February, June and September recorded slight declines in 2016 when compared with 2012.

Estimated Average Temperature for Kingston in 2030

A topic often discussed by climate scientist is "climate departure" which describes the point in time when the average temperature of the coolest year after 2005 is projected to become warmer than the average temperature of the hottest year for a specific location. In a study, published in the journal, *Nature*, it is projected that the Earth will pass climate departure in 2047.

The study revealed that regions nearer the equator will be subject to hotter mean temperatures at least an average of 15 years before the rest of the world. These higher temperatures will put a strain on the biodiversity in those regions. Environments near to the equator are used to stable climate conditions, therefore, without the implementation of effective conservation measures the rapid change will lead to biodiversity loss.

In the case of Kingston, Jamaica, it is estimated that after 2023, Kingston's coolest year will be hotter than any year from before 2005. That is, every year after 2023 will be hotter than the hottest year on record from 1860 to 2005. However, even with carbon mitigation, Kingston would still hit climate departure five years later, in 2023.



Sources: Washington Post at https://www.washingtonpost.com/news/worldviews/wp/2013/10/09/map-these-are-the-cities-that-climate-change-will-hit-first/?utm_term=.19609c8d4c17
SciDevNet at http://www.scidev.net/global/climate-change/news/record-temperatures-set-to-reach-tropics-first.html?utm_medium=email&utm_source=SciDev.Net&utm_campaign=3199139_13%2f10%2f14-Newsletter+GLOBAL&dm_i=1SCG,1WKGZ,AZRQUI,6TXWI,1

Table 7

Donald Sangster: Minimum and Maximum Monthly Temperatures: 2012–2016, °C

	Minimum Temperatures					Maximum Temperatures				
Month	2012	2013	2014	2015	2016	2012	2013	2014	2015	2016
January	22.6	22.7	22.4	22.9	22.6	30	30.8	30.3	30.4	30.8
February	22.4	22.1	22.8	22.1	22.3	30.2	30.7	30.9	29.9	29.5
March	22.5	22.7	23.3	23.1	23.2	30.6	29.9	31.2	31.1	31.4
April	23.5	23.8	23.9	24	24.6	30.9	31.9	32.3	32	32
May	24.2	24	23.6	24.6	24.7	32.2	32	32	33	32.8
June	24.5	25	24.9	25.4	25	33.5	34	33.3	33.4	33.4
July	25.1	25.3	25.3	25.4	25.3	33.3	33.5	34.1	33.9	34.2
August	25.3	25.3	25.3	26.1	25.3	33.1	33.6	33.9	34.2	33.5
September	25	24.6	24.8	25.2	24.9	33.6	33	33.2	33.5	33.4
October	24.3	25.2	24.4	24.8	25	31.9	33	32.6	32.6	32.2
November	23.8	24.8	24.3	24.3	24.6	30.4	32.3	31.6	32.3	31.1
December	23.1	23.6	23.1	23.3	23.9	30.6	31.2	30	31.6	30.6

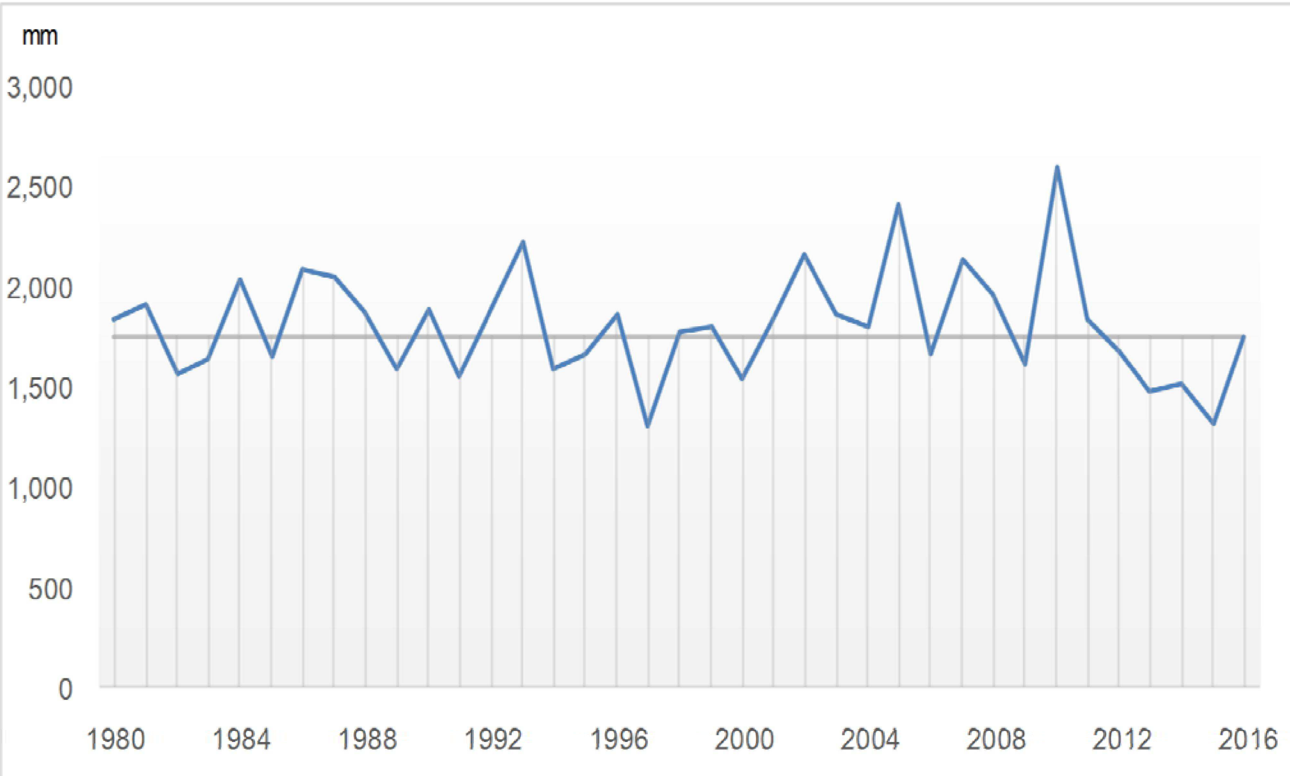
Source: Meteorological Service of Jamaica

Precipitation

Rainfall in Jamaica is referred to as bimodal, that is, having two seasons. The first season reaches its maximum point around May/June and the second season in October. Figure 7 shows that rainfall has fluctuated between 1980 and 2009, but there has been a decrease in rainfall since 2010, with the exception of an increase in 2016. This decrease in rainfall is projected to continue as is stated by GCM models. There were, however, increases in rainfall due to extreme weather conditions between 2008 and 2016. Tropical storms Gustav and Nicole occurred in 2008 and 2010 respectively while hurricanes Sandy and Matthew came in 2012 and 2016.

There are some differences with GCM models as it relates to future rainfall projections for Jamaica, with some models indicating a decrease and others showing an increase. The majority of the models, however, have shown a decrease in the amount of rainfall the island is projected to receive. Projected rainfall changes range from -44.0 per cent to +18.0 per cent by the 2050s and -55.0 per cent to +18.0 per cent by the 2080s. The early wet seasons of March, April, May (MAM) and June, July, August (JJA) are projected to see the greatest annual decrease in rainfall. There is less consistency with changes to rainfall in the wettest season September, October, November (SON) between the models.

Figure 7
Total Annual Mean Rainfall: 1980–2016



Source: Meteorological Office of Jamaica

Table 8 shows the mean rainfall recorded for each month between 1997 and 2016. From the data, rainfall peaks in May and June and again in October as was previously stated. The years 2002, 2005, 2007 and 2010 were the only times rainfall exceeded over 2,000 mm. These years all had adverse weather conditions with 2002 experiencing the May/June floods, 2007 having hurricane Dean and 2010 witnessing tropical storm Nicole.

Table 9 reveals that Portland receives the most rainfall in the country, followed by the parishes of St Mary and St Ann. Westmoreland, Manchester and Hanover recorded the least amount of rainfall ranging from 19 mm to 21 mm. October, May, November, April and August all recorded rainfall figures above 2,000 mm for Jamaica.

DSIA receives and records more rainfall than NMIA, as is evidenced from data in Table 10. In 2012, NMIA received 43.8 per cent more rainfall than DSIA; 92.6 per cent more in 2013; 78.2 per cent in 2014, and a significant increase of 140.0 per cent in 2015. For the DSIA, 49.0 per cent more rain days was recorded in 2016 when compared to NMIA.

Table 8

Mean Rainfall by Month: 1997–2016, mm

Month	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
Annual	**1,303**	**1,784**	**1,805**	**1,547**	**1,857**	**2,159**	**1,861**	**1,807**	**2,412**	**1,665**
January	81	112	117	80	136	89	189	67	101	73
February	69	39	122	40	40	39	45	35	7	97
March	59	194	126	23	58	43	69	122	12	34
April	54	61	54	76	147	125	153	129	176	131
May	96	88	156	209	310	512	235	256	224	127
June	182	106	155	88	49	198	117	50	234	170
July	95	151	103	105	142	83	116	141	488	142
August	109	146	166	62	86	117	233	158	147	180
September	146	186	274	257	139	595	154	454	168	156
October	201	277	270	222	313	132	215	159	578	196
November	136	205	211	112	247	109	147	76	200	240
December	75	219	51	273	190	116	188	160	77	119
	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Annual	**2,139**	**1,960**	**1,621**	**2,597**	**1,839**	**1,682**	**1,473**	**1,518**	**1,314**	**1,760**
January	111	78	112	99	83	70	45	117	94	67
February	37	37	140	62	86	51	55	72	71	151
March	236	114	84	45	70	135	69	58	108	43
April	82	140	120	137	88	201	89	121	80	176
May	264	138	270	269	215	140	212	222	128	253
June	116	156	121	203	313	93	90	47	39	91
July	79	153	59	198	205	90	107	46	72	105
August	304	369	145	191	195	214	193	162	106	169
September	152	210	161	561	184	194	206	183	107	147
October	395	261	176	590	254	237	167	123	218	295
November	294	257	90	135	68	159	148	170	163	178
December	69	47	143	107	78	98	92	197	128	85

Source: National Meteorological Service

Table 9

Mean Rainfall by Month, by Parish: 2016 (mm)

Parish	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Kingston & St Andrew	23	100	32	82	200	41	72	94	94	249	222	79
St Thomas	39	72	16	115	388	76	51	199	60	187	207	89
Portland	161	402	126	509	558	308	143	331	164	697	808	330
St Mary	110	253	57	94	151	27	32	114	115	383	302	181
St Ann	100	216	35	108	278	68	54	123	147	418	231	177
Trelawny	135	178	12	90	222	58	49	119	176	267	77	36
St James	68	208	25	67	234	101	145	178	190	218	79	42
Hanover	52	193	64	100	362	185	196	226	262	155	28	21
Westmoreland	61	99	36	159	276	91	222	193	247	182	16	19
St Elizabeth	40	61	51	246	150	72	131	167	150	304	77	43
Manchester	35	47	40	408	136	82	98	182	120	297	63	20
Clarendon	11	32	39	158	154	26	44	136	74	223	71	23
St Catherine	32	100	19	151	179	52	124	130	113	260	127	49
All Jamaica	**867**	**1,960**	**553**	**2,284**	**3,287**	**1,187**	**1,362**	**2,193**	**1,912**	**3,839**	**2,308**	**1,109**

Source: Meteorological Service of Jamaica

Note: This is the monthly average of measurable rainfall for all rain gauge locations in each parish.

Table 10

Number of Rain Days at Selected Airports, by Month: 2012–2016

	Norman Manley					Donald Sangster				
Month	2012	2013	2014	2015	2016	2012	2013	2014	2015	2016
January	2	1	5	0	3	8	6	9	5	6
February	1	2	3	5	6	4	6	3	6	11
March	7	5	7	3	2	6	6	5	12	4
April	5	4	4	0	4	9	7	5	4	4
May	6	6	8	1	9	11	10	14	8	6
June	5	5	0	0	5	6	7	6	5	6
July	5	4	1	5	6	6	5	4	3	12
August	12	9	7	2	8	8	14	10	7	13
September	6	7	3	1	5	6	15	11	10	10
October	8	5	2	6	11	16	11	12	14	14
November	2	2	9	5	7	7	9	10	4	7
December	5	4	6	7	1	5	8	9	6	7
Total	**64**	**54**	**55**	**35**	**67**	**92**	**104**	**98**	**84**	**100**

Source: Meteorological Service of Jamaica

Drought

Drought is defined as a long period of weather without rain (Heinemann English Dictionary). The more precise definitions for specific areas of concern that are most commonly used are:

- Agricultural drought – a period when soil moisture is inadequate to meet the demands for crops to initiate and sustain plant growth.
- Hydrological drought – a period of below average or normal stream-flow and/or depleted reservoir storage.
- Meteorological drought – a period of well-below average or normal precipitation (rainfall) that spans from a few months to few years.

Two of the most severe Caribbean droughts in terms of intensity, geographical extent and economic impact on agriculture occurred in 1997–1998 and 2009–2010.[8] Jamaica experienced below normal rainfall from December 1996 into 1998 with the greatest damage occurring in the agricultural sector (more than US$8 million in losses) with a significant portion of the losses due to bushfires.[9] In late 1997, losses

[8] Drought Characteristics and Management in the Caribbean, FAO Report, p. 42.

[9] Ministry of Agriculture, Government of Jamaica, 2010

Table 11

Drought Indices by Month, by Parish: 2016

Parish	Jan/ Feb	Feb/ Mar	Mar/ Apr	Apr/ May	May/ Jun	Jun/ Jul	July/ Aug	Aug/ Sept	Sept/ Oct	Oct/ Nov	Nov/ Dec
Kingston & St Andrew	87	96	71	115	96	70	79	53	77	118	126
St Thomas	63	59	82	198	140	44	83	60	46	78	89
Portland	92	112	135	192	174	120	115	102	142	180	135
St Mary	115	127	61	85	67	30	71	86	160	159	103
St Ann	169	165	87	154	137	75	109	136	207	192	143
Trelawny	179	131	68	136	120	63	92	121	149	122	47
St James	219	195	60	104	96	86	113	96	97	95	58
Hanover	121	121	64	100	92	74	84	87	70	41	21
Westmoreland	106	80	86	105	75	72	84	83	84	51	17
St Elizabeth	70	63	108	90	57	78	88	73	92	99	66
Manchester	65	56	173	135	62	87	109	82	91	90	42
Clarendon	50	73	159	151	77	46	106	74	78	92	58
St Catherine	123	102	111	134	87	91	119	81	103	127	99
All Jamaica	**111**	**107**	**101**	**130**	**99**	**75**	**95**	**85**	**101**	**115**	**90**

Source: Meteorological Service of Jamaica

Value of drought index is calculated as: {(Month 1 + Month 2) / (Normal month 1 + Normal month 2)} x 100

Indicates extreme and severe drought.

Indicates normal drought.

in the sugar sector prompted the Jamaican government to offer the sector a US$100 million assistance package. Rainfall was less than average in some places between October 1999 and March 2000. This resulted in crop losses of approximately US$6 million (Jamaican Information Service, 2007). In 2013, of the 4,564 hectares under cultivation in selected parishes, 1,606 hectares were severely impacted by drought, resulting in crop yield reductions from 2.0 per cent to 70.0 per cent. Value added for the Agriculture, Forestry and Fishing industry experienced a reduction of 0.7 per cent in 2013 when compared to 2012. This was largely attributed to the lingering effects of hurricane Sandy which occurred in October 2012 and drought conditions in the first half of 2013.[10]

[10] National Income and Product 2013, Statistical Institute of Jamaica.

Seas

Sea Level Rise

FDES Topic .1.2. Hydrological Characteristics

Sea level rise refers to a gradual increase in the level of the surface of the sea in relation to the land. This phenomenon is attributed to climate change and has been linked to the following factors:[9]

- **Thermal expansion**: as the ocean gets warmer due to warmer temperatures it expands and takes up more space than it did before.
- **Melting glaciers and polar ice caps**: Large ice formations such as glaciers and polar ice caps naturally melt during the summer months, but are "replenished" by snow during the winter. However, global warming has caused hotter summers and shorter winters, resulting in an increased rate of melting and less time for the caps to be replenished. Picture 1 shows that this creates more water that is placed in the oceans.
- **Ice loss from Greenland and West Antarctica**: scientists believe that Greenland and West Antarctica are losing ice as a result of warmer sea temperatures which have caused massive ice shelves that extend out from the Antarctica and that melt from below, weaken and break off. It is also believed that the meltwater from above and seawater from below is seeping beneath the ice sheets, effectively lubricating ice streams and causing them to move more quickly into the sea.[11]

Picture 1

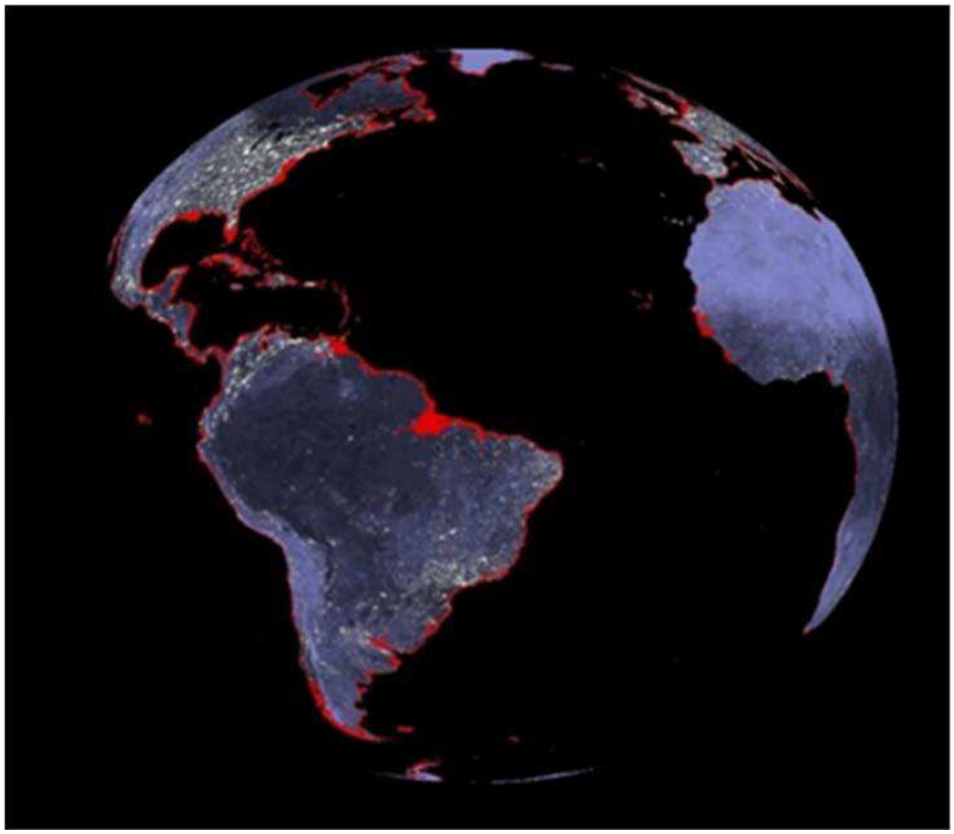
Meltwater Gushing from Ice Cap on Nordaustlandet, in Norway's Svalbard Archipelago

Photograph by Paul Nicklen, National Geographic Creative[10]

[11] http://www.nationalgeographic.com/environment/global-warming/big-thaw/ accessed 6 March 2017.

It is estimated that from 1990–2100, global-average sea level rise will be 7–15 inches for low emission scenarios and 10–23 inches for high emission scenarios.[12] Figure 8 shows how rising sea level will change the earth's appearance as land area will be drastically reduced and covered by sea water. The land that would be covered by water is coloured in red to show the reduction in land as water rises.[13]

Figure 8
Land Being Reduced as a Result of Rising Sea Levels



Source: Science on a Sphere: National Oceanic and Atmospheric Administration[14]

According to Church et al, estimates of sea level rise from 1950 to 2000 (2004)[15], in the Caribbean, appeared to be near the global mean of 0.17 ± 0.05 m. It is projected that sea levels for Jamaica will increase under various scenarios, from a low of 0.18 m to 0.59 m and a high of 1.4 m. This will slow coastal development and influence displacement among population settlements.

12 The Intergovernmental Panel on Climate Change Fourth Assessment Report: Climate Change 2007.

13 John C Kostelnick. College of Mathematics and Natural Science, Haskell Indian Nations University.

14 Science on a Sphere datasets that shows rising sea level and changes in the Earth's appearance. https://sos.noaa.gov/Datasets/dataset.php?id=184 accessed 6 March 2017.

15 Church, JA., et al. 2001. Changes in sea level. In *Climate Change 2001: The Scientific Basis. Contribution of Working Group I to the Third Assessment Report of the Intergovernmental Panel on Climate Change,* Houghton, JT, et al. (eds.). Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, pp. 639–693.

In Jamaica, the Mona Climate Studies Group has estimated that continued sea level rise will cause progressive retreat and will require mitigation through sea walls and off -shore breakers. They also stated that salt water intrusion from rising sea levels coming into contact with aquifers may render the water useless for human consumption and agricultural use. Finally, vegetation in wetlands may change as a result of sea level rise and this will in turn affect fish that spawn and grow in wetland areas.

Physical Conditions: Natural Extreme Events and Disasters

Jamaica is located in the Atlantic Basin that includes the Atlantic Ocean, Caribbean Sea and the Gulf of Mexico, an area prone to hurricanes. The Atlantic hurricane season officially begins 30 June and ends on 30 November each year. Table 12 gives a list of hurricanes and other extreme climate events along with the economic impact associated with each.

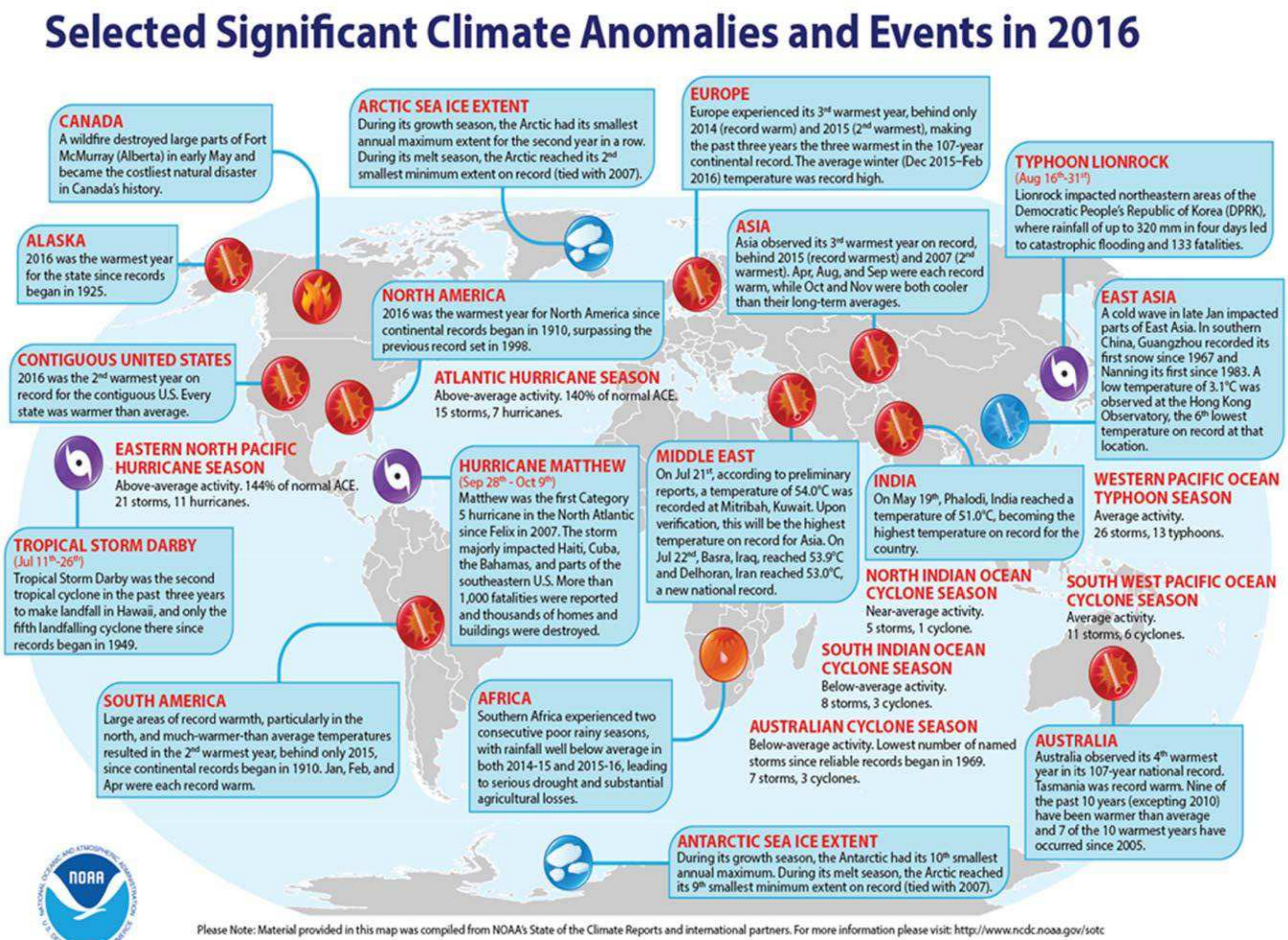
Table 12

Estimated Economic Impact of Recent Extreme Climate Events on Jamaica

Event	Year	Category	Cost (J$ billions)	Impact (% of GDP)
Hurricane Michelle	2001	4	2.5	0.8
May/June Flood Rains	2002		2.5	0.7
Hurricane Charley	2004	4	0.4	0.0
Hurricane Ivan	2004	3	36.9	8.0
Hurricanes Dennis & Emily	2005	4	6.0	1.2
Hurricane Wilma	2005	5	3.6	0.7
Hurricane Dean	2007	4	23.8	3.4
Tropical Storm Gustav	2008		15.5	2.0
Tropical Storm Nicole	2010		20.6	1.9
Hurricane Sandy	2012	1	9.7	0.8
Hurricane Matthew	2016	4	n.a.	n.a.

Source: Planning Institute of Jamaica and Office of Disaster Preparedness and Emergency Management (ODPEM)

n.a. = not available


Selected Significant Climate Anomalies and Events in 2016
CANADA
A wildfire destroyed large parts of Fort McMurray (Alberta) in early May and became the costliest natural disaster in Canada's history.
ALASKA
2016 was the warmest year for the state since records began in 1925.
CONTIGUOUS UNITED STATES
2016 was the 2nd warmest year on record for the contiguous U.S. Every state was warmer than average.
EASTERN NORTH PACIFIC HURRICANE SEASON
Above-average activity. 144% of normal ACE.
21 storms, 11 hurricanes.
TROPICAL STORM DARBY
(Jul 11th-26th)
Tropical Storm Darby was the second tropical cyclone in the past three years to make landfall in Hawaii, and only the fifth landfalling cyclone there since records began in 1949.
ARCTIC SEA ICE EXTENT
During its growth season, the Arctic had its smallest annual maximum extent for the second year in a row. During its melt season, the Arctic reached its 2nd smallest minimum extent on record (tied with 2007).
NORTH AMERICA
2016 was the warmest year for North America since continental records began in 1910, surpassing the previous record set in 1998.
ATLANTIC HURRICANE SEASON
Above-average activity. 140% of normal ACE.
15 storms, 7 hurricanes.
HURRICANE MATTHEW
(Sep 28th - Oct 9th)
Matthew was the first Category 5 hurricane in the North Atlantic since Felix in 2007. The storm majorly impacted Haiti, Cuba, the Bahamas, and parts of the southeastern U.S. More than 1,000 fatalities were reported and thousands of homes and buildings were destroyed.
SOUTH AMERICA
Large areas of record warmth, particularly in the north, and much-warmer-than average temperatures resulted in the 2nd warmest year, behind only 2015, since continental records began in 1910. Jan, Feb, and Apr were each record warm.
AFRICA
Southern Africa experienced two consecutive poor rainy seasons, with rainfall well below average in both 2014-15 and 2015-16, leading to serious drought and substantial agricultural losses.
EUROPE
Europe experienced its 3rd warmest year, behind only 2014 (record warm) and 2015 (2nd warmest), making the past three years the three warmest in the 107-year continental record. The average winter (Dec 2015–Feb 2016) temperature was record high.
ASIA
Asia observed its 3rd warmest year on record, behind 2015 (record warmest) and 2007 (2nd warmest). Apr, Aug, and Sep were each record warm, while Oct and Nov were both cooler than their long-term averages.
MIDDLE EAST
On Jul 21st, according to preliminary reports, a temperature of 54.0°C was recorded at Mitribah, Kuwait. Upon verification, this will be the highest temperature on record for Asia. On Jul 22nd, Basra, Iraq, reached 53.9°C and Delhoran, Iran reached 53.0°C, a new national record.
INDIA
On May 19th, Phalodi, India reached a temperature of 51.0°C, becoming the highest temperature on record for the country.
NORTH INDIAN OCEAN CYCLONE SEASON
Near-average activity.
5 storms, 1 cyclone.
SOUTH INDIAN OCEAN CYCLONE SEASON
Below-average activity.
8 storms, 3 cyclones.
AUSTRALIAN CYCLONE SEASON
Below-average activity. Lowest number of named storms since reliable records began in 1969.
7 storms, 3 cyclones.
ANTARCTIC SEA ICE EXTENT
During its growth season, the Antarctic had its 10th smallest annual maximum. During its melt season, the Arctic reached its 9th smallest minimum extent on record (tied with 2007).
TYPHOON LIONROCK
(Aug 16th-31st)
Lionrock impacted northeastern areas of the Democratic People's Republic of Korea (DPRK), where rainfall of up to 320 mm in four days led to catastrophic flooding and 133 fatalities.
EAST ASIA
A cold wave in late Jan impacted parts of East Asia. In southern China, Guangzhou recorded its first snow since 1967 and Nanning its first since 1983. A low temperature of 3.1°C was observed at the Hong Kong Observatory, the 6th lowest temperature on record at that location.
WESTERN PACIFIC OCEAN TYPHOON SEASON
Average activity.
26 storms, 13 typhoons.
SOUTH WEST PACIFIC OCEAN CYCLONE SEASON
Average activity.
11 storms, 6 cyclones.
AUSTRALIA
Australia observed its 4th warmest year in its 107-year national record. Tasmania was record warm. Nine of the past 10 years (excepting 2010) have been warmer than average and 7 of the 10 warmest years have occurred since 2005.
NOAA
Please Note: Material provided in this map was compiled from NOAA's State of the Climate Reports and international partners. For more information please visit: http://www.ncdc.noaa.gov/sotc

Climate Change Impacts and Vulnerability

Land Cover, Ecosystems and Biodiversity

Ecosystems and Biodiversity

FDES Topic 1.2.2. Ecosystems and biodiversity

Jamaica has a very robust and dynamic ecosystem which is threatened by human impacts such as changes in land use, pollution, over harvesting of commercially valuable species (e.g., fish, lobster and molluscs such as conch) and invasive species (such as lion fish). Stressors such as increasing land and sea temperatures, changing rainfall and runoff patterns, sea level rise and intense hurricanes can have adverse effects on ecosystems.

Beach Erosion

Natural erosion of a beach occurs mainly through the removal of sand by wave action, tidal currents, wave currents, high winds or drainage from rivers. Man-made causes of erosion come from illegal sand mining, shoreline alterations during development and the removal of the natural defences of a beach (mangroves and seagrass). During 2016, beach erosion data were collected from 34 sites in six parishes. In comparison with 2015, there was a 17.4 per cent increase in beach width across all locations assessed in 2016 (Table 13).

Table 13

Cumulative Summary of Beach Erosion in Jamaica: 2016

Parish/Location	No. of Sites	Cumulative Mean Beach Width (m) 2015	Cumulative Mean Beach Width (m) 2016	% Change 2015–16
Portland	5	18.6	23.98	29.0
Kingston	9	48.43	50.11	3.5
Trelawny	2	20.67	18.75	-9.3
Westmoreland (Other)	2	14.3	15.3	7.0
Negril (Hanover/Westmoreland)	14	31.75	37.39	13.0
Clarendon	2	16.87	27.15	60.9
Average		**25.1**	**28.78**	**17.4**

Source: National Environment and Planning Agency

Table 14

Coral Reef Index by Location: 2016

Site	CRHI		Location
Classroom Reef	2.5		
Sergeant Major	3.8	3.2	Montego Bay Marine Park
Airport Reef West	3.3		
Relocation 1	2.3	2.3	Falmouth
Oyster Bay	2.3		
Dairy Bull	2.8	2.3	Discovery Bay
Pear Tree Bottom	1.8		
RIU Nursery	2	2.4	Ocho Rios Marine Park
Dickies Reef	2.8		
Boscobel West	3.3	2.9	Sandals Boscobel Special Fishery Conservation Area
Boscobel Flat	2.5		
Commander Reef	1.5		
Golden Eye Coral Garden	2.3	1.8	Oracabessa Bay Special Fishery Conservation Area
Outer Bank	1.8		
Lime Cay	1.8	1.8	Palisadoes Port Royal Protected Area
Big Pelican Cay	1.3		
Wreck Reef	2.5	2.2	Portland Bight Protected Area
Pigeon Island West	2.8		
Old Bay	3.3	2.8	Whitehouse
Sandals Reef	2.3		
Cottage Reef	2.5	2.5	Belmont
Peter Tosh Reef	2.5		
El Punto Negrilo	2.3		
Bloody Bay	1.8	2.3	Negril Marine Park
Ireland Pen	2.8		
Round Hill	3.5	3.5	Hopewell

Overall CHRI –2.4

Source: National Environment and Planning Agency

Table 15

Reef Sites Assessed and Parameters Measured: 2016

Location/Site Name		Hard Coral (%/100m^2)	NIA (%/100m^2)	Total Herbivorous Fish (g/100m^2)	Total Commercial Fish (g/100m^2)
Montego Bay Marine Park	Classroom Reef	27.5	30.6	1682.2	0
	Sergeant Major	40.0	4.4	1339.5	1873.2
	Airport Reef West	51.3	2.5	565.2	759.6
Falmouth	Relocation 1	11.9	31.3	2016.5	60.9
	Oyster Bay	28.8	21.3	771.7	45.3
Discovery Bay	Dairy Bull	38.1	18.8	739.7	863.9
	Pear Tree Bottom	17.5	51.3	920	159.3
Ocho Rios Marine Park	RIU Nursery	12.5	51.9	1345.5	62.3
	Dickies Reef	36.9	1.9	121.6	35.2
Sandals Boscobel Special Fishery Conservation Area	Boscobel West	40.6	4.4	385.1	606.5
	Boscobel Flat	34.4	15.0	1087.1	107.6
Oracabessa Bay Special Fishery Conservation Area	Commander Reef	6.9	63.1	1242.1	89.2
	Golden Eye Coral Garden	15.6	48.8	2854.9	299.2
	Outer Bank	11.3	75.0	2208	117.8
Palisadoes Port Royal Protected Area	Lime Cay	8.8	36.3	261.5	81.6
Portland Bight Protected Area	Big Pelican Cay	1.3	55.6	880.9	171.5
	Wreck Reef	26.9	13.1	203.5	117.3
	Pigeon Island West	15.0	8.8	1495.1	58.9
Whitehouse	Old Bay	18.8	19.4	780.8	3336.9
	Sandals Reef	19.4	35.0	1616	249.6
Belmont	Cottage Reef	25.6	17.5	785.4	156.3
	Peter Tosh Reef	20.0	23.8	1727.3	30.2
Negril Marine Park	El Punto Negrilo	35.0	28.1	907	20.3
	Bloody Bay	11.9	55.6	959.7	11.3
	Ireland Pen	23.1	35.6	1519	174.7
Hopewell	Round Hill	53.8	3.8	2456.2	59.4
	Overall Average	**24.3**	**28.9**	**1187.4**	**367.2**

Source: National Environment and Planning Agency

NIA – nutrient indicating algae

Coral Reef Status

The 2016 Coral Reef Health Index (CRHI) Report from NEPA is based on assessments conducted on 26 reef sites. Four indicators: coral cover, macro-algal cover, herbivorous fish abundance and commercially important fish abundance are used to determine the reef index. Two reef sites that were assessed were ranked as being in good condition; 11 sites were ranked as poor; seven were ranked as fair and six as critical. The 2016 overall average index of 2.4 points to Jamaica's reefs being in poor condition. In 2015, the overall average index was 2.2 showing no major improvement or decline in reef health (see Table 14).

Reef health has been negatively affected by illegal and over-fishing as well as a lack of stewardship. The reef assessment also highlights the macro-algal dominance, often due to the reduction of key herbivore and high pressure of fishing. Fifty per cent of the reef sites assessed had coverage of over 20% while average hard coral cover was assessed at 24.3%/100m^2 as seen in Table 15. Coral cover is a measure of the proportion of the reef surface that is covered by live stony corals which form the three -dimensional network of the reef. **Reef Biota Index:** Herbivorous fish abundance measures the biomass of sturgeon and parrot fish; the most important grazers on plants that could overgrow the reef. Commercial fish abundance measures the biomass of commercially significant fish: grunts, groupers and snappers.

Biodiversity

Tables 16–18 highlight the number of species in Jamaica and those that are currently threatened, as reported by the International Union for Conservation of Nature (IUCN) as at December 2016. Table 18 refers to endemic species and the number of them which are deemed to be threatened. Tables 17–19 refer to the number of species that have been assessed (whether endemic or otherwise).

Table 16

Summary of Jamaica's Biodiversity

Group	No. of Species	% Endemic
Plants	>6,000	28
Butterflies	>120	~15
Frogs	19	17
Breeding birds	113	26
Migrant birds	100	0
Mammals	22	~4
of which:		
Bats	21	–

Source: National Environment and Planning Agency

Table 17

Threatened Species by Taxonomic Group: 2016

Specie	Number
Mammals	6
Birds	10
Reptiles*	21
Amphibians	15
Fish*	30
Molluscs*	–
Other Invertebrates*	15
Plants*	214
Total	**311**

Source: IUCN Red List version 2016.3

Table 18

Total Endemic and Threatened Species by Taxonomic Group: 2016

Specie	Endemic	Threatened
Mammals	7	4
Birds	31	5
Amphibians	21	15
Conifers	2	2
Cacti	5	2

Source: IUCN Red List version 2016.3

Endemic species = those known to occur naturally within one country only.

Threatened species = those assessed in any of the three threatened Red List categories (Critically Endangered, Endangered, Vulnerable)

Table 19

Red List Category Summary: 2016

Item	Animals	Plants
Extinct	4	2
Extinct in the Wild	–	–
Critically Endangered	20	41
Endangered	30	55
Vulnerable	47	118
Not Threatened	41	75
Lower Risk	–	–
Data Deficient	89	7
Least Concern	1,149	135
Total	**1,380**	**433**

Source: IUCN Red List version 2016.3

Dr Dale Webber of the UWI, Mona highlighted ways in which Jamaica's biodiversity is likely to be impacted by climate change[16] citing that **increases in land temperature** will alter the number of species and the way in which they are currently distributed within their ecosystems. Some species will adapt to the changing environment by genetically mutating while others will seek higher altitude. Some plants may experience changes in the length of their growing pattern and others may become extinct. Increased sand temperatures may reduce the male turtle population, thus causing changes in their sex ratios.

Changes in rainfall and runoff may result in the loss of species and alterations in the community composition as a result of the drying ecosystems due to a lack of water. The area an ecosystem currently occupies may be changed thereby impacting the types of species living in, and making up, that ecosystem. On the other hand, there could be flooding of nests of various species consequently leading to the death of the nestlings.

Sea level rise may result in changes in the coral reefs and shallow water marine communities. There may be increased flooding of coastal wetlands and lowlands as well as intrusion of salt water vegetation into freshwater ecosystems in coastal areas. A loss of estuarine – place where the river meets the sea and salt water is diluted by freshwater – coastal species, and communities. Estuaries are very productive and house many species that are not found in the sea or river, they provide food and shelter to many species. Endangered turtle species and crocodiles may be at risk of losing their nesting and feeding habitats.

[16] Dale Webber's Climate Change Impact on Jamaica's Biodiversity. https://www.uwi.edu/physics/sites/default/files/physics/uploads/Dr.%20Dale%20Webber%20-%20Climate%20Change%Impacts%20On%20Jamaica%27S%20Biodiversity.pdf.

Higher sea surface temperature can create conditions that support invasive species to thrive in new areas. Can cause coral bleaching or the death of corals, as well as the elimination of coral reefs that are habitats for a large number of species.

Changing hurricane intensity may not only lead to the loss of vulnerable species, but may cause damage to nest and nesting sites. In addition, there may be changes in species competitive interaction and community composition, and the range of invasive species; destruction of coral reefs, mangrove and terrestrial (particularly forests) ecosystems.

Forests

Forest area

Between 2010 and 2014, there has been a 30.2 per cent increase in Jamaica's total forest area as seen in Table 20. Protected forest area increased by 8.5 per cent, from 113.1 hectares in 2010 to 122.7 hectares in 2014, while total land area experienced a slight decline of 0.05 per cent. During the years 2010–2012, 33.6 per cent of the total forest area was protected followed by declines of 27.9 per cent and 28.0 per cent in 2013 and 2014 respectively.

Table 20

Protected Forest Area as Percentage of Total Land Area: 2010–2014, '000 ha

Category	2010	2011	2012	2013	2014
Total forest area	337.1	336.7	336.4	439.9	438.8
Protected forest area	113.1	113.0	112.9	122.7	122.7
Total land area	1,095.1	1,094.9	1,094.7	1,094.5	1,094.5
Protected forest area as a % of total forest area	33.6	33.6	33.6	27.9	28.0
Protected forest area as a % of total land area	10.3	10.3	10.3	11.2	11.2

Source: Forestry Department

Land: Land Use - Area Under Land Use Category

Land Use, Land Use Change and Forestry (LULUCF)

FDES Topic 2.3.2.
Use of forest land

The change in land use and forestry is believed to contribute to GHG emissions, as forests, wetlands and grasslands are destroyed for housing or road developments. There is a 0.4 per cent annual deforestation rate when comparing 1998 and 2013 forest land use cover as seen in Table 21.

Table 21

Land Use in Jamaica: 1988 and 2013, hectares

Category	1988	2013
Forest Land Use/Cover >75%	337,223.0	439,937.8
Mixed Land Use Cover (first class > 50%, second class >25%	299,458.6	199,573.5
Non-Forest Land Use/Cover	459,570.7	459,589.8
Small Islands	164.0	…
Total Area	**1,096,416.3**	**1,099,101.1**

Source: Forestry Department

Jamaica has seen an afforestation rate of 0.4 per cent in 2013 when compared to 1998. This is largely due to an increase in secondary forests (bush) and a slight increase in plantations, as seen in Table 22. Contrasting this, all major forest categories, which include open dry forest short, open dry forest tall and closed broadleaf forest recorded declines over the period.

Table 22

Land Use/Cover Change in Jamaica: 1988 and 2013, hectares

Forest Land Use /Cover >75% Land Use/Cover Classification	1988	2013	Difference (hectares)	Per Cent Loss/Gain
Closed broadleaf forest[1]	88,364.0	84,645.7	-3,718.3	-4.2
Disturbed broadleaf forest	178,323.3	175,258.4	-3,064.9	-1.7
Open dry forest – Tall	41,998.8	37,571.6	-4,427.2	-10.5
Open dry forest – Short	12,104.1	2,619.6	-9,484.5	-78.4
Plantation	4,172.5	8,326.8	4,154.3	99.6
Secondary forest*[2]		40,973.4	40,973.4	
Mangrove forest	9,748.0	9,751.7	3.7	0.0
Swamp forest	2,247.1	122.9	-2,124.1	-94.5
Sub-total	**336,957.7**	**359,270.2**	**22,312.4**	**6.6**
Annual deforestation rate				0.4
Secondary forest*		82,024.7		
Total Forest Cover		**441,294.9**		

Table 22 (cont'd)

Land Use/Cover Change in Jamaica: 1988 and 2013, hectares

Forest Land Use /Cover >75% Land Use/Cover Classification	1988	2013	Difference (hectares)	Per Cent Loss/Gain
Mixed Land Use/Cover (first class> 50%, second class> 25%)				
Fields and secondary forest	117,828.3	166,379.2	48,551.0	41.2
Bauxite and disturbed broadleaf**	2,819.3			
Bamboo and secondary forest	12,685.9	36,819.4	24,133.6	190.2
Disturbed broadleaf and fields**	166,395.1			
Sub-total	**299,728.5**	**203,198.7**	**-96,529.8**	**-32.2**
Mixed land use/cover growth rate				-2.01
Non Forest Land Use/Cover				
Bamboo	2,980.4	4,667.4	1,687.0	56.6
Bamboo and Fields	29,190.0	66,835.1	37,645.1	129.0
Bauxite Extraction	4,919.5	3,393.1	-1,526.4	-31.0
Bare Rock	933.9	2,405.4	1,471.6	157.6
Cultivation: (Fields) Herbaceous crops, fallow, cultivated vegetables	274,313.9	153,665.1	-120,648.8	-44.0
Fields: Pasture, grassland*		6,626.8		
Herbaceous wetland	10,914.2	14,500.1	3,586.0	32.9
Crop plantation: Tree crops, shrub crops, sugar cane, banana	82,491.1	70,230.9	-12,260.2	-14.9
Buildings and other infrastructure	52,278.7	117,362.5	65,083.8	124.5
Water bodies	1,586.1	5,176.0	3,589.9	226.3
Quarries*		720.3		
Bare land*		7,203.2		
Sub-total	**459,607.7**	**452,785.9**	**-6,821.8**	**-1.5**
Non-forest land use/cover growth rate				-0.09
Small islands	164.0			
Total	**1,096,457.9**	**1,097,279.4**		

Source: Forestry Department
* New categories added to land use classification.
** Category removed from land use classification.
1. >75% broadleaf forest and <25% fields (this differs from disturbed broadleaf which has a maximum of 15% fields).
2. Secondary forest includes 75% of secondary forest and fields + 75% of *secondary forest and bamboo.
3. The 25% of the fields from the "secondary forest & fields" was added to the category "fields and secondary" while the 25% of the bamboo was added the category "bamboo & secondary".
4. Plantation includes hardwood and other.

Mitigation and Adaption

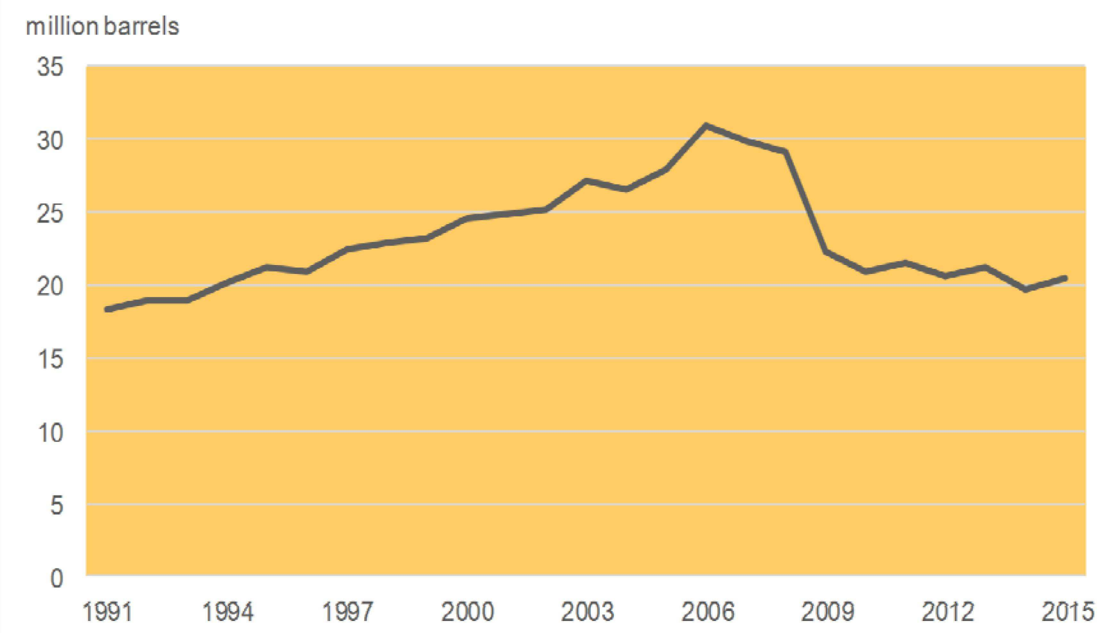
Energy Resources

FDES Topic 2.2.2. Production, trade and consumption of energy

Jamaica has a widespread energy infrastructure with almost all the population, 93.3 per cent of households using electricity having access to electricity[17]. The country has been looking to diversify its energy portfolio by introducing renewable energy sources to include wind turbines and ethanol dehydration. The Government of Jamaica's policy is that 30.0 per cent of energy to the national grid will be renewable sources by the year 2030. However, the level of energy intensity in Jamaica has increased over the last two decades, rather than decreased, and progress towards increasing the use of renewables has been modest[18].

Figure 9

Total Petroleum Imports 1991–2015, million barrels



Source: Ministry of Science, Energy and Technology

Jamaica remains heavily dependent on imported petroleum fuels which account for over 90.0 per cent of the energy mix (shown in Table 23) with the remainder derived from renewable sources. Bagasse, fuelwood and charcoal are the main sources of renewable energy, followed by hydro, wind, ethanol and solar. Charcoal production (along with farming and housing development) are major contributors to Jamaica's deforestation rate of about 0.5% per annum.

[17] Jamaica Survey of Living Conditions 2014

[18] Sustainable Energy for All; Rapid Assessment Gap Analysis Jamaica at http://www.se4all.org/sites/default/files/Jamaica_RAGA_EN_Released.pdf

Table 23

Primary Energy Supply by Source: 2011–2015 ('000 boe)

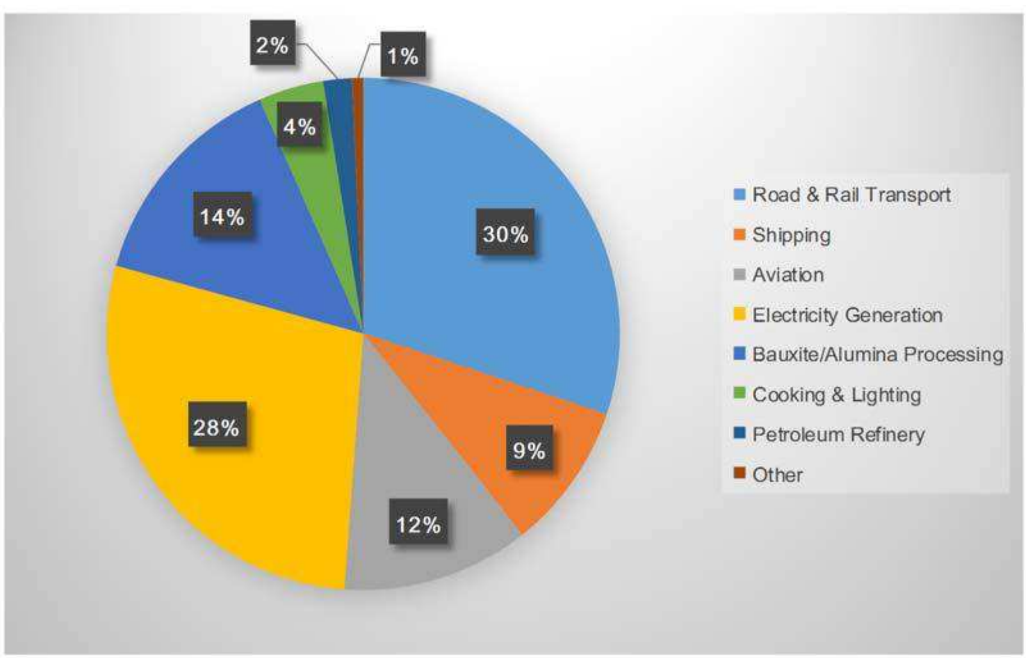
Source	2011	2012	2013	2014	2015[p]
Petroleum[1)]	19,807	19,280	19,183	19,183	18,106
Hydropower	94	93	77	84	80
Wind	57	67	71	74	78
Coal	327	284	450	574	511
Bagasse	579	570	626	677	621
Fuelwood	n.a.	n.a.	n.a.	n.a.	n.a.
Total Alternative Energy	**1,057**	**1,014**	**1,224**	**1,409**	**1,290**
Total	**20,864**	**20,294**	**20,407**	**20,592**	**19,396**

Source: Ministry of Science, Energy & Technology
boe – barrel of oil equivalent
[1)] Does not include asphalt, lubricants and petrochemicals

Road and rail, electricity generation and bauxite/alumina processing are the largest users of energy. This is followed by aviation, shipping and cooking and lighting as seen in Figure 11.

Figure 11

Petroleum Consumption by Sector: 2015, '000 barrels



Source: Ministry of Science, Energy and Technology

The total production of Jamaica's alternative energy has remained relatively stable between 2011 and 2015, with a 15.0 per cent increase in 2014 over 2013 as can be seen in Table 24. The preliminary data for 2015 showed a decrease of 119 boe.

Table 24

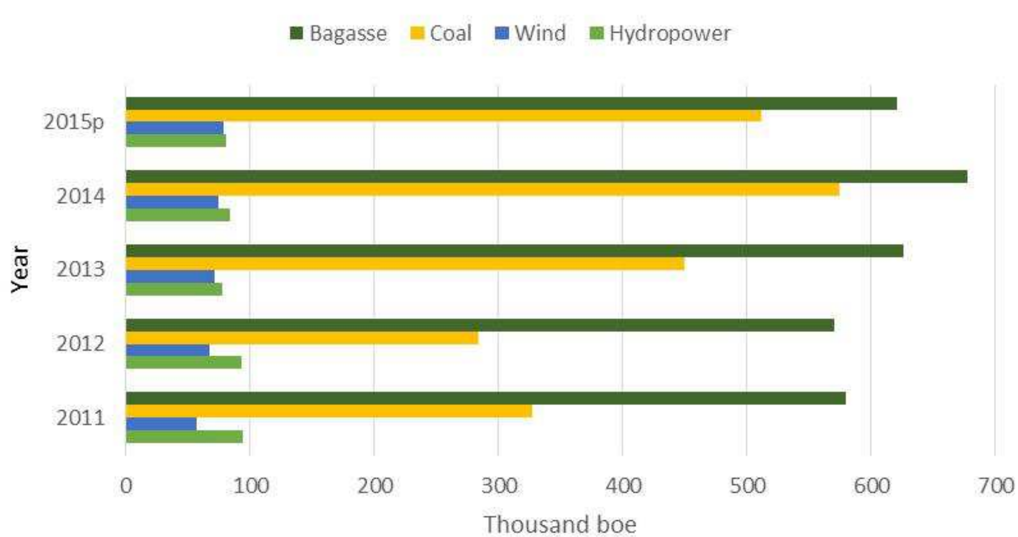
Total Alternative Energy Production: 2011-2015

Energy Source	Unit	2011	2012	2013	2014	2015[p]
Hydropower	'000 mwh	152	151	124	136	129
	'000 boe	94	93	77	84	80
Wind	'000 mwh	91	107	115	119	125
	'000 boe	57	67	71	74	78
Coal	'000 tonnes	65	56	89	114	101
	'000 boe	327	284	450	574	511
Charcoal	'000 boe	n.a.	n.a.	n.a.	n.a.	n.a.
Bagasse	'000 boe	579	570	626	677	621
Fuelwood	'000 boe	n.a.	n.a.	n.a.	n.a.	n.a.
Total Alternative Energy	'000 boe	**1,057**	**1,014**	**1,224**	**1,409**	**1,290**

Source: Ministry of Science, Energy & Technology

Figure 12

Total Alternative Energy, '000 boe



Source: Ministry of Science, Energy & Technology

Jamaica has developed an energy sector policy which was completed in 2009 and energy is one of the strategic priority areas of the National Development Plan, Vision 2030. Jamaica's National Energy Policy 2009–2030 states that Jamaica is to develop its renewable energy sources and enhance its international competitiveness and energy security while simultaneously reducing its carbon footprint.. One of the main purposes of setting these national targets is to encourage investment and relevant research.

International Environmental Conventions Which Jamaica Has Either Signed or Ratified

FDES Topic 6.2.3. Participation in MEAs and other global environmental conventions

1 Vienna Convention for the Protection of the Ozone Layer, 1985

2 Montreal Protocol on Substances that Deplete the Ozone Layer, 1987

3 London Amendment to the Montreal Protocol on Substances that Deplete the Ozone Layer, 1990

4 Copenhagen Amendment to the Montreal Protocol on Substances that Deplete the Ozone Layer, 1992

5 United Nations Framework Convention on Climate Change, 1992

6 Kyoto Protocol to the 1992 United Nations Convention on Climate Change, 1997

7 Convention on Biological Diversity, 1992

8 United Nations Convention to Combat Desertification in those Countries Experiencing Serious Drought and/or Desertification, particularly in Africa, 1994

9 Stockholm Convention, 2001

Conclusion

While climate is measured slowly, spanning decades and centuries across time, climate change (the long term shift in weather conditions) is said to be changing more rapidly as a result of human activities. Carbon dioxide is released into the air as a result of the burning of fossil fuels termed greenhouse gases which contribute to global warming. Temperature, precipitation and sea level rise have been altered as a result of climate change.

Jamaica's overall temperature is said to be increasing and hurricanes are occurring with greater degrees of intensity. This change in climate impacts the ecosystem, energy, tourism, health and agriculture and creates dissonance in the lives of the citizens and policy makers. Several sectors within the Jamaican economy, including energy, agriculture, waste and forestry, contribute to GHG emissions.

The country has implemented several strategies aimed at mitigating the effects of climate change. These include policies governing the energy sector; and giving climate change a prominence by including it as a division within a government ministry currently housed under the Ministry of Economic Growth and Job Creation. The country is also a signatory to the United Nations Framework Convention on Climate Change

(UNFCCC), among others. Several reports and publications have been written about the impact of climate change on Jamaica. These are aimed at assisting policy makers and influencing policy change. Climate change also holds a central theme in the country's development plan, Vision 2030. Agencies, both government and non-government have offered loans at reduced rates for households and businesses to procure energy saving implements such as light bulbs and solar water heaters.

Although there has been improvement in the area, more that can be done to ensure a holistic approach to climate change and a buy-in of the public at the community level. Development projects should include climate change mitigation features as it relates to *inter alia* energy, waste, ecosystem, greenhouse gas emissions, water, etc. Children and the general public should be made aware through educational campaigns how a person's actions can cause changes in the environment and the resultant impact of those actions. In addition, persons should be taught how to measure their carbon footprint with a view of consciously reducing same over time. Increased funding for climate change initiatives within the top greenhouse gas-producing sectors, as well as rehabilitation efforts for areas that have shown higher levels of susceptibility to the impacts of climate change are other suggestions.

Appendix I

The United Nations Framework for the Development of Environment Statistics (FDES) organises environment statistics into components, sub-components and statistical topics. The Basic Set of Environment Statistics, which is organized in three tiers, based on the level of relevance, availability and methodological development of the statistics, can be used to measure the statistical topics. Tier 1 defines the Core Set of Environment Statistics, a set of statistics which it is recommended that countries consider producing in the short term. The scope can be gradually widened to the statistics contained in Tier 2 and Tier 3 as national priorities require and as data availability and resources permit.

Application of the FDES to climate change statistics

While the FDES does not contain a component on climate change statistics, those statistics are considered to be cross-cutting as they combine statistics from various components included in the FDES. Aspects of climate change statistics which are related to environment statistics are listed below. The list reflects the drivers of climate change, the evidence, impacts and the vulnerability of planet as well as data that can be used for mitigation and adaptation.

FDES Climate Change Statistics

(**Bold Text** – **Core Set**/Tier 1; Regular Text – Tier 2; *Italicized Text – Tier 3*)

Climate Process Drivers

Sub-component 1.3: Environmental Quality

1.31.1 Air Quality

1.3.1.b: Global atmospheric concentrations of greenhouse gases

- 1.3.1.b.1 Global atmospheric concentration level of carbon dioxide (CO_2)
- 1.3.1.b.2 Global atmospheric concentration level of methane (CH_4)

Sub-component 3.1: Emissions to Air

3.1.1 Emissions of greenhouse gases

3.1.1.a: Total emissions of direct greenhouse gases (GHGs), by gas:

- **3.1.1.a.1: Carbon dioxide (CO_2)**
- **3.1.1.a.2: Methane (CH_4)**
- **3.1.1.a.3: Nitrous oxide (N_2O)**
- 3.1.1.a.4: Perfluorocarbons (PFCs)
- 3.1.1.a.5: Hydrofluorocarbons (HFCs)
- 3.1.1.a.6: Sulphur hexafluoride (SF_6)

3.1.1.b: Total emissions of indirect greenhouse gases (GHGs), by gas:

- **3.1.1.b.1: Sulphur dioxide (SO_2)**
- **3.1.1.b.2: Nitrogen oxides (NO_x)**
- 3.1.1.b.3: Non-methane volatile organic compounds (NM-VOCs)
- 3.1.1.b.4: Other

3.1.2: Consumption of ozone depleting substances

3.1.2.a: Consumption of ozone depleting substances (ODSs), by substance:

- 3.1.2.a.1: Chlorofluorocarbons (CFCs)
- 3.1.2.a.2: Hydrochlorofluorocarbons (HCFCs)

3.1.2.a.3: Halons
3.1.2.a.4: Methyl chloroform
3.1.2.a.5: Carbon tetrachloride
3.1.2.a.6: Methyl bromide
3.1.2.a.7: Other

Climate Change Evidence

Sub-component 1.1: Physical Conditions

1.1.1: Atmosphere, climate and weather
1.1.1.a: Temperature
1.1.1.a.1: Monthly average
1.1.1.a.2: Minimum monthly average
1.1.1.a.3: Maximum monthly average
1.1.1.b: Precipitation (also in 2.6.1.a)
1.1.1.b.1: Annual average
1.1.1.b.2: Long-term annual average
1.1.1.b.3: Monthly average
1.1.1.b.4: Minimum monthly value
1.1.1.b.5: Maximum monthly value

1.1.2: Hydrographical characteristics
1.1.2.e: Seas
1.1.2.e.4: Sea level

Sub-component 4.1: Natural Extreme Events and Disasters

4.1.1: Occurrence of natural extreme events and disasters
4.1.1.a: Occurrence of natural extreme events and disasters
4.1.1.a.1: Type of natural extreme event and disaster (geophysical, meteorological, hydrological, climatological, biological)
4.1.1.a.2: Location
4.1.1.a.3: Magnitude (where applicable)
4.1.1.a.4: Date of occurrence
4.1.1.a.5: Duration

Sub-component 1.1: Physical Conditions

Topic 1.1.2: Hydrographical characteristics
1.1.2.a: Lakes
1.1.2.a.1: Surface area
1.1.2.a.2: Maximum depth
1.1.2.b: Rivers and streams
1.1.2.b.1: Length
1.1.2.c: Artificial reservoirs
1.1.2.c.1: Surface area
1.1.2.c.2: Maximum depth
1.1.2.e: Seas
1.1.2.e.5: Area of sea ice
1.1.2.g: Glaciers

1.1.4: Soil characteristics

1.1.4.b: Soil degradation

1.1.4.b.2: Area affected by desertification

Sub-component 1.2: Land Cover, Ecosystems and Biodiversity

1.2.1: Land cover

1.2.1.a: Area under land cover categories

1.2.2: Ecosystems and biodiversity

1.2.2.a: General ecosystem characteristics, extent and pattern

1.2.2.a.1: Area of ecosystems

1.2.2.b: Ecosystems' chemical and physical characteristics

1.2.2.b.2: Carbon

1.2.2.c: Biodiversity

1.2.2.c.1: Known flora and fauna species

1.2.2.c.2: Endemic flora and fauna species

1.2.2.c.3: Invasive alien flora and fauna species

1.2.2.c.4: Species population

1.2.2.c.5: Habitat fragmentation

1.2.3: Forests

1.2.3.a: Forest area

1.2.3.a.1: Total

1.2.3.a.2: Natural

1.2.3.a.3: Planted

1.2.3.a.4: Protected forest area (also in 1.2.2.d)

1.2.3.a.5: Forest area affected by fire

1.2.3.b: Forest biomass

1.2.3.b.1: Total

1.2.3.b.2: Carbon storage in living forest biomass

Sub-component 1.3: Environmental Quality

1.3.3: Marine water quality

1.3.3.b: Organic matter

1.3.3.b.1: Biochemical oxygen demand (BOD)

1.3.3.b.2: Chemical oxygen demand (COD)

1.3.3.f: Physical and chemical characteristics [of marine water bodies]

1.3.3.f.1: pH/Acidity/Alkalinity

1.3.3.f.2: Temperature

1.3.3.f.3: Total suspended solids (TSS)

1.3.3.f.4: Salinity

1.3.3.f.5: Dissolved oxygen (DO)

1.3.3.f.6: Density

1.3.3.g: Coral bleaching

1.3.3.g.1: Area affected by coral bleaching

Sub-component 2.3: Land

2.3.1: Land use
2.3.1.a: Area under land use categories
2.3.2: Use of forest land
- 2.3.2.a: Use of forest land
- **2.3.2.a.1: Area deforested**
- 2.3.2.a.2: Area reforested
- 2.3.2.a.3: Area afforested
- *2.3.2.a.4: Natural growth*

Sub-component 4.1: Natural Extreme Events and Disasters

4.1.2: Impact of natural extreme events and disasters
4.1.2.a: People affected by natural extreme events and disasters
- **4.1.2.a.1: Number of people killed**
- 4.1.2.a.2: Number of people injured
- 4.1.2.a.3: Number of people homeless
- 4.1.2.a.4: Number of people affected

4.1.2.b: Economic losses due to natural extreme events and disasters
- 4.1.2.c: Physical losses/damages due to natural extreme events and disasters
- 4.1.2.d: Effects of natural extreme events and disasters on integrity of ecosystems
- *4.1.2.d.1: Area affected by natural disasters*
- *4.1.2.d.2: Loss of vegetation cover*
- *4.1.2.d.3: Area of watershed affected*
- *4.1.2.d.4: Other*

Sub-component 5.1: Human Settlements

5.1.3: Housing conditions
- 5.1.3.c: Population living in hazard-prone areas
- 5.1.3.d: Hazard-prone areas

Sub-component 5.2: Environmental Health

5.2.3: Vector-borne diseases
- 5.2.3.a: Vector-borne diseases
- **5.2.3.a.1: Incidence**
- **5.2.3.a.2: Prevalence**
- **5.2.3.a.3: Mortality**
- *5.2.3.a.4: Loss of work days*
- *5.2.3.a.5: Estimates of economic cost in monetary terms*

5.2.4: Health problems associated with excessive UV radiation exposure
5.2.4.a: Problems associated with excessive UV radiation exposure
- *5.2.4.a.1: Incidence*
- *5.2.4.a.2: Prevalence*
- *5.2.4.a.3: Loss of work days*
- *5.2.4.a.4: Estimates of economic cost in monetary terms*

Mitigation and Adaptation

Sub-component 2.2: Energy Resources

2.2.2: Production, trade and consumption of energy

2.2.2.a: Production of energy

- 2.2.2.a.3: Production from renewable sources

Sub-component 6.1: Environment Protection and Resource Management Expenditure

6.1.1: Government environment protection and resource management expenditure

6.1.1.a: Government environment protection and resource management expenditure [on climate change mitigation activities]

- **6.1.1.a.1: Annual government environment protection expenditure**
- 6.1.1.a.2: Annual government resource management expenditure

6.1.2: Corporate, non-profit institution and household environment protection and resource management expenditure

6.1.2.a: Private sector environment protection and resource management expenditure [on climate change mitigation activities]

- 6.1.2.a.1: Annual corporate environment protection expenditure
- *6.1.2.a.2: Annual corporate resource management expenditure*
- *6.1.2.a.3: Annual non-profit institution environment protection expenditure*
- *6.1.2.a.4: Annual non-profit institution resource management expenditure*
- *6.1.2.a.5: Annual household environment protection expenditure*
- *6.1.2.a.6: Annual household resource management expenditure*

Sub-component 6.2: Environmental Governance and Regulation

6.2.2 Environmental regulation and instruments

6.2.2.a: Direct regulation

- **6.2.2.a.1: List of regulated water pollutants and description** (e.g., by year of adoption and maximum allowable levels) [related to climate change]
- 6.2.2.a.2: Description (e.g., name, year established) of licensing system to ensure compliance with environmental standards for businesses or other new facilities [related to climate change]
- 6.2.2.a.3: Number of applications for licenses received and approved per year [related to climate change]
- 6.2.2.a.4: List of quotas for biological resource extraction
- 6.2.2.a.5: Budget and number of staff dedicated to enforcement of environmental regulations [related to climate change]

6.2.2.b: Economic instruments [related to climate change]

- *6.2.2.b.1: List and description (e.g., year of establishment) of green/ environmental taxes*
- *6.2.2.b.2: List and description (e.g., year of establishment) of environmentally relevant subsidies*

6.2.2.b.3: List of eco-labelling and environmental certification programmes

6.2.2.b.4: Emission permits traded

6.2.3: Participation in MEAs and other global environmental conventions

6.2.3.a: Participation in MEAs and other global environmental conventions

6.2.3.a.1: List and description (e.g., country's year of participation[(a)]) of MEAs and other global environment conventions [related to climate change]

Sub-component 6.3: Extreme Event Preparedness and Disaster Management

6.3.1: Preparedness for natural extreme events and disasters

6.3.1.a: National natural extreme event and disaster preparedness and management systems

6.3.1.a.1: Existence of national disaster plans/programmes

6.3.1.a.2: Description (e.g., number of staff) of national disaster plans/ programmes

(a) Participation means that the country or area has become party to the agreements under the treaty or convention, which is achieved through various means, depending on the country's circumstances, namely: accession, acceptance, approval, formal confirmation, ratification and succession. Countries or areas that have signed but not become party to the agreements under a given convention or treaty are not considered to be participating.

List of Tables, Figures and Boxes

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