

"Let's Make A Difference..."

A Caribbean Primer on Climate Change



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And The Climate Studies Group, Mona



SGP The GEF
Small Grants
Programme



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OF JAMAICA

Let's Make a Difference:

A Caribbean Primer on
Climate Change

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and the Climate Studies Group, Mona

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Story: Is it alive anyway? © Sharon Bramwell-Lalor

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Introduction

Climate Change and You!

Climate change is a topic that has been in focus in recent times. What is it and should you be concerned? This book was written to help you to understand what climate change is, its causes, impacts and what we can do to address it. This book will feature real-life local, regional, and international examples linked to climate and climate change. You will also notice that climate change is already included in the subjects you are learning at school.

Some of the things you will learn about in this book are:

- **Unit One** - An overview of the science of living things.
- **Unit Two** - Why is the Earth's climate changing?
- **Unit Three** - What are the trends in the changing climate?
- **Unit Four** - An overview of what has happened to the Earth because of climate change and what may happen in the future if our climate continues to change.
- **Unit Five** - How humans can work on reducing the effects of climate change.

Why is a book like this necessary? Young persons are more likely to have to live with the long-term effects of a changing world. They are also expected to be the ones who will need to make wise decisions which will improve the lives of those around them for decades. In order to make decisions that lessen future impacts, it is essential that students learn all they can about issues such as climate change. This book will also assist teachers in supporting students' understanding of climate change.

We hope that you will find this book helpful and informative.



***Climate has changed. Climate will change.
Climate demands change!***

Professor Michael Taylor, The Grace Kennedy
Foundation Lecture (2015) Kingston, Jamaica



UNIT ONE

**Basic Principles
of the Science
of Living Things**



**Data at the time from the
*World Meteorological
Organization suggested that
July 2019 might have been the
hottest month in the recorded
history of the Earth.**

*

World Meteorological Organization is an International organisation focused on weather, climate and water data analyses to assist countries by providing early warnings for extreme weather and climate events.

Jamaica is among the countries that experienced very hot temperatures in 2019. Two headlines from different sources then were: *Hot Spell Sets New Record-Breaking Temperatures for Jamaica*¹ and *It's Getting Hotter Still*².

Were those just one-off situations? Or has the Earth been getting warmer as the years go by? Have you heard your parents and older family members complaining about feeling hotter now than in times past? What is the cause? Is this just a natural development? If the Earth's climate is changing and continues to change, what will happen to living things and natural resources? If the climate is changing, can anything be done to reverse it or slow it down?

According to scientists, the Earth's climate has been changing for a while, and the role of humans in the rate of the change has been a cause for concern. There are many people however, who question whether climate is in fact changing. As a result, in 1989, the Intergovernmental Panel on Climate Change (IPCC) was set up by the World Meteorological Organization and the United Nations Environment Programme to provide scientific information about climate change to governments across the world.

Climate change affects every aspect of our lives. If you watch or listen to the news you will see that disastrous climate-related events are being experienced around the world. This makes climate change an urgent issue for all of us, but especially for young people like you who may have to face its most severe effects in the future.

For us to know and understand more about climate and why it is changing, let's start by looking at the Earth, its inhabitants and the many relationships that exist among these components.

1 Meteorological Service of Jamaica, August 2019, <https://www.jamaicaclimate.net/hot-spell-sets-new-record-breaking-temperatures-for-jamaica/>

2 The Jamaica Observer, July 15, 2019; https://www.jamaicaobserver.com/opinion/it-s-getting-hotter-still_169960

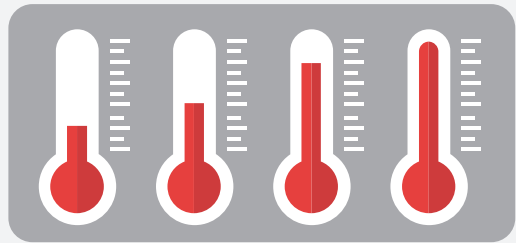


Internet Safety Reminder!

When you use the Internet to conduct research for your school activities, play interactive games or communicate with your teachers or classmates, please **DO NOT** share any personal photos or other information about yourself to anyone online. Please speak to your teacher or an adult at home if you see and hear anything on the Internet that makes you uncomfortable.

Activity One Let's get started!

1. Do a quick Internet search to see if the record hot temperature in July 2019 has since been broken.
2. If it has, use it as the starting point for your discussion on whether climate change is real!



Lesson One: Living Things - The Basics of Life

When you have completed this lesson you should be able to:

1. Define what living things are.
2. State the characteristics of living things.
3. Identify what living things need for survival.
4. Identify the energy usage of humans in everyday life and provide reasons for the usage.
5. State some sources of energy.

Is it alive anyway?

© Sharon Bramwell-Lalor

Part One

It was mango season, and siblings Adrian and Christal could not wait for the dismissal bell to end the school day. All day they had fantasized about eating the juicy and succulent Julie mangoes from the huge mango tree! This tree was located at a playfield next to Mr. Bigga's yard which they would pass on their way home. As soon as they heard the bell, they hurried out. They got to the tree; bags fell on the ground, plop! The ripe mangoes seemed to stare invitingly at them. Getting to these mangoes, however, would prove a difficult task because the tree was very tall.



Adrian was uncertain about climbing the tree; he vividly remembered his father telling him stories about how he fell from an apple tree when he was a child and broke his leg. Adrian, remembering this, turned to his little sister and said, "It seems like I'll have to stone them if we are to get any mangoes". Grabbing a stone slightly bigger than his fist, Adrian flung it with all his might in the direction of the fruits. Down came some small, unripe mangoes. He shook his head in disappointment and tried again...no luck. Each time he threw a stone, unripe fruits fell while the ripe, prized targets remained in the tree.



In frustration, Adrian threw his next stone wildly at the tree. Christal shouted, "Adrian! Let's just go home!" "I'm not leaving without some ripe mangoes!" he replied angrily. "Adrian!" his sister insisted, "look how many young mangoes you hit down". Adrian glanced at the fruits on the ground, and there was not one ripe mango in sight – only green ones and a few seedlings here and there. Adrian then said to his sister, "So?... Why does it bother you? Are they alive anyway?"

Is it living or non-living? How can you tell?

Do you have the same question as Adrian? Is the tree alive? You can easily say that **you** are alive. What makes you believe that? Scientists have also asked the same question, "What makes living things different from non-living things?" Based on their studies we use some specific properties to decide if something is alive or not. These are called the **characteristics of living things**.

What do all living things have in common?

Table 1.1: The Characteristics of Living Things

Characteristics of living things	Description
Respiration	Respiration is a process by which an organism takes oxygen (which is a gas) from the air, into its cells and uses it to get energy from food. The energy is used for all the tasks which help the organism to grow and to be healthy. As a result of respiration, the cells produce another gas called carbon dioxide .
Growth and development	Growth and development occurs when an organism changes in size and appearance over time. For example, a mango, apple, or June plum seed looks nothing like the tree they grow to become. Another example is your growth. You can visibly see how much you have changed in photographs over time by looking at your baby pictures and comparing them with what you look like at this moment.
Movement	Movement is more visible in some living things than others. For example, you often see when butterflies, birds, cows, and fish move from one place to another. It is, however, not so easy to see plants moving on their own because they are rooted to one spot. If you look carefully at plants, you may see their flowers open and close or their seedlings developing over time.
Response to changes in surroundings	The surroundings or environment of living things changes. Living things make adjustments to survive in their surroundings. For example, plants grow towards light, and lizards hide in cool places on hot days. Lizards will also move to keep themselves safe.
Removal of waste products	When living things carry out their functions, they have "left-overs" which they don't need or cannot use. They get rid of these "left-overs" in a process called excretion . If they do not remove this waste, it will pile up and some can become harmful. Urine and carbon dioxide are examples of waste products.

Reproduction

For living things to continue to exist, they make more organisms like themselves. This is called **reproduction**. They do this in different ways.

All living things or **organisms** are made up of tiny units called **cells**. You cannot see cells with the naked eye. A special instrument called a **microscope** has to be used to recognize them. Some organisms, such as **bacteria**, have only one cell, while some **animals**, such as cats and dogs, have many cells. Inside these cells are structures that carry out specific activities to keep the organism alive. Anything that does not have cells and does not carry out these specific functions is not alive and is called a **non-living** thing. Some non-living things show one or two of these characteristics. For example, a rolling marble moves, and a car moves, when it has gas in it. However, things that are alive have **all of the features** at the same time.

Is it alive anyway?

Part Two

Adrian turned his attention back to the tree. He took up a long stick and said, "I must get even one..." Adrian's sentence was cut short as suddenly, Mr Bigga's dog Max came charging towards him threateningly. Adrian had never seen Max so upset before. He hastily dropped the stick and grabbed his bag. He shouted, "Christal! Over the fence! Quickly!" without realizing that Christal was already on the other side. When Adrian got over the fence he looked back and saw that a piece of his shirt was stuck in the fence!



When they got home, Grandma Agnes was in the kitchen stirring the contents of a pot with a big spoon. To avoid questions from Grandma about his torn shirt Adrian quickly said, "Evening Grandma, can I change and then help you with anything?" "That's nice of you Adrian. Yes, you can feed the cat. She is constantly hungry these days because she recently gave birth to kittens." Adrian changed his clothes quickly and went outside to feed the cat. As he looked at the tiny, helpless kittens, his mind flashed back to the small, green mangoes and tiny seedlings at the playfield. The amplified sound of Max barking angrily at him cut through his thoughts. He asked himself "Is a mango tree really alive?" Christal's voice penetrated his thoughts and brought him back to the present, "Adrian! Remember you promised to help me to finish collecting pictures for my science homework. I need four more pictures of living things".

Activity Two

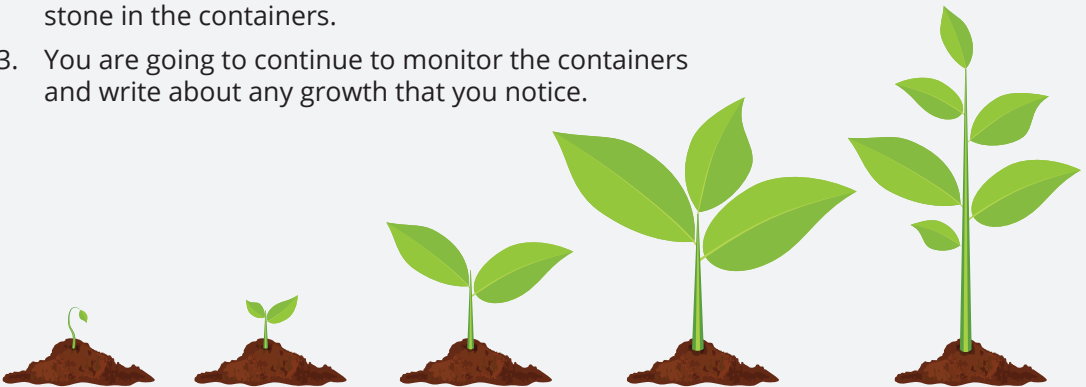
1. Read the story again (Part One and Part Two).
2. Make a list of all the living things and non-living things mentioned in the story. Write your answer in your notebook in the form of a table with two columns.
3. Suggest four living things that Christal could use to complete her science homework.
4. Can you answer Adrian's question? Are trees living things? If you think they are living things write three reasons you think so.

Activity Three

Subject Links: Science - Living Things Grow!

Things you need: 2 small containers, soil, marker, water, labels, pea, small stone, notebook, phone or camera (optional)

1. Fill the two small containers with soil. Label one container "Living" and the other "Non-living". Place a pea grain in the "Living" container and a small stone in the "Non-living" container. Add water to both of them.
2. In your notebook, write the date when you placed the pea and the stone in the containers.
3. You are going to continue to monitor the containers and write about any growth that you notice.



Activity Four

Subject Links: Language

Based on what you have learned about living and non-living things in this lesson, write one paragraph to finish the story about Adrian and Christal.

Living Things: What are their Energy Needs?

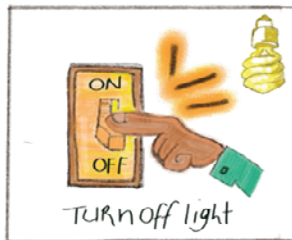
Living things need food, water, and special gases from the air to carry out all the activities that keep them alive. Energy is very important for carrying out these activities. For example, some organisms actively move from place to place with the help of their muscles. Muscles need energy to work properly. Even organisms such as plants that do not actively move need energy to make food and move it through tubes in their bodies. You read earlier that living things get the energy they need from food. We need energy to make our bodies work, but we also need energy to do other daily activities at our home, school, workplaces, and communities. Can you think of any activities we do that need energy? Use the images below (1a, 1b, 1c) for ideas.

What is energy used for?

1a



1b



1c



Where does energy come from?

The sun has a lot of energy, but most organisms cannot use it. However, plants and some other organisms can change the sun's energy into a form that they can use. This process is called **photosynthesis**. Humans and many other organisms cannot use the sun's energy for their body functions, and so they receive their energy by eating plants or other animals that have eaten plants.

The sun is a major source of energy for planet Earth. Apart from the sun, there are other sources of energy such as wind, water and **biofuels** which are plant-based. Ethanol which is made from corn and sugarcane is an example of a biofuel. Wind, water, and biofuels are called **renewable energy** sources because they can easily be replenished. Fossil fuels (e.g., coal, oil) supply energy also. However, they are called **non-renewable** energy as they are limited in supply and will run out one day.

Lesson Two:

Living Things – How do they Relate to their Environment?

Humans interact with the environment to obtain food, water, fuel, medicines, building materials and many other things. Do non-living things play a role in the environment?

When you have completed this lesson, you should be able to:

1. Define and correctly use the words - Environment, Ecosystem and Biodiversity.
2. Describe the water and carbon cycles.
3. Describe the ways in which humans use natural resources.
4. Explain the importance of conserving the natural environment.

Earlier in this Unit, you read a story about Adrian and Christal, and you made a list of living and non-living things. Read the list again. Everything on your list is a part of the **environment**. The environment is everything around us - all the living and non-living things.

Adrian and Christal live near a pond. They love to visit the pond to look at the fish that are often seen swimming in it. Some plants live in the water, such as the water lily. Sometimes when it rains heavily, soil from the land washes into the pond, and the water becomes muddy.

Figure 1.1: A pond ecosystem



When Adrian and Christal go to the pond, they wear clothing to cover their skin so that they do not get bitten by mosquitoes. The area where the pond is located is called an **ecosystem**. An ecosystem is a more specific part of the environment. It is a **community** of living things interacting with each other and the non-living environment.

Activity Five

1. Identify and make a list of all the components of the ecosystem in Adrian and Christal's community.
2. Draw a table with two columns and write the living components of the ecosystem in one column and the non-living parts in the other.
3. Can you think of two impacts that mud could have on the organisms in the pond? Talk with your classmates about it and then report it to your teacher.

Ecosystems have many different types of organisms which have specific roles. What kinds of relationships take place between and among the components of ecosystems? Animals hide from danger under non-living things like rocks and dead trees. Water is used for drinking but also serves as a **habitat** for organisms. The atmosphere supplies oxygen which is needed for respiration. Some large ecosystems (for example, some types of forests) are very important for providing medicine, food, and other material for humans.

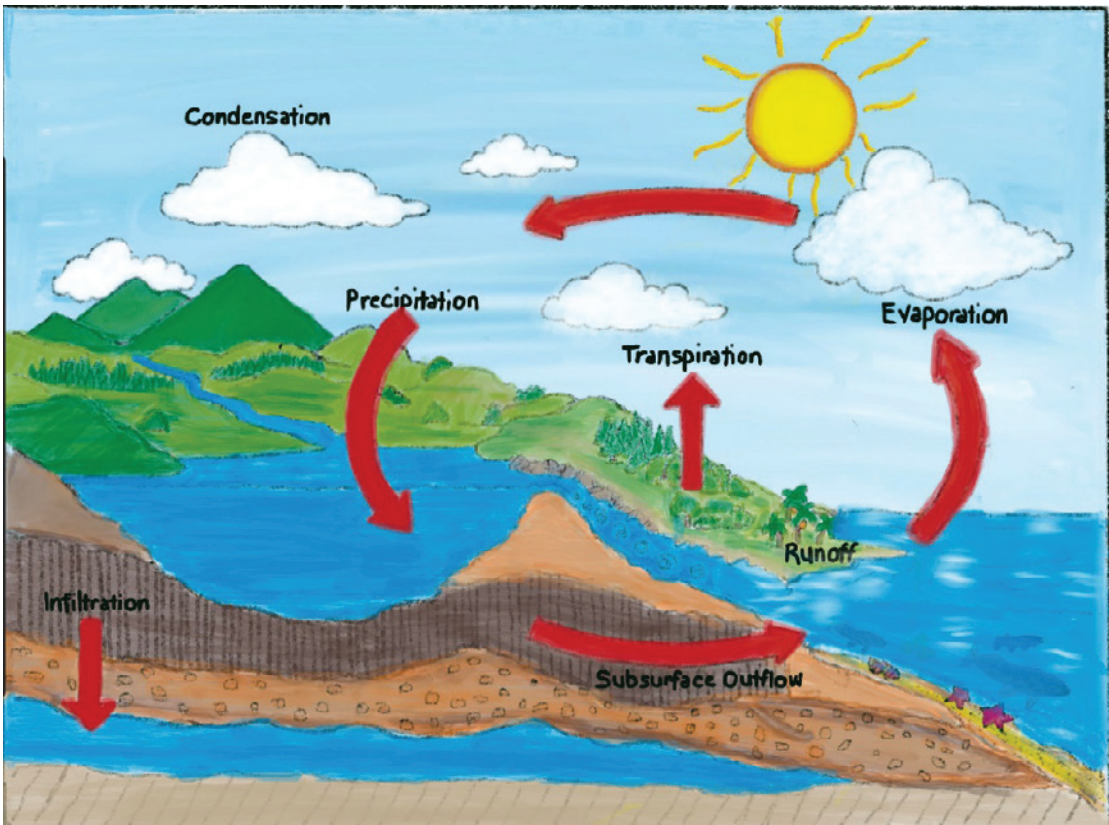
Biodiversity is the variety of organisms in an ecosystem. It is important to make choices that will protect and preserve the **balance of the variety of relationships between and among living and non-living things in ecosystems**. This will help all the living things to continue to have the resources they need to live.

Balancing Ecosystems: Nutrient Cycles

Earlier you read that living things need basic things such as food, water, and special gases from the air to carry out all the activities that keep them alive. You will now recognize that these substances are a part of the **non-living environment**. If living things keep using these substances endlessly the Earth will eventually run out of them. However, this does not happen because the substances are constantly being **recycled**. Some important cycles include the water cycle and the carbon cycle.

The Water Cycle

The Water Cycle is a term used to describe the movement of water around the Earth. It is called a cycle because there is no clear beginning or end. It is like a circle. From the Figure of the water cycle (Figure 1.2), you will notice there is a link between rainfall and water that is available for living things to use. You may live in an area where there are water restrictions from time to time. This happens especially when there is a dry season with not enough rainfall for a long time. I am sure that when that happens, it makes you very uncomfortable!

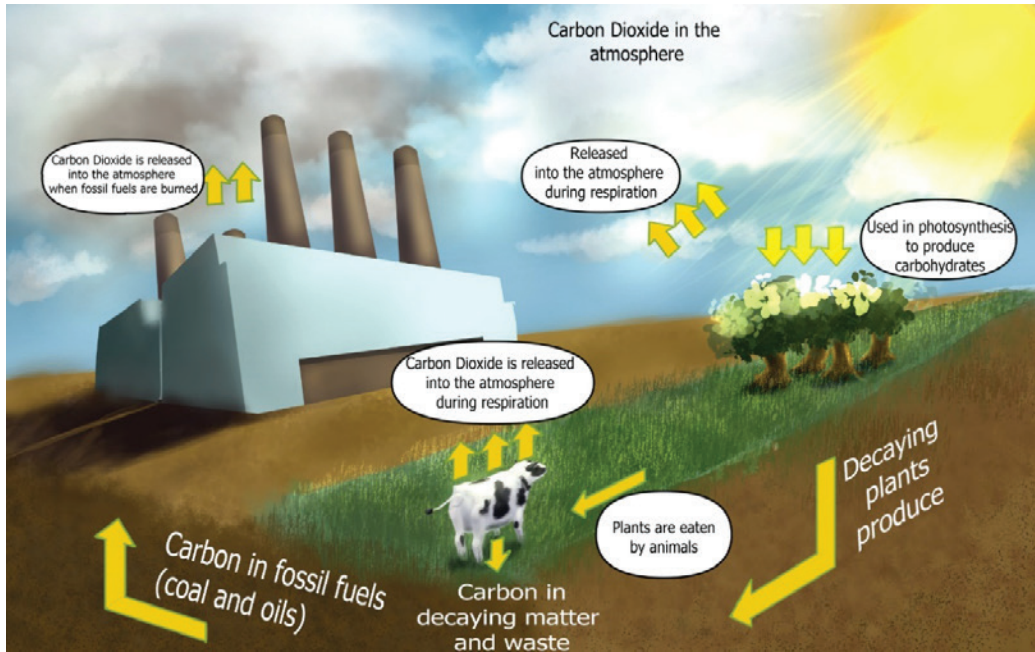
Figure 1.2: The Water Cycle

In the Caribbean, large water bodies form rivers, ponds, streams, swamps, marshes, and the sea. Some water on the surface of these bodies of water **evaporates** (changes to vapour or gas) because of heat from the sun. When cooking at home, you will see something similar when water in pots starts boiling and steam leaves the pot. Water that evaporates from water sources goes into the sky and forms **clouds**. As time passes, the clouds become so full of water that they form drops (**condensation**) that fall back to the Earth. This will present itself as rain, snow, sleet, or hail and is called **precipitation**. This will allow the water to fall right back into the various water bodies. The cycle will continue as the water evaporates again.

The Carbon Cycle

Carbon is a chemical substance that is used in many processes on Earth. Carbon is needed in the **atmosphere** as well because it helps to keep the Earth warm and without it, we would all be freezing. Carbon, like water, is cycled between living and non-living things in ecosystems (Figure 1.3). Carbon dioxide in the air is a big source of carbon in ecosystems.

Figure 1.3: The Carbon cycle



There are several activities involved in the carbon cycle:

- **Photosynthesis** – Do you remember what this is? You read previously that this is how plants, and some other organisms change the sun’s energy into a form which is stored in food. During photosynthesis, water and carbon dioxide combine in special plant parts in the presence of sunlight to form sugars.

Organisms that live in water bodies also carry out photosynthesis. There are different ways in which they get the carbon dioxide.

- *Some carbon dioxide from the air dissolves in the water and remains as gas.*
- *Some carbon dioxide from the air combines with the water to form a weak acid (carbonic acid).*
- *Organisms in the water can also use the carbon dioxide directly from the air.*
- **Carbon** can combine with calcium to form calcium carbonate, which is used by organisms in the sea to make their shells. These shells will eventually become rock (limestone).



NOTE CAREFULLY:

All the organisms that carry out photosynthesis remove large amounts of carbon from the atmosphere.

In a cycle, if carbon is removed from the atmosphere, it must be returned or else we will run out of it eventually.

How is carbon returned to the air?

- **Respiration** – This is one way in which carbon is returned to the air. You already learned about this process in Lesson One (Table 1.1) as one of the features of living things. In this process, oxygen is used to get energy from food. At the same time that respiration is happening, **carbon dioxide is released** and goes back into the atmosphere.
- **Death and Decay** – When organisms on land and in water die, they decay or rot. When this happens, the carbon in their body will either be released into the atmosphere or stored in the ground as **fossil fuels**.
- **Combustion (burning)** – When plants, trees, or fossil fuels are burned, carbon is released into the atmosphere.

Look again at Figure 1.3 and spot all the places where photosynthesis and respiration take place.

For Reflection

Look again at images 1a, 1b and 1c and the activities that involve the burning of **fossil fuels**. What is one effect on the carbon cycle of cutting down too many trees without replanting?

Balancing the Cycles

Already you have learned that human beings interact with their environment in various ways. These include getting food, water, fuels and land for growing crops and building homes. Humans produce waste from these activities including from their bodily reactions, from factories, agriculture and mining. Waste from living things is released and becomes a part of the non-living environment.

It is important for life and nature to balance the amount of nutrients available through the various cycles. If the nutrient cycle balance in ecosystems is disturbed, one or more of the various types of organisms may not survive. This will affect the well-being of other organisms. Disruptions can happen naturally, however, human beings also cause disruptions through activities like overfishing and burning fossil fuels.

Activity Six

- One way of reducing our dependence on fossil fuels is by using other sources of energy. Conduct research on alternative sources of fuel.
- Create a poster to explain two of these other forms which can be used.

Hint: Look again at the section on “Where does energy come from?” to help you.

- Your poster can either be made on cartridge paper or you can use your computer or tablet to make one and then print it. Be prepared to share your poster in class!

Lesson Three:

Human Impact on the Earth’s Physical Environment



Did you know?

In recognition of the extensive forest cover on the island of Jamaica, the original inhabitants, the **Tainos**, named the island **Xaymaca**, meaning the **land of wood and water**. Today, that forest cover has been significantly reduced due to human activities!

When you have completed this lesson, you should be able to:

1. State the role of forests and the different types of human activities that contribute to deforestation.
2. Identify the causes and effects of changes in the landscape in your community.
3. State ways of reducing deforestation and its effects.
4. Define the term pollution.
5. Demonstrate an awareness of the harmful effects of pollution.
6. Propose measures to reduce or eliminate selected sources of pollution.



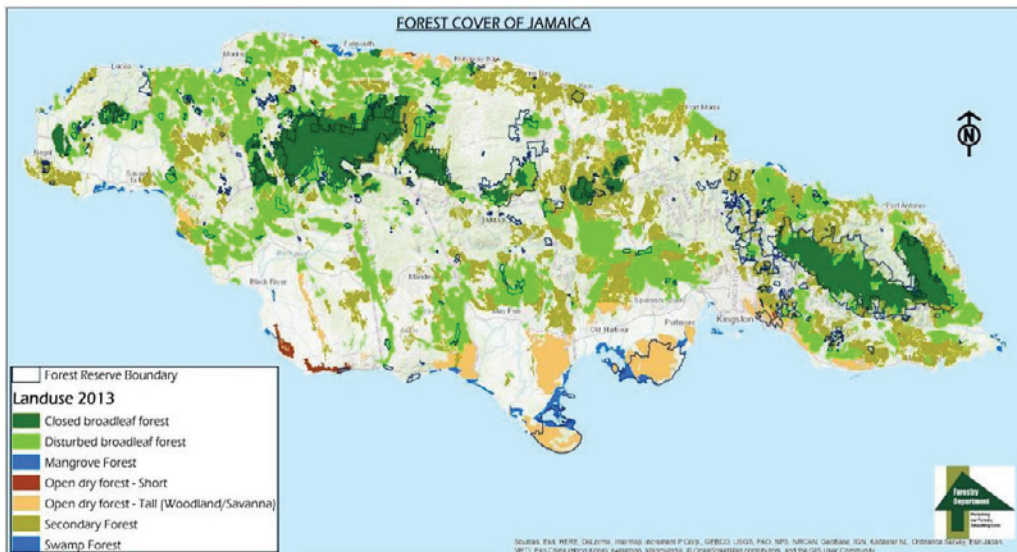
NOTE CAREFULLY:

Humans impact the physical environment in many ways including deforestation and pollution.

Forests and Deforestation

Forests are thick vegetation (a collection of plants). Forests exist in Jamaica and the entire Caribbean. As much as 15% of Jamaica was once forest. However, urbanization, which is the process of people moving in large numbers from rural areas to towns and cities, has resulted in significant forest loss.

Figure 1.4: Map showing forest distribution in Jamaica



Source: https://www.forestry.gov.jm/resourcedocs/forest_cover-the_jamaican_scenario.pdf

Forests are important because they:

- Serve as a natural **sink** for carbon dioxide. A sink is like a reservoir that 'absorbs' more carbon dioxide than it releases. Through photosynthesis, the plants in forests remove carbon from the atmosphere by incorporating it into their bodies (**please review the Carbon Cycle**).
- Are significant sources of fuel (e.g., charcoal, ethanol).
- Support the Water Cycle which maintains the availability of fresh water (**please review the Water Cycle**).
- Function as a habitat for wildlife (providing food and shelter).
- Support the livelihood of many indigenous peoples (food, shelter, medicine).

Deforestation

Deforestation is the permanent removal of trees from forests or other areas. Some deforestation happens naturally, for example, forest fires caused by lightning strikes. However, the main cause of deforestation is human activity. The major human-related causes include clearing land for agricultural purposes (to plant crops and raise livestock), urbanisation (to construct buildings and roads), and mining for oil and minerals.

There are many consequences of deforestation. Can you think of any?
Compare your answers to those listed in column one in Table 1.2.

Table 1.2: The effects of deforestation and possible actions taken for its reduction

Effects of Deforestation	Reducing Deforestation
<ul style="list-style-type: none"> » Soil erosion » Increased flooding » Loss of habitat for wildlife » Reduction in biodiversity » Desertification (fertile, productive land becomes desert due to disruption in the water cycle) » Increased carbon dioxide concentration in the atmosphere 	<ul style="list-style-type: none"> » Enacting and enforcing laws to protect forests » Planting trees » Implementing sustainable logging practices » Going paperless (reduce use of paper where possible) » Buying recycled products » Raising awareness of the need to reduce, reuse, and recycle » Promoting/training in alternative livelihoods (substituting environmentally damaging income-generating activities with lower impact ones)

Environmental Pollution

Pollution is a term used to describe the process of introducing harmful substances (**pollutants**) into the environment. There are several types of pollution caused by humans: air, land, water, noise, thermal (heat), and radiation pollution. However, in this lesson we will focus on the three main types which affect the physical environment: air, water, and land pollution.

Clean air consists mainly of nitrogen and oxygen and a small percentage of other gases including carbon dioxide.

- **Air pollution** is the addition of harmful substances (gases or particles) to the atmosphere. Some common air pollutants include the gases carbon dioxide (in excessive amounts), nitrogen oxide, methane, sulphur dioxide and chlorofluorocarbons (CFCs). Some sources of these gases include aerosol sprays, motor vehicles, landfill fires, power plants that produce electricity and eruptions from volcanoes (See Figure 1.5a).
- **Land pollution** is the addition of harmful substances to land. Common land pollutants

are radioactive waste from nuclear power plants, agricultural waste (e.g., pesticides, fertilisers) and solid waste (e.g., plastic, paper) (See Figure 1.5b).

- **Water pollution** is the addition of harmful substances to water bodies. Some examples of water pollutants include hot water, chemicals such as pesticides, fertilizers, lead, mercury and non-biodegradable material (e.g., plastic) (See Figure 1.5b).

Figure 1.5a: Air pollution

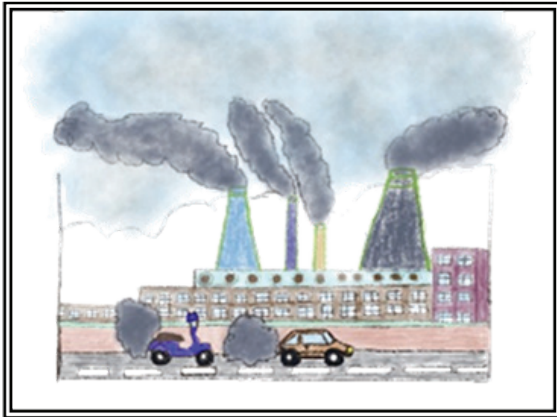


Figure 1.5b: Land and water pollution



Activity Seven

For any three of the named pollutants that affect the air, land, or water:

- State their sources.
- State the effect they will have on human health.
- Suggest ways in which they can be reduced.

Look again at Figures 1.5a and 1.5b to get some ideas.

The Ozone Layer

Ozone is a colourless gas containing oxygen that makes up part of the Earth's upper atmospheric layer. Its role is to absorb the invisible **ultraviolet (UV) radiation** from the sun which is harmful to humans. Excessive exposure to the ultraviolet rays can cause changes in skin cells which can lead to skin cancer. The ozone layer is formed and broken by a series of chemical reactions that occurs naturally. When the rates of ozone formation and depletion are equal, the overall amount of ozone in the upper atmosphere stays constant. However, human activities that release gases such as chlorofluorocarbons into the air disturb this balance. This results in a decrease in the thickness (depletion) of the ozone layer, referred to as a **hole in the ozone layer**, which leads to more harmful ultraviolet radiation reaching the Earth's surface.

Activity Eight

1. Observe the school compound or surrounding community (e.g., classroom, canteen, home, stores, market) to identify various types of waste and the sources of this waste.
2. Use a phone or a camera to take pictures of the waste.
3. Classify the waste into various categories such as reusable, recyclable, will decompose, will not decompose.
4. Print and paste the pictures in your scrap book or place them in your Electronic folder.

Activity Nine

Subject Links: Mathematics

1. Use appropriate methods such as counting, weighing etc. to determine the volume of waste produced in your class each day.
2. Use the information gathered to draw a graph or make a chart.



UNIT TWO

The Science of
Climate change



Johnny: Mom, should I take my raincoat to school today?

Mom: I'm not sure, son. What does it look like outside?

Johnny: Umm, umm...Mom I see dark clouds, just a little sunlight, and there's a slight breeze blowing.

Mom: Ok son, pack your raincoat!

In the dialogue above, what are Johnny and his mother talking about? Is it the weather or the climate? Are they the same, or are they different?

Lesson One: Weather and Climate

When you have completed this lesson, you should be able to:

1. Tell the difference between weather and climate.
2. Determine how weather and climate influence human activities.
3. Define and use the following terms correctly: natural hazard, precipitation, storm, hurricane, drought.

Are Weather and Climate the same?

What is Weather?

When we receive daily news reports from the radio or television, there is a segment for the weather, and we will find out if it may be sunny, cloudy, warm, or rainy in our parish and in

other parishes. The term **weather** refers to *the day-to-day condition of the atmosphere over a specific place*. In the above scenario, Johnny's mother advised him to take his raincoat to school because the atmospheric conditions suggested that it would rain.

WEATHER

The state of the climate system (normally the atmosphere) at a specific time and place.



Elements of Weather: How do we study the weather?

How can we know what the weather will be like each day? Atmospheric conditions are affected by a combination of factors such as air pressure, temperature, and humidity. The scientist who studies these atmospheric factors and makes predictions about the weather is called a **meteorologist**. These predictions (forecasts) are usually 'educated guesses' based on the atmospheric factors that the scientists study with the help of technological instruments.



NOTE CAREFULLY:

Always bear in mind that these forecasts will change because the weather changes continuously on a daily basis.

Usually, the weather may be forecast with some accuracy for up to 10 days.

An Automatic Weather Station at The University of the West Indies, Mona.³



³ The Climate Studies Group Mona through its partnership with the Meteorological Service Jamaica and the Planning Institute of Jamaica installed an Automatic Weather Station at The University of West Indies, Mona in March 2021, aimed at enhancing the quality of climate-related data in Jamaica.

The table below lists the elements of weather and the instruments used by meteorologists to measure and describe atmospheric conditions.

Table 2.1: Elements of weather, instruments, and units of measurement

Element of weather	Instrument	Unit/Symbol
Temperature	Thermometer	Degrees Celsius (°C)
Air (Atmospheric) Pressure	Barometer - rising air pressure signals fair weather while decreasing air pressure indicates bad weather (e.g., rainy or stormy conditions)	Millibars (mb)
Cloud Cover	Human sight – estimates how many eighths of the sky are covered by cloud	Oktas
Sunshine	Sunshine Recorder	Hours per day
Wind Speed	Anemometer	Meters per second (m/s) or Miles per hour (miles/hour)
Wind Direction	Wind Vane	Cardinal point (e.g., East, North)
Rainfall	Rain Gauge	Millimeters (mm)
Humidity	Hydrometer - measures the amount of water vapour in the atmosphere	Percentage (%)

How Does Weather Influence Human Activities?

In the opening scenario of this lesson, Johnny had to decide for that day what to wear to school if it rained. Weather therefore can affect decisions about **what clothes we choose to wear** daily. We choose our clothing appropriately for the weather, but, apart from these decisions, how else can weather affect us? Some afternoons it may rain very heavily and the streets may become flooded making it difficult to **walk or drive**. Maybe Johnny's mother was planning to take him to the park after school. If it rains, they would have to wait until another day when it is warm and sunny. In this case our **leisure activities** can

be affected by the weather. Weather can even affect our **mood**. How do you feel on a rainy day when you are locked inside when you would rather go outside and play football or hang out with your friends?

Activity One

What is the weather like where you are now? Pretend you are a weather forecaster for a local newspaper. Ask an adult to assist you in completing this activity.

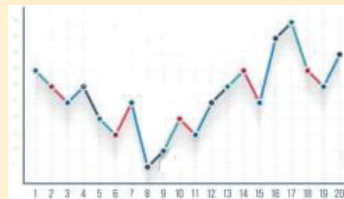
- Record three weather reports from the television, radio or the Internet.
 - Listen to them again.
 - Write down the first five lines of your weather report. If possible, use some of the terms in Table 2.1.
 - Pretend you are presenting the weather forecast and read your weather report to your family.
- Do you think it is important to listen to or read the weather forecast? Give **three reasons** for your answer.

What is Climate?

Climate is the **average atmospheric condition of a place (or region) over a long period of time** (usually 20-30 years). This is generally reliable because it is based on data gathered and averaged over many years. Climate data include sunshine, rainfall, air temperature, humidity, and wind.

CLIMATE

The *average pattern of variation of meteorological variables, such as rainfall and temperature, over a long period of time and for a particular region.*



Activity Two

Subject Link: Social Studies

Climates around the world vary because of differences in the amount of solar radiation received in these areas.

- Use your atlas or search the Internet to identify some countries near to the equator and some farther away and learn about the types of climates.

In your search look for some reasons why places near the equator are generally hotter than those near the poles.

Places located closer to the Equator receive more heat from the sun because the sun is always generally directly overhead. These places are warmer than the areas closer to the North and South Poles where it is extremely cold. Therefore, the Earth is divided into **climatic zones** (Table 2.2) based on the amount of sunshine (or heat) and precipitation received in each area. Countries with similar weather patterns are in the same climatic zone.

Table 2.2: Examples of climatic zones, their features and examples of locations across the world.

Climatic zones	Features	Examples of places
Tropical	<ul style="list-style-type: none"> Hot, humid, average temperatures greater than 18°C year-round More than 1,500 mm of rainfall each year A wet season and a dry season each year 	The Caribbean, Congo Basin, West Africa, Indonesia
Dry or Arid	<ul style="list-style-type: none"> Daytime temperatures as high as 40°C Dry, very little rainfall; moisture rapidly evaporates Few, scattered, or no plant life 	Saharan Desert, Arabian Desert
Mild (Temperate)	<ul style="list-style-type: none"> Warm or hot and humid summers Thunderstorms and mild or cold winters Some areas may have long, cool winters 	Areas around the Mediterranean Sea (e.g., Greece, Southern France, Spain, the Middle East) Cities such as Savannah, Seattle, Georgia, (USA); Shanghai (China); Sydney (Australia); Wellington (New Zealand)
Continental	<ul style="list-style-type: none"> Extreme seasonal changes: Warm to cool summers and freezing winters. In the winter, can experience snowstorms, strong winds, and temperatures sometimes falling below 3°C Long-lasting snow 	Parts of North America, Canada, Asia and Europe, e.g., Northern China, Scandinavia, Siberia

Climatic zones	Features	Examples of places
Polar	<ul style="list-style-type: none"> Extremely cold and dry, temperature below 0°C all year (does not go above 10°C). Snow and/or ice always present Very few forms of life. 	Greenland, Arctic (North Pole); Antarctic (South Pole)

Adapted from: <https://scijinks.gov/climate-zones/> and <https://www.nationalgeographic.org/article/all-about-climate>

How Does Climate Affect Human Activity?

The variety of climates that exist influences the variety of life on Planet Earth. Climatic conditions help in the formation of various ecosystems on which humans and other organisms depend. Climate influences the development of cultures. This is because **geographical climates** influence our lives. People everywhere have adapted in various ways to the climates in which they live. Climate influences our clothing, agricultural practices, types of housing, and vacation time. For example, persons in countries with cold winters may go to countries with tropical climates during winter. We will learn more about the impacts of climate change in another Unit.

IN SUMMARY

Weather changes moment by moment.

Climate is more stable, and looks at average weather changes that occur over a long time.

Activity Three

Career Link: When I grow up, I would like to be a...

In the weather and climate discipline there are various professions that you can choose. In this activity, use the Internet or your parish or school library to gain information on these weather and climate-related careers. These include professions such as:



Weather and climate-related careers

- Meteorologist
- Climatologist
- Storm Chaser
- Hydrologist
- Environmental Scientist
- Environmental Engineer

In this activity, write an essay OR, make a PowerPoint presentation, OR share with your classmates about which of these careers you find most interesting.

Glossary

Here are some terms that you should learn as they are often used when discussing the weather and climate.

Natural hazard: A destructive, natural event that disrupts human activity. It may result in severe damage to the environment and loss of lives. For example, earthquakes, volcanic eruptions, drought, flooding, tsunamis, hurricanes. The amount of damage they cause can be made worse by human activity.

Precipitation: All forms of moisture that return to the Earth, e.g., rain, hail, snow, sleet. We met this in one of the cycles that we studied. Which one was it?

Drought: A long period of below-normal precipitation (e.g., very little or no rainfall) resulting in water scarcity for domestic, agricultural, and industrial use.

Storm: An atmospheric disturbance caused by low atmospheric pressure that produces heavy rainfall, thunder, lightning, powerful winds, hail or snow.

Hurricane: A tropical storm (cyclone) with minimum sustained wind speeds of 74 miles/hour.

Activity Four Riddle

Question: What did the mother hurricane say to her mischievous baby hurricane?

Answer: I've got my eye on you.

Homework

Do some reading or ask an adult to help you find out:

- (i) What is the '**eye**' of the hurricane?
- (ii) What are the features of this '**eye**'?

Be prepared to share your answers in the next class.











Activity Five

Unscramble these words related to weather and climate.

- | | |
|--------------------|-------------------------|
| 1. ULDOC | 6. REPURESS |
| 2. DIWN | 7. UNS |
| 3. ARNI | 8. URCHARNIE |
| 4. THO | 9. ICEIONAPTRIPT |
| 5. NESHUNSI | 10. STOCRAFE |

Assessment Activity

Table 2.3: Showing a 10-day weather forecast for Kingston, Jamaica

Day	Description	Temperature °C (High/Low)	Chance Of Precipitation (%)
TUE MAR 23 	Chance of showers	29/23	30
WED MAR 24 	Mostly sunny	30/23	20
THU MAR 25 	Isolated thunderstorms	31/24	30
FRI MAR 26 	Scattered thunderstorms	29/23	50
SAT MAR 27 	Cloudy	28/23	20
SUN MAR 28 	PM showers	29/23	40
MON MAR 29 	Partly cloudy	30/23	20
TUE MAR 30 	Partly cloudy	29/21	30
WED MAR 31 	Mostly sunny	30/22	15
THU APRIL 1 	Sunny	31/23	< 5

Use the information in Table 2.3 to answer the following questions in your notebook.

1. Is the weather the same for each day over the ten days?
2. On what days are we likely to experience the (i) highest and (ii) lowest temperatures?
3. On which day/date is it most likely to rain?
4. Your school is planning its annual Sports Day competition. On which of the ten days is it best to have this activity?

Lesson Two: Climate Change



Listen to one of the following songs and answer the questions that follow:

'1.5 to Stay Alive' at: <https://youtu.be/ZzTI4J7NBto>

OR

'One World' at: <https://youtu.be/sZhUW9p2RCI>



1. What is the song you chose speaking about generally?
2. What are some of the main points in the song?
3. How did the song make you feel?

When you have completed this lesson, you should be able to:

1. Explain the key concepts, basic science, and causes of climate change.
2. Explain what is meant by mitigation and adaptation.
3. Outline mitigation and/or adaptation strategies at the local level.
4. State the implications of climate change for the Caribbean region.
5. Identify how personal actions contribute to greenhouse gas emissions.

The Greenhouse Effect

Especially in cold countries, greenhouses are used to keep the plants inside them warm. In these countries, greenhouses are often made of glass (Figure 2.1). It is said that the atmosphere acts like the glass of a greenhouse because it regulates incoming and outgoing radiation from the sun and the Earth to keep the planet warm. Let's explore this some more.

Figure 2.1: A greenhouse



Recall we get our energy from the sun which is very far away. For us to use this energy, radiation from the sun must first pass through the atmosphere. Some of the radiation is immediately reflected by the atmosphere, some is absorbed by certain gases in the atmosphere when passing through, but most of it reaches the Earth's surface.

Of the radiation reaching the Earth, some is reflected from the Earth's surface, but most is absorbed and warms the Earth. The warming Earth now gives off its own radiation which goes into the atmosphere. Again, the gases in the atmosphere absorb some of the Earth's radiation, some of which it sends back to Earth (further warming the Earth) while some goes back into outer space.

This whole process is called the **Greenhouse Effect** and is summarized in Figure 2.2 below. Without the natural processes involved in the Greenhouse Effect the Earth would not be warm enough for us to live on it.

Figure 2.2: The Greenhouse Effect

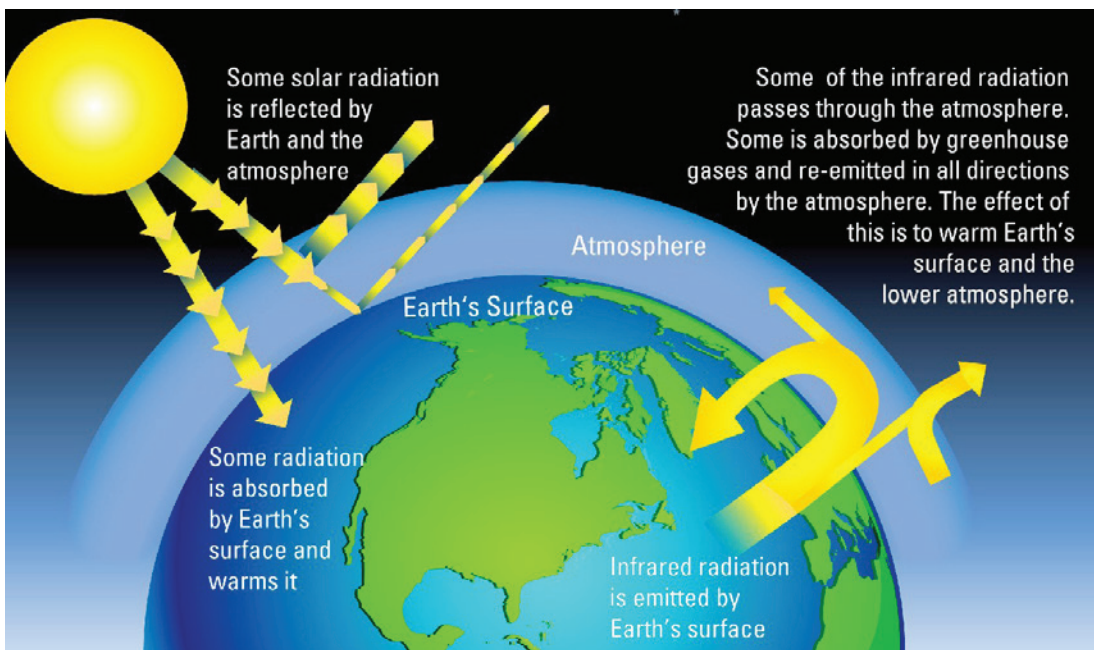


Image by The Royal Society

The gases in the atmosphere that absorb radiation from both the sun and Earth are called **greenhouse gases**. The radiation they absorb and which they send back to the Earth is called **infrared radiation**. We have met some of the greenhouse gases before (e.g., chlorofluorocarbons and methane) in Lesson Three of Unit One. In addition to those gases, another major greenhouse gas is carbon dioxide. Carbon dioxide is very good at absorbing infrared radiation and causing the warming of the Earth.

Activity Six

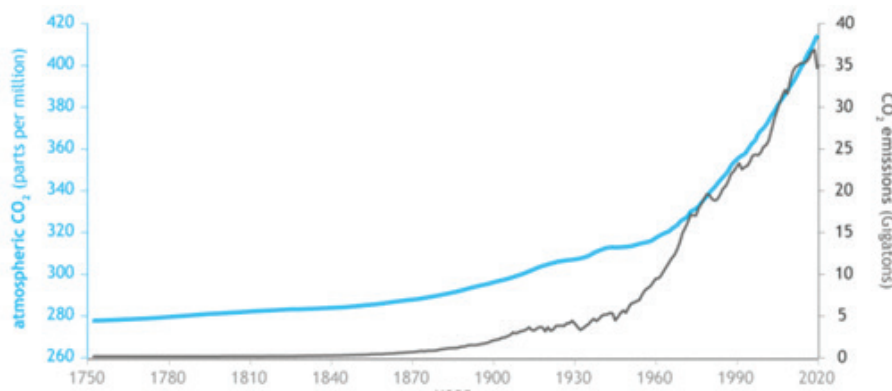
Answer the following questions in your notebook.

1. How does a greenhouse work and why do people use them?
2. Name two ways in which the atmosphere acts like the glass in a greenhouse.
3. Do you think the Greenhouse Effect is a good thing? What would happen if it did not occur?

What is Global Warming?

Human activities that are carried out to meet personal needs have increased the concentration of **greenhouse gases** in the atmosphere, especially carbon dioxide. This has led to changes in Earth's climate. For example, human activities such as combustion of fossil fuel used for driving cars, operating factories, and generating electricity release more carbon dioxide into the atmosphere than can be absorbed by plants for photosynthesis. Cutting down large numbers of trees without replacing them also causes more carbon dioxide to be released into the air. Measurements of the Earth's atmosphere worldwide show that the amount of carbon dioxide is rising (Figure 2.3).

Figure 2.3: Carbon dioxide in the atmosphere (blue line) and human emissions (grey line) from (1750 – 2020)



Source: <https://www.climate.gov/news-features/understanding-climate/climate-change-atmospheric-carbon-dioxide> (NOAA)

The excess carbon dioxide in the atmosphere traps and re-radiates more and more infrared radiation from both the sun and the Earth back to the Earth. Therefore, more concentrations of greenhouse gases in the atmosphere will lead to a much warmer Earth. This is referred to as **global warming** and is believed to be the root cause of the phenomenon called **climate change**.

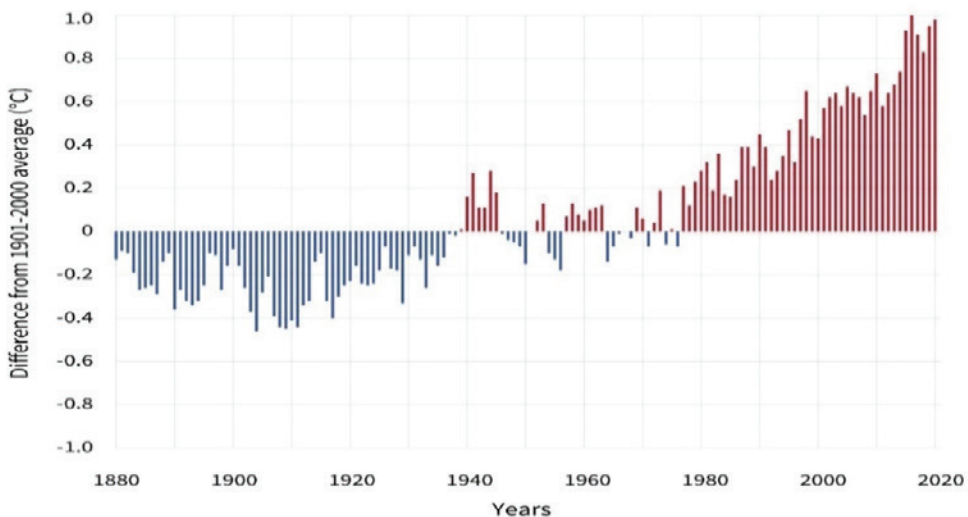
What is Climate Change?

Various natural and man-made factors cause **climate change**. Natural factors include, for instance, volcanic eruptions. Man-made factors, also called **anthropogenic** factors, include activities resulting from population and economic growth. Examples of these activities include transportation (when we drive a car or fly in an aeroplane), electricity generation (from burning fossil fuels), deforestation (cutting down trees for housing developments), or agricultural production (planting crops and raising livestock).

Most times when we refer to climate change today, we are referring to the changes we have seen in the weather-related elements due to man-made factors. These activities release greenhouse gases into the air. These greenhouse gases when released enhance the natural Greenhouse Effect which warms the earth and sustains life. The first climatic change that is therefore often observed is a **long-term increase in average temperatures**. The world has steadily warmed due to human factors since the pre-industrial period (e.g., 1850-1900 before combustion was used globally) (Figure 2.4). The warming of the world has led to other changes in climate, such as rainfall patterns, storm events, and sea levels.

Figure 2.4: Global average temperatures 1880 – 2020

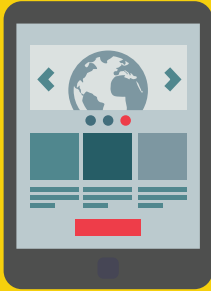
The yearly surface temperatures are compared to the 20th-century average from 1880–2020. Blue bars indicate cooler-than-average years while red bars show warmer-than-average years.



Source: <https://www.climate.gov/news-features/understanding-climate/climate-change-global-temperature> (NOAA)

Tracking Global Climate Change

There are several institutions worldwide that are tracking how Earth's climate is changing. Here are some sites you can check out to get the latest global information:



NOAA Global Climate Dashboard:

<https://www.climate.gov/climatedashboard>

The UK Met Office Climate Dashboard:

<https://climate.metoffice.cloud>

NASA Climate page: <https://climate.nasa.gov>

WMO Climate: <https://public.wmo.int/en/our-mandate/climate>

IPCC: <https://www.ipcc.ch/about>

Climate change is not just taking place globally. It is also taking place regionally and locally. Some of the evidence of climate change in the Caribbean region includes warmer temperatures, greater variability in rainfall patterns, rising sea levels, and increases in the frequency of extreme weather events (such as floods and droughts).

Climate change is a very present and real threat and can have a range of environmental, economic, and social impacts on the Caribbean region. We will explore this some more in Unit Four.

Examples of these impacts include:

- Coastal erosion.
- Loss of coral reefs, mangroves and other ecosystems.
- Saltwater intrusion into coastal agricultural lands and aquifers.
- Increase in the frequency and intensity of hurricanes/tropical storms.
- Increase in frequency and severity of coastal inundation and flooding.
- Disruptions in precipitation (causing drought) and availability of potable water supplies.

Climate change can also result in expensive relocation and rebuilding exercises or as an extreme worst case, an entire island can be made inhospitable.

The impacts on our natural resources and environment ultimately affect our economies because we depend heavily on our natural resources for economic activities such as tourism and agriculture.

- » **Economic impacts** include infrastructural and property losses, such as land loss, tourism infrastructure, airports, seaports, hotels and housing. Higher temperatures

lead to greater energy costs because of the need for cooling, and beach and coral reef losses can lead to a loss of earning due to reduced tourism demand. Changes in precipitation patterns and water supply can affect the agricultural sector. Excessive sea surface temperatures may cause damage to coral reefs through, for instance, coral bleaching where the corals lose their colour, resulting in income losses for the fisheries sector.

- » **Social impacts:** Our social sectors will, of course also be impacted. Extreme weather events (e.g., hurricanes) can affect education through school closures or if educational institutions are destroyed. The health sector is another which the threat of climate change can burden. This can occur through increase in vector-borne diseases (e.g., dengue fever), mental health impacts (for those experiencing loss of property, livelihood and/or loved ones), disability and death.

Can we cope with climate change?

Although climate change is a clear and present threat to the region, particular strategies can be undertaken to help address the causes and impacts. These can be grouped into **mitigation** and **adaptation** strategies.

- » **Mitigation strategies** refer to human interventions to reduce the **sources** of greenhouse gases (e.g., from burning fossil fuels) or enhance the **sinks** (sites where carbon dioxide is captured and stored, for example, forests). Some mitigation strategies include: forest conservation, preventing and controlling forest fires, using renewable energy (such as solar energy, wind energy and wave energy), energy conservation, reducing the use of fossil fuels, recycling waste, and using waste to produce energy.
- » **Adaptation strategies** refer to how humans can change how they live in response to actual or expected events related to the climate. By doing this we can minimize harm or make use of beneficial opportunities. Adaptation strategies include:
 - building infrastructural defenses such as sea walls,
 - regulating urban and physical planning, also known as **zoning**, to prevent buildings from being constructed near coastlines,
 - updating and enforcing building codes,
 - introducing crops in agriculture that can tolerate drought, heat, salt and flooding,
 - ensuring there are strategies for storing and distributing water and food in low production times and disasters. Adaptation strategies may also include behavioural strategies such as scheduling certain activities (e.g., sporting activities) for periods of the day when it is cooler.

Can I help?

We can make lifestyle choices that delay or reduce the impact of climate change. For example, because most of our electricity comes from burning fossil fuels, many of our simple everyday choices about energy use can make a difference. Similarly, conserving water is an important adaptation strategy because under climate change our rainfall is very variable. Some simple things we can do is to be mindful about turning off lights when they are not being used, not leaving the tap running while washing the dishes or reducing the time spent standing before an open refrigerator while deciding what we want to remove.

Activity Seven

1. Working in groups of four, do research on the **Paris Agreement**.
 - (i) What year did the Agreement enter into force?
 - (ii) What are some of the important elements of the Agreement?
 - (iii) How many countries have ratified (agreed to abide by) the Agreement?
 - (iv) Which Caribbean countries have ratified the Agreement?
2. Find out what measures the Caribbean Community (CARICOM) has put in place to address climate change for the region.

Be prepared to share your findings in class!

Here are some additional activities that you may want to try!

1. Build an instrument to measure any element of the weather you choose (for example, rain gauge or wind vane to record data on rainfall or wind direction).
2. Visit sites (field trip) where weather data are recorded regularly.
3. For 10 days, collect and record data on some weather elements for the parish in which you live by listening to the daily weather report or reading daily weather reports online.
4. Use newspaper articles and other resources to discuss how the elements of weather affect life in (i) your community and (ii) Jamaica or another Caribbean country.



Quick Quiz

Let's see how well you will do on the following quiz!

Instructions: Match the terms on the left with the correct descriptions/definitions on the right.

Term	Definition
1. Climate Change	a. A measure of the average pattern of variation of meteorological variables (e.g., rainfall, temperature) over a period of time and for a particular region.
2. Global Warming	b. Distinct changes in climate lasting for a long period of time due to events including human actions.
3. Adaptation	c. A human intervention to reduce the sources or enhance the sinks of greenhouse gases.
4. Greenhouse Effect	d. The state of the climate system (usually atmosphere) at a specific time and place.
5. Climate	e. The average increase in the temperature near Earth's surface and in the atmosphere which can contribute to changes in global climate patterns.
6. Greenhouse Gases	f. The trapping and accumulation of heat in the atmosphere near Earth's surface.
7. Weather	g. The atmospheric gases responsible for causing global warming and climate change.
8. Mitigation	h. An adjustment in natural or human systems to reduce harm or make use of beneficial opportunities in response to actual or expected climatic changes or their effects.

Should the Caribbean region worry about climate change?

The Caribbean region includes 25-30 countries and dependent territories located mainly in or bordering on the Caribbean Sea. Many of the countries are low-lying islands. Some islands, such as Grenada and Montserrat, have volcanic mountainous interiors and short coastlines whilst others, such as Jamaica and Barbados, have hilly interiors. The region has a sub-tropical to tropical climate, with warm weather all year round.

Because the region tends to be warm year-round, Caribbean climate is very often defined by changes in rainfall for example we talk about a **wet season** versus a **dry season**. Additionally, many countries in the region are in the hurricane belt and every year are threatened by numerous storms usually between June and November, some of which develop into hurricanes. For this reason, we also refer to a **hurricane season**.

In general, the geography of the region is identified by:

- limited land area (except for the Caribbean continental territories),
- limited amounts of flat land suitable for agriculture
- fragile tropical ecosystems, and
- limited non-renewable resources.

Because the economies of the region are heavily dependent upon natural resources, this makes them quite vulnerable to the threats that climate change presents. This means that the region's economies stand to be continually devastated by repeated incidents of climate related events. For example, one impact of climate change on the Caribbean is the greater variability in rainfall patterns seen in the intensity (strength), frequency (how often), and duration (length) of weather events such as hurricanes, drought and intense rainfall leading to flooding. Severe floods and droughts seriously impact Caribbean economies.

Sea level rise is another clear impact of climate change in the region. Many Caribbean beaches and coastal towns are under threat due to sea level rise. Global warming is causing sea levels to rise in two main ways.

- Firstly, the melting of the glaciers and ice sheets in colder parts of the Earth is adding more waters to the oceans.
- Secondly the volume of the ocean is expanding as the water warms (consider what happens **when you heat water**). Continued sea level rise will have severe effects on low lying small island developing states (SIDS) such as those in the Caribbean.

We will explore a lot more about how the Caribbean is experiencing climate change in the next Unit.



Did you know?

The Climate Studies Group Mona (CSGM) based at The University of the West Indies, Mona Campus, Jamaica has researched climate change in the Caribbean region.

Activity Eight

Read the following news story about the floods in Guyana in 2005:

<https://www.stabroeknews.com/2020/02/03/news/guyana/remembering-the-great-flood-15-years-later/>

1. What were some of the impacts of the flooding?
2. What are some strategies that can be put in place to reduce the impact from future events?

Carbon Footprint



Carbon footprint is a term used to describe the total amount of greenhouse gases (including carbon dioxide) generated by humanity's actions.

(Nature Conservancy ><https://www.nature.org/en-us/get-involved/how-to-help/carbon-footprint-calculator>).

This means that every time we do something that releases greenhouse gases into the atmosphere, we are contributing to climate change.

Our activities have an impact on Planet Earth. Everyday choices we make about what we eat, how much electricity we use, whether we should walk or drive, can contribute to climate change by increasing our carbon footprint. The carbon footprint is measured by the amount of carbon dioxide (tonnes) released into the air. When we know our footprint, we can find ways of reducing it.

Based on data, Jamaica's total greenhouse gas emission increased between 1990 to 2013, with a peak in 2006. A downward trend between 2006 and 2012 was largely due to a reduction in fuel used by the bauxite sector. This shows that our fuel choice has a significant impact on a country's carbon footprint. Generally, the Caribbean region contributes minimally to the percentage of greenhouse gases globally, but remains committed to its reduction as its countries are the most vulnerable to the impacts of climate change.

Activity Nine

Subject Links: Mathematics

Get together with your family and do this fun exercise to calculate your **carbon footprint** (e.g., electricity bill, car mileage, air travel)!

Use one of the following online tools to help you:

- » <https://www.carbonfootprint.com/calculator.aspx>
- » <https://offset.climateneutralnow.org/footprintcalc>
- » <https://www.nature.org/en-us/get-involved/how-to-help/carbon-footprint-calculator>

1. What were the results? Draw a table or graph to show them.
2. Which activities (e.g., transportation, electricity generation) generated the most emissions?

Let's Reflect!

Think about the results of your carbon footprint calculations.

1. Did anything surprise you?
2. How did you feel?
3. Would you like to make any changes to any of your daily activities to reduce your carbon footprint? What would that be?
4. Write these thoughts in a short (one-page) essay. Be prepared to talk about these with your teacher and classmates.





UNIT THREE

**Caribbean Climate:
Historical and
Future Trends**

The Caribbean region is experiencing the impacts of a changing climate, particularly changes associated with increased temperatures, sea level rise, changes in rainfall patterns, frequency and intensity of storms and hurricanes and drought conditions. You learned in the previous units that many of these changes are caused by human activities which result in rising levels of carbon dioxide and other greenhouse gases and which lead to increases in temperature. A warming climate can cause sea water to expand and ice over land to melt, both of which can cause a rise in sea levels. Projections show that these changes will continue.



Figure 3.1: Satellite image showing three simultaneous hurricane systems in the Caribbean on September 8, 2017. Katia in the Gulf of Mexico, Irma approaching the Bahamas, and Jose approaching the Leeward Islands. NASA/NOAA



Lesson One:

How has the Climate been Changing?

When you have finished reading this lesson you will be able to:

1. State how temperature, rainfall, hurricanes and sea levels have changed in the Caribbean with a changing climate.
2. Describe the patterns of change in past and present climates.

Temperature

The latest Assessment Report from the Intergovernmental Panel on Climate Change (IPCC)⁴ has revealed that Earth's temperature is rising (global warming). **Global surface temperatures** have increased by about 1.07°C (between 0.8°C and 1.3°C) from 1850-1900 to 2010-2019 due to human activities. Around the world, **sea surface temperatures** are also increasing.

There have been notable warming trends for the Caribbean similar to the rest of the world. Research shows that average surface temperatures are increasing at a rate of 0.09°C per decade (10-year period) between 1900 and 2014 (or about 1°C over the same period).⁵ According to the Intergovernmental Panel, average temperatures in the Caribbean region have increased by 0.6°C since the 1960s. It is also notable that the number of **very cool days** and **very cool nights** has reduced over a similar period.

Rainfall

Global rainfall trends vary widely by region and over time. There have generally been significant changes in amount, intensity (how strong), frequency (how often), and type of precipitation (e.g., rain, snow, hail, sleet) for various parts of the world. For example, there has been an increase in the number of heavy precipitation events during the past century over North Eastern and South America, Northern Europe and Northern and Central Asia. Precipitation has, however, decreased (leading to a greater prevalence of droughts) in parts such as the Tropics since the 1970s.

For much of the Caribbean, there is usually a **wet season (May to November)** and a **dry season (December to April)**. The wet season can be divided into early (May to July), and late (September to November). More than 70% of the rainfall is received during the wet season.



NOTE CAREFULLY:

July to August is typically a dry period in parts of the Caribbean and is sometimes referred to as the **mid-summer drought**.

⁴ Climate Change 2021: Working Group 1 Contribution to the Sixth Assessment report of the IPCC.

⁵ State of the Caribbean Climate Report (2020)

There is a lot of irregularity in rainfall patterns in the Caribbean with some years being very dry and others being very wet. We say, therefore, that the rainfall pattern is very **variable**. This also means that when the amount of rain is considered over many decades, there is no discernible overall trend (this means the region is not getting wetter or drier). However, although there exists no clear trend in the amount of rainfall in the very long term, there are observed increases in the extreme events that may cause an increase in drought and flooding. For example, more droughts are being reported in months that are usually wet.

Recent research has also highlighted that the region is experiencing more dry days between rainfall events, and that when it rains it is oftentimes a heavier downpour. As a result, the region has been varying between extremes of **flooding events** on one hand and **drought** periods on the other.

Tropical storms and hurricanes

Beginning in 1995, data analysis showed a dramatic increase in hurricane activity (measured by intensity, duration and frequency) in the north Atlantic, with an almost doubling of the number of category 4 and 5 (intense) hurricanes. Whereas there is general agreement that climate change is playing a part, there is still, however, a lot of debate about how big that role is compared with other natural events which can also influence hurricane activity.

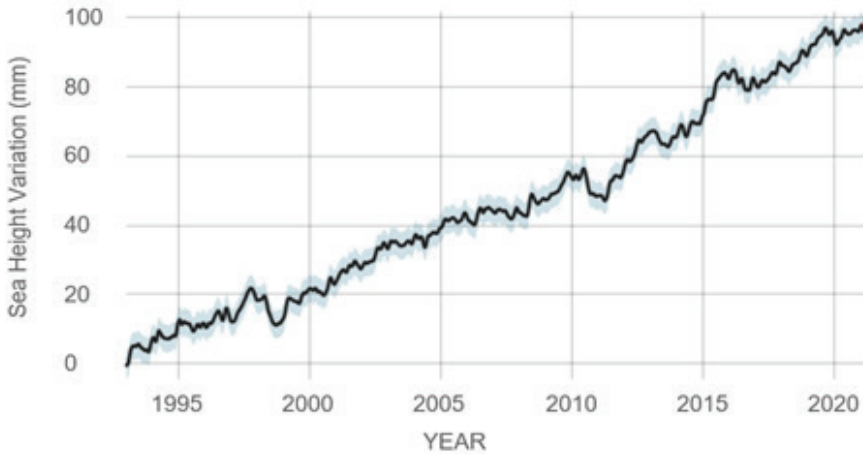
In the Caribbean, the trend is similar to the wider tropical Atlantic, with an increase in most measures of hurricane activity (intensity, duration and frequency) since 1995. In particular, there has been an increase in the number of category 4 and 5 hurricanes, as well as in the rainfall intensity, peak wind intensities and average rainfall associated with the stronger hurricanes, over the same period.

Sea level rise

Global average sea level increased by 0.20 m, [0.15 m to 0.25 m] between 1901 and 2018. However, the rate at which sea levels have been rising has been speeding up since the middle of the 20th century.

During the 20th century, sea levels rose at an average rate of 1.3 [0.6 to 2.1] mm/yr between 1901 and 1971, increasing to 1.9 [0.8 to 2.9] mm/yr between 1971 and 2006, and further increasing to 3.7 [3.2 to 4.2] mm/yr between 2006 and 2018. Figure 3.2 shows the rise in sea level at the end of the 20th Century into the 21st Century.

Figure 3.2: Sea Level change (1993 – 2021)



Source: https://en.wikipedia.org/wiki/Sea_level_rise#/media/File:NASA-Satellite-sea-level-riseobservations.jpg (NASA/NOAA)

Observed estimates from 1950 to 2000 suggest that the sea level rise in the Caribbean was similar to the global pattern. Recent analysis of satellite measurements, estimate that the global sea level has been rising at an even greater rate of about 2 to 4 cm every decade for the past 30 years.

Lesson Two:

How will Caribbean Climate Change in the Coming Years?



When you have completed this lesson, you should be able to:

1. State what climate might look like in the future.

There are many scientists all over the world, including in the Caribbean who are working hard to provide a picture of what the climate will look like in the future. They use sophisticated computer models called '**climate models**' to make their projections. The science is pretty certain that the climate of the Earth including that of the Caribbean will continue to change. How much it will change will depend on the worldwide response to climate change, for example whether we continue emitting greenhouse gases at the same rate we are doing now (this is often referred to as a '**business-as-usual**' future) or whether we take drastic steps to begin to cut our emissions.

Temperature

It is expected that temperatures will continue to rise for all countries at least through the end of the current century. The Intergovernmental Panel on Climate Change Sixth Assessment Report suggests that the average global temperature could increase by between 1°C and 5°C by 2100 depending on how much greenhouse gases the world emits. Caribbean focused studies suggest that for the region, there will be warming that is in line with world-wide projections. This means that there will be:

- Substantial increases in the frequency of days considered 'hot'. For many countries, 'hot' days and nights may occur 95% of the time in the 2090s.
- Decreases in the frequency of days and nights considered 'cold'.
- Land areas warming more than ocean areas.

Studies done for Jamaica⁶ show that the minimum, maximum and average temperatures will continue increasing up to the end of the century. The same studies suggest that: the average temperature increase will be between 0.65 and 0.84 °C by the 2030s, between 0.85° and 1.80°C by the 2050s and between 0.82 and 3.09 °C for 2081-2100. Overall, the average annual temperature for Jamaica is projected to increase by between 1.1 °C and 3.2 °C by the 2090s.

The annual frequency of warm days in any given month may increase by 2-12 days in the near future, and 4-19 days by the middle of the century.

There will be continuous increases in sea-surface temperatures for Jamaican waters with projected increases ranging between 0.9 °C and 2.7 °C by the 2080s.

Rainfall

Rainfall patterns in the Caribbean are also expected to change. The scientists suggest that the Caribbean will get gradually drier as we approach 2100. Their models suggest that the Caribbean as-a-whole may receive up to 20-35 % less rainfall each year by the end of the century. This will be primarily due to less rainfall during the latter part of the wet season (September-November). The studies for Jamaica also suggest that:

- The number of back-to-back dry days is expected to increase.
- By the mid-2020s, there will be up to 2% less rainfall annually.

⁶ *State of the Jamaican Climate 2015: Information for Resilience Building (Full Report).*

- By the 2050s, Jamaica may be up to 10% drier.
- Under the business-as-usual future Jamaica may experience 21% less rainfall by 2100.

Hurricanes

There is expected to be little or no change in the frequency of Atlantic hurricanes. However, there will likely be a shift towards stronger storms (category 4 and 5) by the end of the century. Some studies suggest that maximum wind speeds may increase by up to 11% while rainfall rates may increase by up to 30%. Stronger hurricanes in the future will pose a significant challenge of the Caribbean if the region is not prepared for them.

Sea levels

For the Caribbean, the science suggests that the projected rise in sea levels may range from 0.26 and 0.87m (0.8 to 2.9 feet) by 2100. Higher sea levels plus stronger storms will lead to devastating storm surges and severe flooding of some Caribbean coastal towns and cities.

Activity One Social Studies

1. Examine the graph for sea level change (Figure 3.2).
 - a. Calculate the overall increase (year final minus year initial).
 - b. Identify the highest value for sea level and the corresponding year for this value.
2. If you live in a community near to the sea, arrange to talk to two or three elderly persons (perhaps within your family). Ask them if the beach has changed since they were a child and how. If you do not live near to the beach, ask them about rainfall patterns instead.

Activity Two Class Debate

Did you notice that projections of climate are often given over a range (from a possible lower value to a higher value)? This is done because scientists do not know for certain what the future will look like so they make projections for a **'best possible case'** and a **'worst possible case'**.

1. Your teacher will organise you into two groups of three each to debate the following statement: **"When preparing for future sea level rise it is better to do so for the worst possible case."**





4

UNIT FOUR

**Impacts of
Climate Change in
the Caribbean:
Implications for
Possible
Future Climate
Changes**

Jamaica is a Small Island Developing State (SIDS) which makes it extremely vulnerable to climate change. This means that the impacts of climate change are likely to be worse than in other places due to size and stage of development. Some of these reasons include worsening environmental conditions, dense population centres, poverty, poorly constructed infrastructure and housing built from improper material and located in high risk areas such as 'gully banks'. Jamaica's economy is heavily dependent on its natural environment on which critically important sectors such as tourism, agriculture and fisheries are based. Climate change is therefore a threat to the future development of the country.



Lesson One:

Potential Impacts of Climate Change in the Caribbean – What Does this Mean for the Future?

When you have completed this lesson you should be able to:

1. State some possible impacts of climate change in the Caribbean.
2. Explain how humans and other life may be affected by climate change in the future.

The impacts of Climate Change

The impacts of climate change on Caribbean countries' natural resources will directly affect the country's ability to earn. Avoiding, reducing and recovering from the impacts of climate change require money that governments would need to spend on other important areas like schools, hospitals and health centres and looking after elderly, homeless or mentally ill persons. The loss of natural resources also impacts the number of jobs available which will impact the government's income, as citizens would not be able to pay taxes. It is expected that climate change impacts such as increased temperature, sea level rise, and more intense and frequent incidents of droughts and flooding will significantly affect coastal

areas, water resources, agriculture, human settlements, infrastructure, tourism and health.

Coastal and Marine Resources

Hurricanes and storm surges (abnormal rise in the sea level) are projected to increase and be more intense because of climate change which may result in the destruction of coastal areas.

- Sea level rise can lead to erosion of beaches and the disappearance of sea turtle nesting areas.
- Loss of coastal areas can lead to inland flooding.
- Flooding events will lead to wastewater runoff from the land settling into and choking mangroves, seagrasses and coral reefs.
- Storm surges may contribute to an increase in the presence of invasive species which threaten native species. For example, the Lionfish invaded Caribbean waters between the late 1990s and the early 2000s and became a threat to the health of coral reefs.

Water Resources: Quality, Quantity, Availability

Water is needed for the successful operations of the agriculture, energy, mining, tourism, housing and health sectors of a country. For example, 84 percent of Jamaica's fresh water (used for drinking, bathing and cooking) comes from rainfall. It is expected that increased variability in rainfall patterns will adversely impact both the quantity and quality of fresh water resources.

There could be a change in the availability of water as there could be drought (too little rainfall), and flooding (intense rainfall). Heavy rainfall leads to flooding, which would affect the availability of clean water due to greater sedimentation levels (impurities) in reservoirs and dams. On the other hand, during droughts, it is likely that people may use water sources that are not safe for their daily activities.

Sea level rise can cause the **salinization** (increased saltiness) of underground fresh water sources. Sea level rise and stronger storms can also result in flooding which can damage inland infrastructure important for providing and maintaining water supply to homes, towns and cities. This includes potential damage to roadways, bridges, pipes, electricity power plants, water treatments plants, and human settlements.

Agriculture

Agriculture in the Caribbean, is mostly open-air fields with a heavy dependence on rainfall. It plays a key role in **food security** ensuring adequate supply and reliable access to good food. The sensitivity of the agricultural sector to climate change is evident every time an extreme event such as a drought occurs. For example, the 2014 drought in Jamaica resulted in losses amounting to JD\$900 million due to the loss of 1600 hectares of crops across the island. This had significant social and economic effects.

A major storm or a very bad drought unavoidably results in significant job loss, especially since this sector employs about 180,000 farmers. Crop loss leads to an increase in food importation which results in an increase in food prices. This especially affects the poor who would not be able to afford to purchase food.

In addition to drought conditions, rising temperatures, hurricanes, heavy rainfall and wildfires are some of the climate events that will continue to threaten the local agriculture sector. Some more negative effects of climate change include the following:

- Crop failure.
- Salinization of water.
- Competition for water.
- Sea water (saline) intrusion in coastal agricultural areas.
- Increase in agricultural pests such as the beet armyworm, weeds, fungal diseases.
- Heat stress among livestock, death in extreme cases, especially among poultry.

Figure 4.1: *Impacts of Climate Change on Agriculture*



*Banana plantation after Tropical Storm Gustav in Jamaica (2008).
Photograph: The Gleaner Co. Ltd.*

Activity One Agricultural Collage

Your teacher will ask you to form six groups. Each group will focus on one of the following events in Jamaica. You will find news stories and create a collage highlighting how the event affected agricultural activities.

- Hurricane Ivan (2004)
- Hurricane Charley (2004)
- Hurricane Dennis (2005)
- Hurricane Emily (2005)
- Tropical Storm Wilma (2005)
- Hurricane Dean (2007)
- Tropical Storm Gustav (2008)
- Drought (2004, 2008, 2015)
- Flood rains (2020)

Human Settlements and Infrastructure

Approximately 70 percent of the population of Jamaica live in coastal areas, sometimes in risky areas. Ninety percent of Jamaica's income is earned within the coastal zone. Disturbance of coastal areas such as from extreme climate events can lead to devastating consequences for many individuals.

Human settlements and infrastructure such as tourism facilities and port facilities are likely to be severely affected by flooding from sea level rise and storm surges associated with hurricanes. Death and displacement can occur in extreme cases. Availability of clean water can be disrupted due to floods. Further, flooding can damage roads, bridges, airports and destroy homes (Figure 4.2). The settlements and communities that are most likely to be impacted by climate change are those located within risky areas, such as shorelines and riverbanks. Houses made from improper building material such as cardboard and zinc are also extremely vulnerable to damage from these events.

Figure 4.2: *Impacts of Climate Change on Infrastructure*



Dominica after Hurricane (2018)



Photograph: *Blue Green Initiative (NGO in Barbados)*

Tourism

The tourism sector is an economically important sector for many Caribbean islands. For Jamaica it is estimated that the tourist sector represents more than 30% of the country's income and in 2019 alone, this sector generated USD\$3.7 billion. Tourism relies on a healthy natural environment, that is, crystal blue waters, white sandy beaches and healthy coral reefs to entice visitors to keep coming. Other offerings include: ecotourism, cultural tourism, culinary tourism and sports tourism. However, if climate change makes the region's climate unfavourable (too hot, prone to hurricanes, rising sea levels) or makes the climate of colder countries warmer, the success of this very important sector will be compromised. See Table 4.1 for further information.

Table 4.1: Impacts of Climate Change on Tourism

Climate Change Impacts/Extreme Events	Effects on Tourist Industry
Warmer temperatures	<ul style="list-style-type: none"> • Heat-related illnesses (e.g., heat stroke, stress, dehydration, headaches) • Other health impacts (e.g., vector-borne diseases). The <i>Aedes aegypti</i> mosquito responsible for Dengue and Chikungunya develops quicker in higher temperatures • Higher operating costs for cooling aids such as air-conditioning
Warmer seas	<ul style="list-style-type: none"> • Widespread coral bleaching which will affect the quality of tourist-related underwater activities such as snorkeling, scuba diving and submarine tours
Hurricanes, Storms	<ul style="list-style-type: none"> • Damage to tourism infrastructure (e.g., hotels, airports) • Loss or relocation of hotels/resorts • Interruption of business continuity i.e., cancellations • Increased insurance costs • Damage to natural resources, cultural assets
Changes in precipitation patterns (Droughts/ Flooding)	<ul style="list-style-type: none"> • Water shortages/disruption to water supply • Competition between tourism and other industries for water • Flooding
Sea level rise	<ul style="list-style-type: none"> • Coastal erosion including the erosion of beaches and sea turtle nesting sites • Costs associated with man-made sea defences (e.g., sea walls)

Sources: Simpson, Scott, Trotz (2011), CSGM (2012), Layne (2017)

Activity Two

Research one of the following storms and its impacts on the tourism industry in the respective Caribbean islands. Create a poster of your findings to share with classmates.

- Hurricane Ivan, 2004, Grenada
- Hurricane Tomás, 2010, St. Lucia
- Hurricane Sandy, 2012, the Bahamas
- Tropical Storm Erika, 2015, Dominica
- Three Category 5 hurricanes (Harvey, Irma and Maria), 2017, the Eastern Caribbean
- Hurricane Dorian, 2019, Bahamas

Human Health

The World Health Organization (WHO) defines health as “a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity”. According to the Centers for Disease Control and Prevention in the United States of America, there are five major indicators of health: genetics, behaviour, environment, medical care, and social factors.

The direct impacts of climate change on health are due to the changes in exposure to extremes such as heatwaves, floods and droughts. Climate change impacts the major environmental and social factors of human health, namely, clean air, safe drinking water, safe and secure shelter and adequate food (<https://www.who.int/news-room/fact-sheets/detail/climate-change-and-health>).

Morbidity (the rate of disease in a population) and **mortality** (the number of deaths in a particular population) are subject to increases due to climate related weather events and climate sensitive diseases. According to World Health Organization predictions, there will be 250,000 additional deaths globally between 2030 and 2050 due to climate change related health impacts.

- **Heat, Cardiovascular and Respiratory Illnesses** - The intensified and extreme heat resulting from climate change can lead to or worsen illnesses, such as dehydration, heat exhaustion, sunburn, and sunstroke. Urban air pollution, due to increased levels of ozone and other air pollutants, can affect those who suffer from cardiovascular ailments (e.g., heart disease) and respiratory illnesses (e.g., asthma, bronchitis, allergies). In addition to these illnesses, individuals can also die as a result of extreme

heat. While all individuals can be affected, some segments of the population are more vulnerable than others. These include: the elderly, children, women, the homeless, outdoor workers.

- **Food and Water-Borne Diseases and Other Issues** - Increased flood events pose dangers such as injuries, electrocution, and drowning. Additionally, water and food-borne diseases can result from contaminated water supplies and/or disruptions in water supplies. These include cholera (water-borne), food poisoning, typhoid, diarrheal diseases (food-borne), and malnutrition and undernutrition due to the disruption of food production and distribution systems.
- **Vector-Borne Diseases** - Vectors are “living organisms that can transmit infectious diseases between humans or from animals to humans” (CARPHA, 2018, p. 110). Changes in factors such as temperature and rainfall, migration patterns between populations and lengthened transmission seasons of vector-borne diseases can lead to an increased incidence of vector-borne disease such as dengue, malaria, chikungunya, leptospirosis and zika.

Additionally, stagnant water can create breeding grounds for vectors such as mosquitoes.



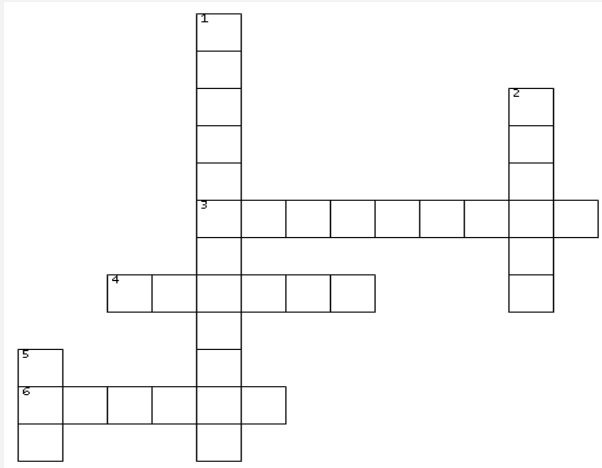
NOTE CAREFULLY:

- » The *Aedes aegypti* mosquito, which is the vector which carries the dengue and chikungunya viruses thrives in warmer temperatures.
- » The mosquitoes mature faster in warmer temperatures and bite more often.

- **Mental Health** - Apart from the physical health impacts, climate change will also affect mental health. Loss of jobs and income, loss of homes and/or forced relocation, injury and/or death due to climate-related events all have the potential to affect individuals' mental health given the disruptions in daily routines, as well as the losses involved. As a result, impacts can include anxiety, stress, disruptions to sleep patterns, depression, and suicidal thoughts and/or suicide. This mental health deterioration can also lead to drug and alcohol abuse.

Importantly, there is also a connection between increased heat and aggression. For example, when it is very hot, this may lead to increased discomfort, hostility, aggressive thoughts and possibly actions.

Activity Three Crossword Puzzle. Let's Have Some Fun!



DOWN

1. There are five major ___ of health.
2. An organism that can transmit infectious diseases between humans or from animals to humans.
5. An acronym for a major global organisation that works to advocate for health

ACROSS

3. The rate of disease in a population.
4. A vector-borne disease found in Caribbean nations.
6. A state of complete physical, mental and social well-being.

ASSESSMENT ACTIVITY

True or False – Consider whether the following statements are true or false.

1. Health can only be defined as the absence of illness.
2. Climate change only impacts the environmental determinants of health.
3. A vector is an organism that can transmit infectious diseases between humans or from animals to humans.
4. Increased heat can worsen respiratory illnesses in the population.
5. Dengue is the only vector-borne disease Caribbean nations have to worry about.

Energy

Climate achange threatens the efficient production of energy and given the high dependence on foreign energy sources across all sectors, this could increase a country's overall economic vulnerability. Hotter weather also drives up the demand for energy for cooling and for the extraction of adequate water from hard-to-reach sources. This means

higher costs for delivering energy. In 2021, Jamaica's primary energy supply was made up of mostly imported fossil fuels with only an estimated 10-14% derived from renewable energy sources.

The energy sector is also threatened by climate change in the following ways: Power stations near coastal areas are likely to be threatened by sea level rise. Drought conditions or inadequate rainfall will reduce the hydropower (liquid form of electricity) because there will be less water in the river to generate this source of energy. More hurricanes and tropical storms will impact power lines, wind and other forms of energy distribution.

Activity Four

Group Research Project and Presentations

You can continue to work in your previous groups. Each group will undertake research on one of the following topics and share its findings with the rest of the class in five-minute presentations.

Visit the World Health Organization (WHO) and other relevant websites to investigate:

- How warmer temperatures affect human health.
- The 2003 heatwave in Europe and the 2010 heatwave in the Russian Federation and their health impacts.
- The leptospirosis outbreak in Guyana in 2005 and its impacts.
- How and why children are particularly vulnerable to the health impacts of climate change.
- The linkages between increased heat and increased aggression/hostility/violence.

Here are some additional activities that you may want to try.

1. Use various resources (newspapers, Internet) to find out about the incidence of flooding, drought, storms, and hurricanes (e.g., date of occurrence, damage caused) in Jamaica over the last 100 years.
2. Become a reporter and interview an older relative or community member who has experienced a natural disaster to find out how they were affected by it. Make a short news video about their experiences or write the lead story for your local newspaper (2 pages maximum).
3. Make a brochure on how to prepare for and cope with either a storm or a flood.
4. Make a collage of newspaper headlines related to weather impacts in your country in the past year. Use the online newspapers and search for key climate words. Copy and save the images in a file on your computer or tablet.



UNIT FIVE

**Let's Make a
Difference!**



I want to help...Do
you think my friends
will help me?

There are different strategies that we can use to address the causes and the impacts of climate change. These strategies can be addressed by countries, sectors within countries, and by individuals. In this lesson we will look specifically at some of these strategies.

Lesson One:

How Should We Respond to Climate Change?

When you have completed this lesson, you should be able to:

1. Define climate change mitigation and climate change adaptation.
2. Outline mitigation and/or adaptation strategies that can be implemented by various sectors.
3. Outline personal actions that can be taken to mitigate and/or adapt to climate change.

Recall that in Unit Two, Lesson Two, you learned that **mitigation strategies** refer to human interventions to reduce the release of greenhouse gas emissions, to increase sites that store and capture carbon dioxide or to remove greater amounts of carbon dioxide such as by planting more trees.

Table 5.1 highlights some of the mitigation strategies that can be done by various sectors within society:

Table 5.1: Mitigation Strategies by Sector

Sector	Strategy
Energy	<ul style="list-style-type: none"> • Improve energy efficiency. • Conserve energy. • Reduce dependence on imported fossil fuels. • Utilise more types of renewable energy (e.g., solar energy, wind energy, wave energy, biofuels). <p>NB. approximately 50% of electricity generation could come from renewable energy sources by 2037</p>
Waste	<ul style="list-style-type: none"> • Minimise the amount of waste produced at various stages (e.g., production, distribution, consumption, disposal). • Recycle waste. • Utilise waste for energy production e.g., for biofuels. • Carbon Dioxide removal technologies
Forestry	<ul style="list-style-type: none"> • Conserve existing forest cover. • Practice agroforestry, which changes farming practices to deliberately grow trees alongside non-tree crops and rear animals on the same piece of land. • Prevent and control forest fires.
Education	<ul style="list-style-type: none"> • Raise awareness about climate change. • Develop awareness, skills, and actions in support of mitigation and adaptation strategies.

Climate Change Adaptation

Recall that in Unit Two, Lesson Two, we learned about **adaptation strategies**. We also discovered that these types of interventions refer to how humans can adjust to actual or expected climate events. By doing this we can minimize harm or make use of beneficial opportunities.

Adaptation strategies can be categorized in four main ways:

- Technical Strategies - e.g., building infrastructural defences such as sea walls.
- Managerial Strategies – e.g., altering farm practices.
- Policy Strategies – e.g., instituting planning regulations or building codes.
- Behavioural Strategies – e.g., modifying dietary choices or recreational choices.

Sectoral Strategies

These are climate change mitigation and adaptation strategies adopted by various sectors within society, including, energy, agriculture, forestry, tourism, water, and health. Let us look at two sectors critical to Caribbean societies to see what strategies can be put in place.

Agriculture is an important sector for Caribbean societies, and is also important with respect to **food security**, that is, ensuring adequate, accessible and nutritional food supply for citizens. Some of the strategies that can be put in place to ensure that this sector adapts to the impacts of climate change include the following:

- Identifying suitable inland areas for agriculture
- Strengthening services and programmes for small and medium sized farms.
- Growing drought, heat, salt, and flood tolerant crops.
- Ensuring efficient irrigation for farms and water harvesting and storage. Employing soil management techniques.
- Instituting mechanisms to control pests and diseases.
- Utilising local and indigenous knowledge with respect to farming practices.
- Making arrangements for storage and distribution of food for low production times, disasters, and emergencies.
- Implementing policies which will facilitate greater investment in agriculture.

For the **Tourism sector**, adaptation strategies can include:

- Utilizing green building designs, for instance, alternative methods for cooling buildings.
- Instituting physical planning measures to ensure resorts and hotels are not built near coastlines.
- Building sea walls.
- Protecting natural coastal and sea defences such as coral reefs and wetlands.
- Promoting alternative types of tourism such as ecotourism, sports, and culinary tourism.

Activity One

1. Working in groups of three, research climate change adaptation strategies that can be adopted by one of the following sectors: water, energy, forestry, health, infrastructure. Be prepared to make 10-minute presentations to the class summarizing your findings.
2. Watch the video *Islands on the Edge (Part Two)* on YouTube. Can you identify some of the mitigation and/or adaptation strategies that are being/can be implemented by the Caribbean region?

Activity Two

Use the Internet to find out more information about the organisations and agreements listed in Figure 5.1.

Figure 5.1: Key Global Milestones in Addressing Climate Change



ASSESSMENT ACTIVITY

I hope you have some ideas now about what you can do to help. Now that you have gained some knowledge about important climate change milestones, write down your ideas in two or three paragraphs. Let your teacher and classmates know what behaviour changes you will make to mitigate and/or adapt to climate change. These can relate to drought, flooding, and sea level rise.

One Final Word!

Living things need energy and to stay alive. The main source of energy for Planet Earth is the sun. The sun provides energy in a form that plants use to make food. Other organisms then get energy from plants. Radiation from the sun warms the Earth and helps us to survive. It is important to maintain an energy balance so that all organisms in ecosystems can benefit.

The sun has an important role in determining the climates of the Earth. Different parts of the Earth have different climates. Climates have formed and changed gradually over time. However, the climate has been changing at a faster rate in recent times, mainly because of human activities such as burning fossil fuels, cutting down large numbers of trees and industrial activities that release large amounts of carbon dioxide into the atmosphere. Excess carbon dioxide in the atmosphere is one of the main causes of climate change. Changing climates affect the survival of humans and other organisms.

Climate change is evident in increasing temperatures which are projected to exceed by 2°C globally over the next 100 years. This will lead to sea level rise, flooding, intense hurricanes, and a decrease in available clean water for domestic purposes critical for health and wellness. These impacts will be greatest for the most vulnerable such as those living in SIDS like Jamaica and other Caribbean islands.

Can we do anything about it? Yes, we can! We can start by learning more about the causes and effects of climate change to be better equipped to deal with it. Remember Adrian in the first lesson? He has joined the 4-H Club at his school, and is a part of their tree-planting project!

Figure 5.2: 4-H Club meeting



Figure 5.3: Tree-planting activity



You can take the right action! You can make decisions that will decrease the production of gases that intensify the warming of the Earth. You can be more mindful in your daily activities to reduce the threat posed by climate change. Let us do all we can to act for the sake of our changing climate!

Answers to Selected Activities

Unit Two: Lesson One, Activity Five

Answer key for the list of scrambled words

WORD	ANSWER
ULDOC	CLOUD
DIWN	WIND
ARNI	RAIN
THO	HOT
NESHUNSI	SUNSHINE
REPURESS	PRESSURE
UNS	SUN
URCHARNIE	HURRICANE
ICEIONAPTRIPT	PRECIPITATION
STOCRAFE	FORECAST

Unit Two: Lesson Two, Activity Six

1. How does a greenhouse work, and why do people use them? **[Ans: Greenhouses allow the sun's rays in to warm the plants inside. They then prevent the warmth from escaping. Especially in cold countries, it allows people to grow crops all year round].**
2. Can you name two ways in which the atmosphere acts like the glass in a greenhouse. **[Ans: (i) Allows most of the sun's radiation to reach the earth. (ii) Traps the heat from the earth, preventing it from leaving].**
3. Do you think the greenhouse effect is a good thing? Could we live on Earth if it didn't occur? **[Ans: Without it, Earth would not be warm enough to live on].**

Unit Two: Lesson Two - Quick Quiz Answers

Term	Definition
1. Climate Change	b.
2. Global warming	e.
3. Adaptation	h.
4. Greenhouse effect	f.
5. Climate	a.
6. Greenhouse gas	g.
7. Weather	d.
8. Mitigation	c.

Unit Four: Lesson One, Activity Three - Crossword Puzzle

DOWN:

- determinants
- vector
- WHO

ACROSS:

- morbidity
- dengue
- health

Unit Four: Lesson One, Assessment Activity - True or False

- Health can only be defined as the absence of illness. - **False**
- Climate change only impacts the environmental determinants of health. - **False**
- A vector is a living organism that can transmit infectious diseases between humans or from animals to humans. - **True**
- Increased heat can worsen respiratory illnesses in the population. - **True**
- Dengue is the only vector-borne disease that Caribbean nations have to worry about. - **False**

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