Wonderful Water

An Environmental Education Programme

A Watery World

Mangrove Ecosystems in TCI

5. Climate Change and Mangroves

Teachers' Guide

TCI
Education Department

Wonderful Water

An Environmental Education Programme

A Watery World

Mangrove Ecosystems in TCI

5. Climate Change and Mangroves

Teachers' Guide

Target Age Group - 9 - 11 years

This environmental education programme has been produced by the UK Overseas Territories Conservation Forum (UKOTCF) and the Turks and Caicos Department of Education.

It was part-funded by the Overseas Territories Environment Programme (OTEP) of the UK Department for International Development and the Foreign and Commonwealth Office.

The project was developed from an original idea by Mr Edgar Howell, Director of Education, Turks and Caicos Islands, and these materials developed by a team co-ordinated by Ann Pienkowski, Environmental Education Co-ordinator, UKOTCF. It is hoped that through the teaching materials developed for this project, students in TCI will gain a greater understanding of the importance of the water ecosystems in TCI, and the need to conserve these.

As a possible model to assist environmental education in other areas of the Caribbean (especially UK Overseas Territories) these materials will be made available to a wider audience.

Contents

Introduction

In devising these teaching materials, reference was made to the TCI Science Curriculum for Grade 5 and 6, and the science teaching materials currently being used in primary schools in TCI.

A curriculum framework has been developed, which links the Wonderful Water themes to curriculum requirements. As part of the curriculum framework, expected levels of achievement for a particular stage in a students' education have been developed into statements of competency which can be used to assess the levels students have reached. The purpose of these statements of competency is to support teachers in their review of students' progress. The objectives given in the pupils' materials relate to these statements of competency.

Assessment criteria / Statements of competency

These level statements relate to levels of attainment given in the Science National Curriculum for England, but are compatible with such statements about expected attainment in many other curricula.

This table gives the level (L) a child is expected to achieve at a particular stage in their schooling:

End of grade:	Expected attainment related to curriculum levels (from National Curriculum for England)		
	Slower progress	Most pupils	Faster progress
4	L2	L3	L3/4
5	L2/3	L3/4	L4/5
6	L3	L4	L5

5 - Climate Change and Mangroves: statements of competency

The assessment criteria / statements of competency, which relate to the unit on Climate Change and Mangroves are given below. These can be used to guide progression.

Climate change and Mangroves

A review of what climate change is

Geography

L2: Know that climate is the general weather in one place over a long time.
L3: Know that climate changes over a long time, but human activities have caused changes to happen quickly.
L4: Know that manmade "Greenhouse Gases" are causing the earth to heat up. Know the meaning of terms such as atmosphere, solar radiation, reflection, Greenhouse Gas, layer.
L5: Understand the process by which "Greenhouse Gases" are causing the world to heat up.

About the possible impact of climate change on wetland ecosystems

L2: Know that climate change will affect the environment.
L3: Provide simple explanations of how climate change might affect mangroves.
L4: Know some of the ways in which climate change can change wetlands (in TCI). Know how climate change could affect lives and activities of people.
L5: Understand some of the ways in which climate change can change wetlands in TCI, and explain what effect this could have.

The pupils' text provides key information for pupils.

The teachers' guide contains further information and resources for teachers, suggested activities for pupils, and example pupil worksheets.

The illustration in this guide, and those in the pupil text, will be provided as powerpoint pdfs.

The suggested pupil activities and worksheets can be carried out by individuals, pairs or small groups.

These materials are a working draft, and any suggestions for further activities, amendments and improvements are welcome.

Any comments / suggestions should be sent to the UKOTCF Environmental Education Co-ordinator, Ann Pienkowski. Email apienkowski@ukotcf.org

The History of Climate Change – A Timeline

1753 Joseph Black discovered carbon dioxide

1827 Jean-Baptiste Fourier is the first to suggest that the earth is kept warm by a layer of gases acting like a greenhouse

1862 The invention of the combustion engine – the beginning of the industrial revolution and the rapid rise in carbon emissions

1896 Svante August Arrhenius proposed that carbon dioxide emissions from the burning of coal would enhance the earth's greenhouse effect and lead to global warming

1957 American scientist sets up the first monitoring programme of CO2 levels in the atmosphere and immediately finds regular annual increases.

1985 The first major international conference on the Greenhouse Effect is held in Austria.

1987 The warmest year on record so far.

1980-1990 The warmest decade on record

1990 The Intergovernmental Panel on Climate Change (IPCC) reports that the planet has warmed by 0.5ºc since 1890.

1995 The hottest year yet. A report by the IPCC predicts that, unless carbon emissions are reduced, global warming will be between 1ºc and 3.5ºc.

1997 The Kyoto Protocol is drawn up to force industrialised countries like the UK and USA to cut carbon emissions significantly by 2010. The USA refuses to be part of the agreement.

1998 The hottest year in the hottest decade of the last century.

1999 The golden toad of Costa Rica is believed to be the first animal to become extinct as a result of climate change

2000 Scientists warn that the earth could warm up by an alarming 6ºc within the next 100 years if things continue as they are.

2005 The warmest year on record in the Northern Hemisphere.

2006 Scientists predict that the sea levels could rise between 9cm and 69cm by 2080, depending on future carbon emissions.

2009 National Aeronautics and Space Administration (NASA) found that 2009 was the second warmest year since 1880, when modern temperature measurement began (warmest being 2005 Worldwide, 2000–2009 was the warmest decade ever recorded.

2011 At the climate change conference in Durban, South Africa, all countries agreed to negotiate a new climate change mitigation regime by 2015 and make it operational by 2020.

2015 Mean global temperature is 14.8°C, the warmest in thousands of years. Level of CO2 in the atmosphere goes above 400 ppm, the highest in millions of years

For an interesting visualisation of changing global surface temperatures from 1884 to 2017 see: **https://climate.nasa.gov/interactives/climate-time-machine**

Further Information about Climate Change

Small islands are particularly vulnerable to the effects of climate change. They have a high ratio of coastline length to land area. Clearly, islands like those forming the Turks and Caicos Islands, with little or no land more than a few metres above sea level are especially vulnerable. More than 90 percent of the Turk and Caicos Islands are less than 33 feet (10 meters) above sea level.

Information from the Florida Keys predicts that over the next 100 years, sea level will rise 8 - 16 inches (20 - 40 cms) with average temperature rising 4 - 10 degrees Fahrenheit (approx 2 - 5 degrees Celsius).

A useful website (**http://flood.firetree.net/**) allows you to see what the effects of sea level rise would be on your part of the world.

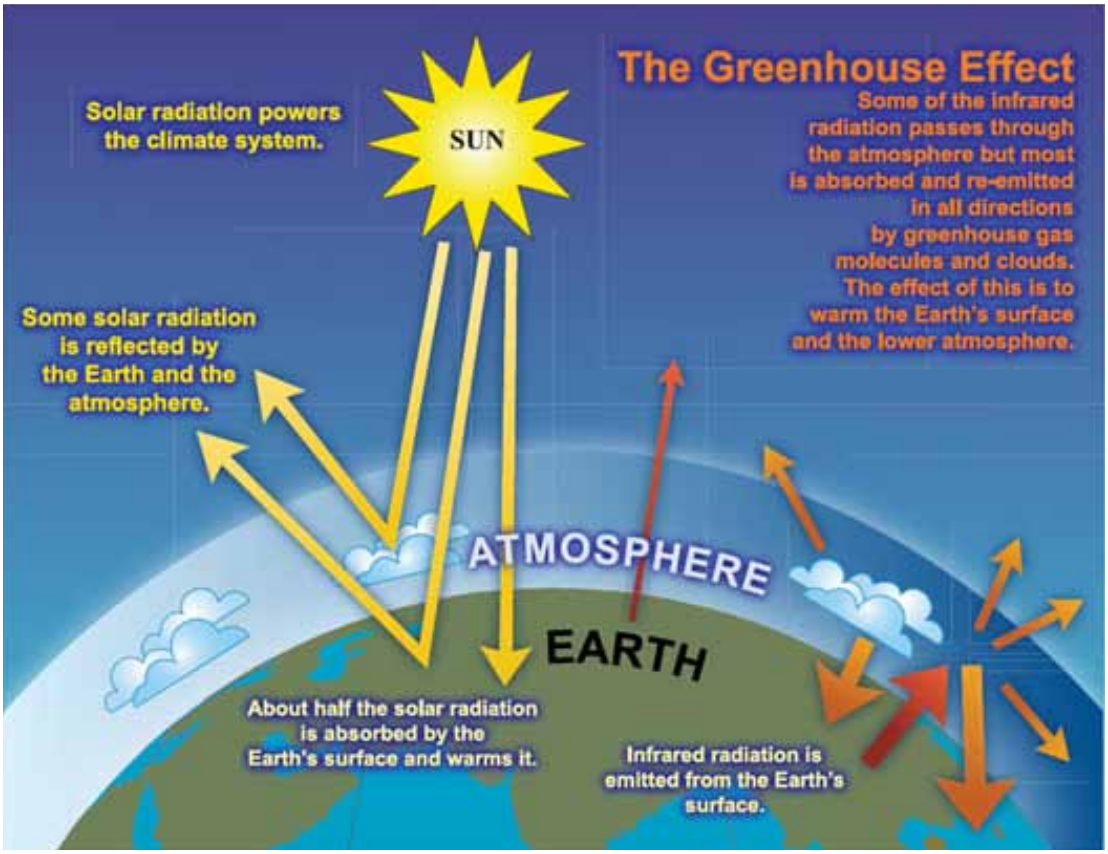
Two predictions for the Turks and Caicos Islands are shown below.

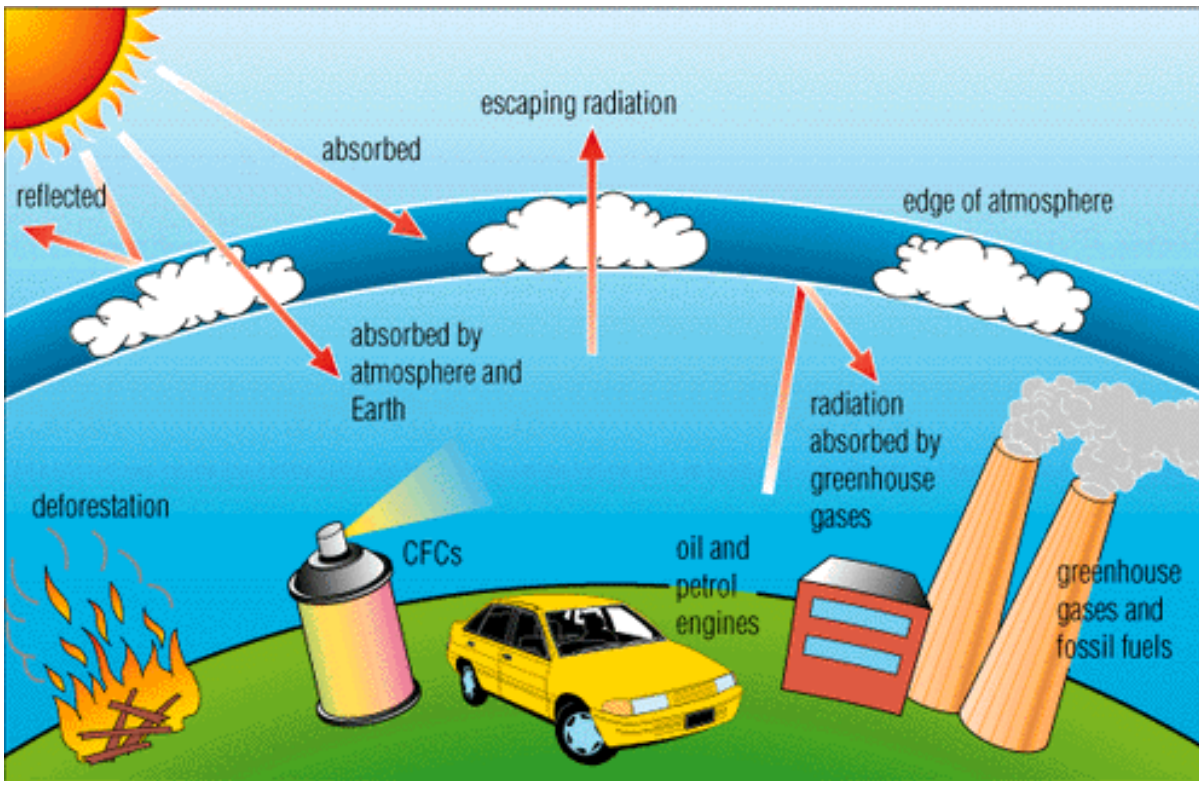
The map on the left shows present sea levels and land areas. The map on the right shows what the land areas would be if sea levels were to rise by 4 metres (13 feet). Of course, a sea level rise of this magnitude from climate change is far outside the limit for the predicted sea level rises for the next 100 years (unless there is a catastrophic collapse of the Greenlandic and Antarctic ice fields). However, another prediction of climate change is the increase in hurricanes and storms, and a storm surge could easily reach 4 metres. Hurricane Ike in 2008 created a storm surge of 2.6 metres (8.5 feet) in Grand Turk.

Satellite image of Hurricane Ike, September 2008

Greenhouse gases and the Greenhouse effect - alternative diagrams.

The pupils' text contains a simple diagram to illustrate the greenhouse effect. Reproduced below are some others which can be used to support explanations of these.





TCI Climate change policy

In October 2018 TCI announced the completion of its first climate change policy, as the effects of the phenomenon are already being felt across the globe.

The policy stipulates how climate change adaptation will be integrated in all Government strategies, spending and investment decisions. There is a green paper to accompany the policy, to ensure that climate change adaptation provisions are included in all national policies, programmes, strategies and action plans. The policy makes clear that addressing climate change and ensuring sustainable development are integral to the Government's overall development agenda.

The policy aims to:

- Educate the wider public on the potential impacts of climate change and the recommended adaptation strategies
- To ensure the protection and wise use of carbon sinks, and to enhance and protect human health.
- To conserve and guarantee a sustainable supply of fresh water, to increase resilience by adapting to the adverse impacts of climate change.
- To achieve the objectives set in the TCI energy conservation policy and implementation strategy, as well as reduce greenhouse gas emissions.
- To achieve greater food security through sustainable agriculture production, while encouraging the use of green technology.
- To advocate sustainable tourism at all levels.

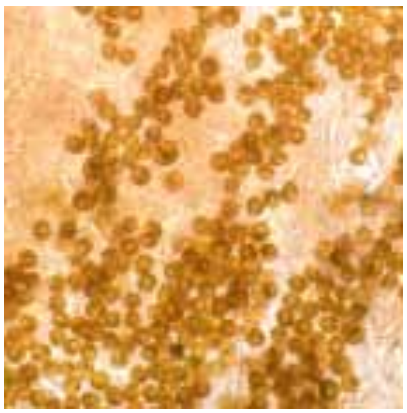
Here are some potential climate change impacts on TCI:

Potential Climate Change Impact	Effect
Temperature Increase	☹ Loss of terrestrial and marine species ☹ Reduced fish stocks ☹ Human health impacts including heat stress and increased vector borne disease
Increased Extreme Events	☹ Damage to physical infrastructure and natural assets such as coral reefs and vegetation
Increased Sea Surface Temperature	☹ Coral bleaching ☹ Ocean acidification ☹ Movement of marine species away from traditional habitats
Sea Level Rise	☹ Erosion of coastal areas including beaches, wetlands and coastal settlements ☹ Saline intrusion
Changes in Precipitation	☹ Depletion of limited water supplies ☹ Changes in water quality ☹ Human health impacts from increased vector borne diseases

It is important that people must be educated to understand the science of climate change, its impact on their lives, and how to live with the challenges. The Caribbean Community Climate Change Centre also known as the Five Cs, has produced education resources for children to teens (6 – 18 year olds), called Climate Wise- Kids. The materials include: downloadable booklets (Climate Change Passport; Waste to Energy Booklet; Five Things To Know About Climate Change; UWI Climate Change Comic Book); a carbon footprint calculator, and videos. These resources can be found at:

http://www.caribbeanclimate.bz/category/climate-wise-kids/

Coral Bleaching - Background Information



Zooxanthellae algae

Most corals have a symbiotic relationship with *zooxanthellae* algae – a microscopic plant that lives inside the tissue of the coral in exchange for providing the coral with up to 90% of its energy requirements.

Like most plants, *zooxanthellae* photosynthesize – using sunlight to turn water and carbon dioxide into carbohydrates (sugars) to feed themselves and the corals. This allows corals to grow much more quickly than they could if they relied on plankton for food. The skeletons of most corals are white – it's the *zooxanthellae* living inside the tissue of the coral polyps that gives corals the browns, greens, purples and other colours we see out on the reef.

Zooxanthellae are fussy about their living conditions. They can't survive in cold deep water, which is why corals reefs are found mainly in the tropics (although some corals that can survive in cold deep waters – for example off Scotland and Norway – they don't have a relationship with *zooxanthellae* and grow too slowly to build the kind of reef systems found in tropical waters.

Unfortunately *zooxanthellae* don't like hot water either. If the sea temperature becomes too warm, the algae develops heat-stress, and stops producing carbohydrates. However, it begins to produce toxic waste products which poison the coral until it rejects the *zooxanthellae* – expelling it into the open water. When this happens, the coral turns white, and this is known as "coral bleaching".

Bleached coral is not necessarily dead. If the sea temperature drops relatively quickly, the coral will survive and within a few months will have fully recovered its *zooxanthellae*.

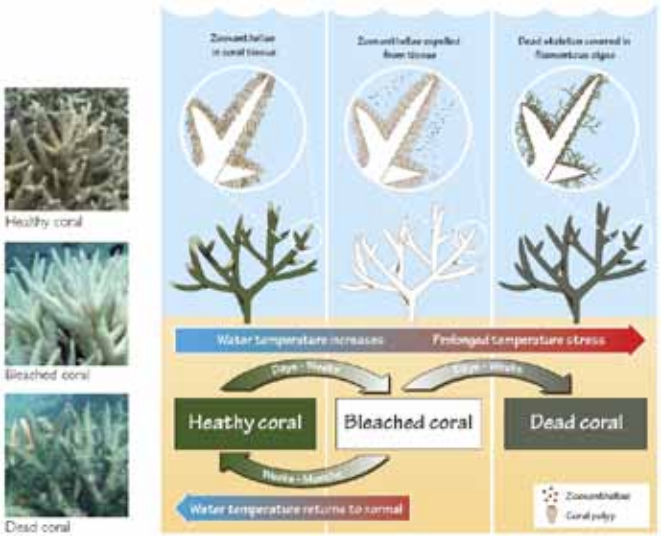


Diagram to explain coral bleaching

However, if that sea temperature stays too high for too long (it's impossible to generalise about how high and for how long because it depends on many variables, such as the particular strain of *zooxanthellae*, the species of coral and it's geographic location, etc) the coral may not be able to feed itself effectively and the polyps will eventually die, leaving the dead, white, calcium-carbonate skeleton behind.

Mangroves and Climate Change

Recent research has shown that mangroves store exceptionally more carbon than most tropical forests. Carbon sequestration is the process through which plant life removes carbon dioxide (CO2) from the atmosphere and stores it as biomass. Plants are therefore called carbon sinks. It is estimated that mangroves sequester large amounts of carbon, approximately 25.5 million tonnes of carbon every year. Conserving mangroves would help in reducing the amount of carbon dioxide in the atmosphere. Reduction of greenhouse gases, including atmospheric carbon dioxide is a key target for the Kyoto agreement. More information about the Kyoto agreement is available at:

http://unfccc.int/kyoto_protocol/items/2830.php

Additionally, mangroves are not only key to climate change mitigation efforts, as summarised above, they also play important roles in adapting to the changing climate. They protect coastlines from storm surges and fluctuations in sea levels, including from tsunamis.

Suggestions for Activities to support learning

How can we make a difference?

The key message to ask students to focus on is the need to reduce usage of fossil fuels, like coal, oil and gas. The last two are particularly relevant to the Turks and Caicos Islands.

Information and discussion points.

1. The electricity generators use gasoil, from a fossil fuel. Electricity costs are very high in the Turks and Caicos Islands. How can use of electricity be reduced (good to save money as well as reducing greenhouse gas emissions). What about alternative ways of generating electricity (for example solar and wind) - that is, using **renewable** energy sources.
2. Engines used in cars and motor boats use fuels from oil. Large cars and vans use more fuel than small cars. A bicycle does not use any fossil fuel, neither does walking. How can this information help us cut down on the use of fossil fuels for transport?
3. The majority of manufactured goods and food supplies are imported into the Turks and Caicos Islands by plane or ship. So as well as the cost of manufacture or production (using a lot of fossil fuel) there is the cost of transporting them to the Turks and Caicos. What can we do to reduce this source of fossil fuel consumption? Discuss Reduce, Re-use, Repair, Recycle - the 4Rs.,
4. Much of the water used in TCI comes from de-salination, which uses fossil fuels. A lot of

bottled water is imported. Can students think of ways to reduce their use of fossil fuels by the way they use water? For example, not buying small bottles of water, but refilling a personal water bottle from a larger container. Water saving measures in the home.

5. Develop survey and interview questions to find out what people think, and about previous hurricane events. Students can ask family members and neighbours about previous hurricanes: what happened, what they did, what it felt like. Older interviewees could be asked whether they thought bad weather events were more frequent now, worse than they were, whether there were changes to the dry and wet seasons, etc. They could be surveyed to find out their views on climate change. All the survey responses could be pooled and analysed, perhaps as a mathematics activity.
6. Stakeholders in the tourism business (for example dive operators, hotel managers, restaurant owners, builders, etc) could also be interviewed, along similar lines to point 5 above.

Outputs from discussions on these topics could be:

- Reports
- Articles for newspapers and magazines
- Letters of Enquiry to find out more, or find answers to specific questions
- Posters
- Information leaflets or brochures
- Oral presentations

Consolidation and Comprehension activities

- Question and answer quizzes
- Written accounts and reports
- Acrostic (=vertical) poems
- Fictional writing - for example "Turks and Caicos when I am 70 years old.", or 2084 (after George Orwell's 1984).

Learning Key Vocabulary

Suggested key words:
atmosphere, carbon dioxide, climate, energy, erosion, flood, fossil fuel, greenhouse gas, hurricane, layer, mitigate, oil, radiate, reflect, solar, storm, sun, temperature

Students can create their own glossary of key vocabulary.

Word puzzles, like cross-words and wordsearches. These can be created for a particular set of vocabulary using online puzzlemakers such as:

www.teachers-direct.co.uk/resources/wordsearches/

http://puzzlemaker.discoveryeducation.com/

Some examples are included at the end of this guide.

Wondrous West Indian Wetlands Teachers Resource Book - Relevant Activities

There is material relating to climate change in this book:
Activity 4-B - Warming Up! on pages 118 - 122.

If you, or your school, do not have a copy of this resource, copies should be available from DECR or the Education Department. If you are unable to find a copy, please contact apienkowski@ukotcf.org

Wordsearch Example Activity Sheet

Climate Change and Mangroves

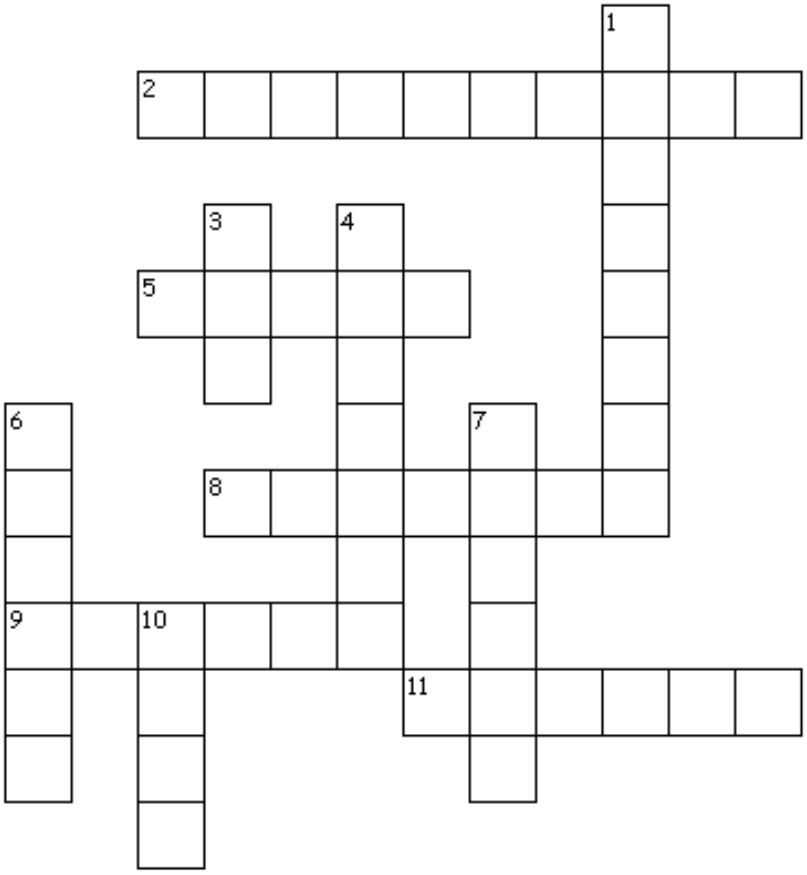
n	g	r	n	i	r	s	a	e	s	w	n	e
t	r	f	n	c	s	e	n	f	e	n	d	f
l	e	b	o	k	l	a	f	h	l	i	v	u
a	e	m	o	s	c	i	r	l	x	o	i	e
y	n	o	p	i	s	e	m	o	e	l	o	o
e	h	s	r	e	v	i	i	a	i	c	t	d
r	o	r	t	s	r	d	l	o	t	h	t	e
e	u	s	m	o	n	a	s	f	o	e	f	e
h	s	u	a	o	r	w	t	o	u	h	m	n
a	e	n	b	o	r	m	h	u	l	e	p	e
e	g	r	a	d	i	a	t	e	r	a	l	r
o	a	t	m	o	s	p	h	e	r	e	r	g
c	s	e	r	o	s	i	o	n	u	e	a	y

Words to find:

atmosphere, carbon dioxide, climate, energy, erosion, flood, fossil fuel, greenhouse gas, hurricane, layer, oil, radiate, reflect, solar, storm, sun, temperature.

Crossword Example Activity Sheet

Climate Change and Mangroves Crossword Puzzle



Across

2. Mangroves are good at _____ shorelines from hurricanes.
5. Hotter seas can cause _____ bleaching.
8. Human activities are speeding up _____ change.
9. The temperature of the sea is _____.
11. Burning _____ fuels increases levels of greenhouse gases.

Down

1. Mangroves help _____ against the impact of climate change.
3. _____ islands like TCI are more at risk from increased sea levels.
4. Greenhouse gases are causing global _____.
6. Climate change is causing more _____.
7. _____ dioxide is a greenhouse gas.
10. Mangroves are a good carbon _____.