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Learning about climate change the Pacific way

A guide for Pacific teachers

Samoa

FA'AVAE I LE ATUA SAMOA

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Compiled by

Coping with Climate Change in the Pacific Island Region
Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ)
and
Secretariat of the Pacific Community

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Introduction

Rationale

Many educational resources available on climate change focus on its causes and its mitigation by reducing the emission of greenhouse gases. There are very few educational resources that address adaptation measures that are specific to Pacific islands. The focus of this resource is on the effects of changes in air and sea-surface temperature, rainfall, sea-level rise and extreme weather events on island environments, economies and people. It is vital to enhance individual and community skills to adapt to these changes – in other words, to reduce risks and maximise potential benefits.

Ways to reduce greenhouse gas emissions at the local level are also explored in this resource – this is everybody's responsibility: it is important to slow down globally.

Expert knowledge has grown during the last decade on the vulnerabilities of Pacific Island countries to the effects of climate change, and on how climate change affects not only a range of sectors (such as agriculture, animal husbandry, fisheries, water and sanitation, forestry, health and infrastructure), but also communities and different groups in society (such as women, men, children, the elderly, and people with disabilities), as well as Pacific Island cultures.

Aim

The aim of this guide is to deliver nationally prioritised key messages relevant to climate change science, the effects of climate change on the Pacific and options to mitigate its causes and to adapt to expected changes.

Development

In 2011, a regional Climate Change Education Planning workshop was held in Nadi, Fiji. This was part of the Coping with Climate Change in the Pacific Island Region (CCCPIR) programme, implemented by the Secretariat of the Pacific Community and the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH on behalf of the German Federal Ministry for Economic Cooperation and Development (BMZ). The workshop was organised in collaboration with the Secretariat of the Pacific Regional Environmental Programme (SPREP) and the University of the South Pacific's Institute of Education and Pacific Centre for Environment and Sustainable Development.

Education representatives from Fiji, Tonga, Samoa, Vanuatu and Kiribati attended the workshop and identified the need to develop new education resources to enhance learning about climate change in Pacific schools and training institutions.

The Pacific-Australia Climate Change Science and Adaptation Planning (PACCSAP) programme commissioned SPC to develop this resource on climate change for the education sector, in collaboration with SPC/GIZ CCCPIR. In addition to the work of education and climate change experts, there are inputs from representatives of each of the five pilot countries (Fiji, Kiribati, Samoa, Tonga and Vanuatu) to ensure that the material and information are culturally relevant to their teachers and students, and the Pacific Climate Change Science Program (PCCSP) of the Australian Government produced country-specific reports on the science and impacts of climate change – information crucial to this resource.

A country-specific version of the guide will be distributed to schools, providers of technical and vocational education and training (TVET) and libraries in the pilot countries. It will be used through the SPC/GIZ CCCPIR programme in its education-related activities to strengthen capacity-building in education ministries, training institutions and schools, as well as to provide education on climate change adaptation and mitigation in the five participating countries. It is hoped that the resource will find further support and use at other levels of education and in other Pacific Island countries.

Approach

For most people, personalised and culturally relevant illustrations are often more appealing than texts and scientific graphs, which can be intimidating and overwhelming. Pictures convey meaning that words cannot. They accommodate the interests of a range of people, and they allow exploration, creativity and storytelling. For this reason, it was decided to make a picture-based resource and to have minimal text in the pictures. This would make them accessible to a wide range of students, from pre-school to TVET, and it is hoped that the pictures can also be used to foster discussion with community groups. The learning activities and suggested outcomes, however, are specifically designed for students at Years 7 and 8; Pacific education ministries perceived this as an appropriate time to introduce students to the science of climate change.

In order for it to be useful in many countries in the Pacific, the guide is published in both English and French, and most of its content is generalised. Pictures 3 and 8 are, however, specifically about the climate of your country, now and in the future.

Using this guide

Learning about climate change the Pacific way: A guide for Pacific teachers was developed to support you, as a teacher, trainer or lecturer, when you teach your students about climate change and increase their resilience to the effects of global warming.

The resource consists of a set of 16 colourful pictures and a country-specific guide for you. The guide has a description of each picture, suggested learning outcomes, suggestions for teaching and learning activities, definitions (in white boxes) and background information (in grey boxes) for you. A glossary of key terminology is provided at the end of this guide. Whether you are a subject teacher or a class teacher, you can use the resource to supplement and complement the work you are doing on topics related to climate change in your science, social science and/or geography classes. To help you select the topic/picture and related activities, the links between your school curriculum and this resource are set out in the next section.

The decision to have separate pictures that can be used in multiple ways was a deliberate move to make the resource as user-friendly and flexible as possible. No teaching resource is used by all teachers in the same way. This resource suggests different learning strategies and activities that you can choose from, depending on the needs and readiness of your students.

Learning outcomes

The learning outcomes for this guide are based on the pillars of education advocated by the United Nations Educational, Scientific and Cultural Organization (Delors 1998).

If you use all the pictures and do some of the suggested learning activities, students should be able to do the following:

Pillar of education	**Learning outcomes – students will be able to:**
Learning to know	• describe the causes of climate change • link Pacific weather and climate to latitude, the water cycle, El Niño Southern Oscillation (ENSO), ocean currents and winds • describe the observed and predicted effects of climate change in their own country and in the Pacific region • explain how increasing levels of greenhouse gases and rising temperatures can affect local ecosystems
Learning to do	• differentiate between adaptation and mitigation activities • interpret maps, graphs and statistics on climate change • plan and participate in the implementation of an adaptation or mitigation activity with their class
Learning to live together	• discuss some possible adaptation and mitigation activities suitable for their community
Learning to be	• make a commitment to a personal adaptation and mitigation action

Teachers: this guide contains a great deal of information that is designed to make the concepts more understandable to you. It is not intended that Year 7 and 8 students need this depth or breadth of knowledge. Use the learning outcomes and your own curriculum documents to guide you.

Samoa curriculum links

This resource can be used by teachers when planning to cover achievement objectives from the social studies and science curriculum statements. While there are no direct references to climate change in the curriculum at these year levels, the causes and effects are referred to indirectly.

The social science curriculum is designed to enable students to develop their knowledge and understanding of the diverse and dynamic nature of society. They learn about how interactions occur among cultures, societies and environments. They learn to investigate society, explore issues, make decisions and work cooperatively with others. The understanding and skills they develop enable them to participate in society as informed, confident and responsible citizens.

The science curriculum at the primary education level allows students to make connections between what they learn in the classroom and their everyday lives. It also stimulates critical thinking and develops students' conceptual understanding and application of science and technology, as they have always played an important part in Sāmoan society and culture. However, scientific knowledge is changing and growing rapidly. This is having major effects on individuals and society. Hence, it is increasingly important for students to be equipped with primary knowledge, skills, attitudes and values that will help them make informed judgements about scientific change and how it should be managed.

Social Studies

STRAND	**ACHIEVEMENT OBJECTIVES** ***STUDENTS LEARN*** ***Picture/s***
Year 7	
Strand 2: Place and Environment (PE)	PE7.1 why people regulate the use of places and the environment *Pictures 1 & 16, 7*
	PE7.2 how people's activities affect places and environments; *Picture 7, 12, 13, 14, 15, 1 & 16*
	PE7.3 how people's perceptions of places and environments reflect changes by information
Year 8	
Strand 2: Place and Environment (PE)	PE8.1 how people seek to resolve differences over how places and environments should be used; *Pictures 1 & 16, 7, 14, 15*
	PE8.2 why it's important for people to solve problems caused from using places and environments *Picture 7*

Science

STRAND	**ACHIEVEMENT OBJECTIVES** ***STUDENTS LEARN TO*** ***Picture/s***
Year 7	
Strand 1: The Nature of Science (NS)	
SUBSTRAND: Participating and contributing	NS 7.4 describe how knowledge of Science is used by people when making decisions about environmental issues. *Pictures 6, 7, 8 & 11*
Strand 3: The World and Beyond (WB)	WB 7.1 recognise the causes and effects of different types of weather and the seasonal variation of weather patterns. *Pictures 3 & 5*
	WB 7.1.2 describe how clouds are formed *Picture 2*
	WB 7.1.3 describe variation in local weather patterns from data they have collected *Pictures 3, 5 & 8*
	WB 7.1.4 predict changes in weather from local weather maps *Pictures 3 & 8*
	WB 7.1.5 explain how weather can drastically affect living things, e.g. through storms, flooding, gales, hurricanes *Pictures 8, 9 & 10*
	WB 7.1.6 describe ways that living things adapt their lives to the different weather conditions, e.g. types of houses built, lifestyles, plumage, fur (e.g. thickness, moulting). *Pictures 12, 13, 14 & 15*
Year 8	
Strand 1: The Nature of Science (NS)	
SUBSTRAND: Participating and contributing	NS 8.4 describe how knowledge of Science is used by people when making decisions about environmental issues. *Pictures 6, 7, 8 & 11*
Strand 4: The World of Materials (WM)	WM 8.1 recognise the different arrangements and motions of particles in solids, liquids and gases and relate this to the properties of some familiar materials. *Picture 2*

Introducing the topic

Try to introduce the topic of climate change in an interesting way in order to arouse the students' curiosity. One way to do this is to put some of the pictures up in the classroom and give your students time to have a good look.

Then do any of the activities described below. Not only will this help to establish the prior knowledge of your class, but it will be fun for the students.

Teaching and learning strategies

1. Postbox

Place the 16 pictures, or as many as you want to use, around the classroom. If your students are not used to this strategy then it would be wise to select no more than eight pictures. Make some 'postboxes' from used ice-cream containers or small boxes with lids and a slot for students to 'post' their responses. If you want, you can label the postboxes Picture 1, 2, 3, etc.
Then:

Either:

- under each picture, place a card with one or two questions on it, such as:
    - What is happening in this picture?
    - What does this picture tell you?
    - What are people doing in this picture?
    - What do you think is going to happen to the people/land in this picture?

  and ask the students to write their answers on a piece of paper and 'post' them.

Or:

- ask the students to write at least one question about each picture on a piece of paper and 'post' it.

Give the students time to look at the pictures and write their answers or questions and post them. Then group the students evenly (no more than four to a group, depending on how many boxes you have) and give each group one box. They will read all the questions/answers and work out a way to categorise or group the responses. To help students with this, give each group a large piece of paper to put all the responses on; the students can move the responses around and glue them into place.

Each group can then present their findings to the class. If you have asked for student questions, decide if each group has to come up with the answers or whether the questions are going to be collated and answered during the unit of work.

2. Shrinking islands

Divide the class into groups – five or six students in a group – and tell them that they are going to draw an imaginary Pacific island.

Materials

1. One piece of plain white or brown paper, about one metre square, per group

2. Felt-tipped pens or crayons – three or four colours per group

Instructions

1. Discuss with the students what they would find on a Pacific island. Draw out the natural features – such as mountains, rivers and trees – and the needs of the people – church, school, houses and shops. How do people get to the island? What crops do they grow and where? Do they have forest plantations? How do they get from place to place? Use your knowledge of your students to decide how much of this discussion will happen first as a class and how much each group needs to think about on their own.

2. Each group then draws their own imaginary island on their piece of paper. Each island should have two or three villages and whatever else they think is necessary. It has to be like a map, or 'birds eye' view, and have a small compass rose to indicate north, south, east and west. They can use symbols and a key, or they can draw pictures. They should use as much of the paper as possible. Groups should name their island. Encourage them to make their islands as self-sufficient and **safe** as possible.

3. Bring the groups into an open space, each holding up their island. Ask each group to report on why their island is self-sufficient and safe. What is the most important feature on their island?

4. Lay the islands on the ground, all with north facing the same way, and explain that the island they have drawn is their home and it supports them, so they all have to stand on the island. They cannot have their feet in the sea. They can hold onto each other if necessary to balance on the island.

5. Ask them to get off the island and talk about the big cyclone that hit their island from the north-west. The waves were very rough and washed away a lot of land. Houses were damaged, trees fell and roads were blocked. The north-west corner disappeared, so they need to fold over the NW corner of their paper – Figure 1.

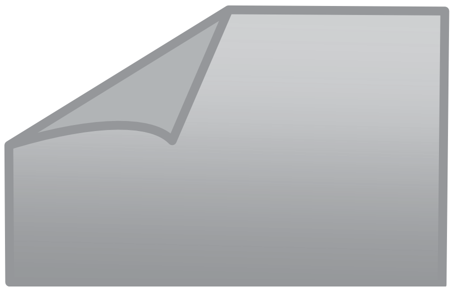


Figure 1

6. Now they need to look at their island – what have they lost? Ask each group if they have lost roads – who is cut off? Have they lost taro patches, wharves, schools, health centres, power lines, ...?

7. Now ask them to stand on their island again. There will be students who won't fit – where will they go? You will need to have a refugee corner – ask the refugees how they feel? Who are they – the young or the old? Those that lived close to the shore or in unstable buildings? Why were they the ones to leave? How do the ones left feel about being separated from family members?

8. The next scenario is rising sea levels, so the students fold down a strip all around their island's shallow coast – Figure 2.

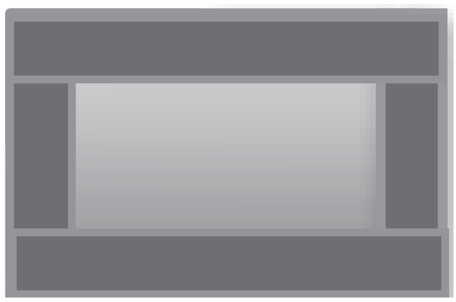


Figure 2

9. What have they lost this time? How many people can fit on the island now? The displaced group is probably getting quite large. Are they in another part of their country or in another country?

10. You can continue with different scenarios one or two more times, depending on the size of the groups and their islands. For example:

    - The water supply under the island has been contaminated with sea water and people must leave as there is no longer enough water for them to live – take away a quarter or third of the population.

11. You can discuss the outcome in various ways with your students. How did they feel about losing their land? Having to be parted from their friends and family? What could they do to protect themselves? It would be valuable to bring all the displaced people back to their island – would they build in different places if given another chance? Did they have higher land they could have used? Are any of these suggestions applicable locally? It is important to clarify with your students that there are many things they can do in reality to avoid having to leave their islands (build on higher ground, protect coasts, look after the natural resources, etc.)

3. Cooperative grid

Copy the cooperative grid in Figure 3 on the board. If you want, you can change the questions to suit your context. Then give each student a piece of paper and tell them to copy the grid.

Students first write down their own answers to each question. They then find a classmate, ask him or her one of the questions, and write the answer in one of the 'Others' boxes. They can try to do this twelve times, with different classmates, so that the boxes are filled.

They must listen to the other student's answer and write it down themselves. This improves their listening skills as well as writing skills. They can ask how to spell a word or ask the other student to repeat an answer if necessary, but they do not ask the other students to write their own answers. All the writing on the sheet will be by one person.

The students have the opportunity to think of their own ideas and then hear from others and write down their ideas and knowledge. They can then craft much deeper answers to the questions, having learned from other students. They can work in pairs to create paragraphs about each question. They may come back to their grid later and add knowledge that they have gained.

Figure 3 Cooperative grid

	Me	Others	Others	Others
What do you know about climate change?				
What are the main human activities that contribute to climate change?				
What actions could be taken to adapt to climate change in my country?				
What are some likely effects of climate change in my country?				

4. Fishbones

- Have the students work in groups. Give each group two sheets of plain paper – A4 is a good size. Ask the students to draw the outline of a fish on each sheet. They can draw fins and a tail to make it look realistic. Then draw a spine with three ribs up and three ribs down. (Figure 4)
- On one sheet, the students create six questions about the topic that they would like to find out about and write them down, one on each rib.

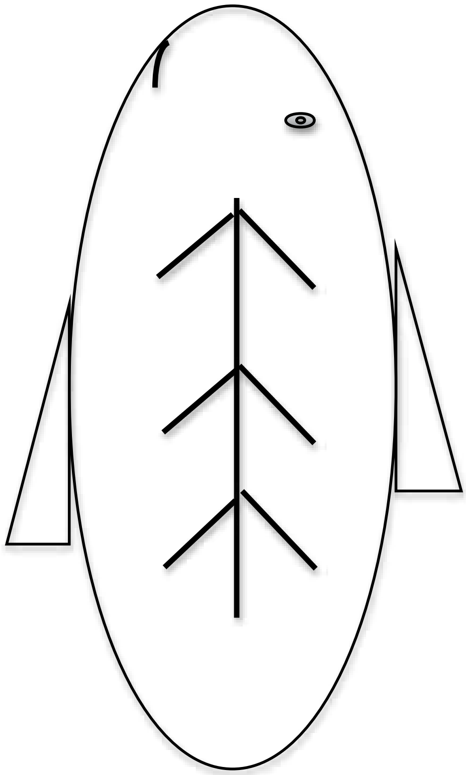


Figure 4 Fishbone template

You may need to check the questions and also give prompts for students to use the five Ws and an H (What, When, Where, Why, Who and How) to develop their questions. They could be given these as a requirement at the start of the activity. Also, guide the students into asking open-ended questions that their group is unable to answer. Questions on climate change would be better if they were like this: How do we know what is going to happen? or Who can help us adapt? (rather than: When did it start? or: What is it?).

Over the course of the unit of work, the students will gather information and at the end they record what they have learnt by answering the questions on the second fish.

It is very effective to have each group go back and write their answers on the matching fish so that the two can be stapled together and stuffed, decorated and hung in the classroom. This will show the students what they have learnt.

(Adapted from SEREAD)

Picture 1 – Pasifika

This picture is an imaginary Pacific scene: a place we will call Pasifika. Pasifika is 'everywhere' whilst being nowhere specific. Common landforms found in Pacific islands can be seen – a raised volcanic island and an atoll. There are some things in the picture that are specific to certain countries, such as the *fale, bure, te kiakia* and *nakamal.*

Possible student learning outcomes **Students will be able to….**	**Teaching and learning strategies**
• identify aspects of their own country in the picture; • identify possible risks as a result of climate change and unsustainable practices.	Picture interpretation with guiding questions Imagine the future

Discussion

Hold the picture up or place it on a wall or table for groups of students to examine and interpret. Stimulate discussion with questions like the ones below.

- Where do you think this is?
- What buildings do you see?
- What parts of the picture are similar to where you live?
- What are the girls and boys doing and why?
- What are the men and women doing and why?
- What is happening on the hills?....on the coast? ….near the river? ….in the village? ….in the town?
- What animals do you see? What does this tell you?
- What plants do you see? What does this tell you?
- What is the weather like? What does this tell you?
- Are there activities happening that may be damaging to Pasifika over time?

Note on traditional knowledge:
The frigate birds hovering over the land are a sign of bad weather coming. The clump of three breadfruit on a branch is also recognised as a sign of bad weather/drought in the future in many Pacific countries.

Teaching and learning activities – 1

1.1 Imagine the future

Allocate students to someone in the picture and/or an area of the picture and ask them to develop a story about the person, their family and their way of life, or about the piece of land, what it is used for and who it belongs to. You could use this to start a discussion about what might be going to happen in the future. Here are some questions to help you.

- What do you think will happen in Pasifika in the next six months? (This will bring out their knowledge of seasonal changes.)
- What assets do the people of Pasifika have (strengths, sources of food, income, supportive village community, resilience to disaster, etc.)?
- What issues might the people face in two or three years' time?
- Could the issues be different for men and women? If yes, explain.
- What might happen in ten years' time? … twenty years' time (in relation to ways of farming and fishing, fresh water, forests and houses)?

Note

Climate change may have been mentioned but their ideas are likely to focus on sea-level rise. This will lead into Picture 2 as a revision of weather.

Picture 2 – The water cycle

This picture shows the water cycle in Pasifika. The key words here are: sunshine, rain, wind, clouds and temperature.

The important concepts behind this picture are: (a) that the heat energy of the sun is the main driver of weather and (b) that the water cycle consists of the processes of evaporation, condensation and precipitation. The arrows in the picture indicate the movement of water molecules in the form of liquid (precipitation as raindrops) and gas (water vapour).

Possible student learning outcomes **Students will be able to…**	**Teaching and learning strategies**
• describe the processes of evaporation, condensation and precipitation; • describe the role of the sun in the water cycle; • label a diagram of the water cycle.	Discussion on the importance of water to life The water cycle – An experiential learning activity Water cycle picture dictation Investigating evaporation The water cycle song Investigating what happens to water when it is heated Investigating the effect of melting floating ice on sea-level

Ask your students to describe what they see on the picture. If they know what the words evaporation, condensation and precipitation mean, ask them to explain the cycle. If they don't, let them try and guess what the words mean from the picture.

The first discussions on this picture might centre on the importance of water to life.

- Why is water important?
- How do people use water?
- How do plants use water?
- How do you get water at your house?
- Where has this water come from?
- Who fetches the water (if not from a tap)?
- Do you have different words for different types of water?

The water cycle

This is how you can explain the water cycle step by step, starting by pointing at the sun and the ocean:

Step 1: Heat from the sun warms the liquid water that is on the earth's surface. Most of this water is in the oceans, but it is also in lakes, rivers, soil and plants.

Step 2: The liquid water is turned into a gas, usually invisible, which we call water vapour. The warm molecules of water vapour rise in the air. This is called evaporation. If the water vapour comes from plants it is called transpiration. Evapotranspiration is used for all water vapour coming from a land area with vegetation.

Step 3: As warm air rises, the water vapour cools, and changes back from gas into tiny droplets of liquid water. This process is called condensation. We see these droplets condensing together as clouds.

Step 4: When the clouds get full of water they become darker in colour. When the water droplets become too heavy, they fall as precipitation – in the South Pacific usually as rain, in colder climates or high altitudes also as snow or hail.

Step 5: Rain water soaks into the ground, filters through the soil and 'accumulates' in an aquifer, or water lens, or ends up in a river. Fresh water is again used by plants and animals or ends up in the ocean (either directly or via a river).

The amount of evaporation depends on the amount of heat energy coming from the sun, cloudiness and wind speed.

Children find it hard to comprehend the water cycle just as a picture. Children understand concepts better when they are actively involved in building their own knowledge of the concept. Hands-on investigations are good learning experiences for this reason. Using an experiential learning activity such as the one described below, and having the students act as water molecules makes it much more understandable to them. The scientific terms are more likely to be remembered if they are associated in students' minds with saying the words and acting out the movement of the molecules in different states. It is important, however, to stress that the following activity is a model and all models have limitations. The time frame for water molecules to complete this cycle can be as long as 100 years. Some water will be locked up as ice or snow for even longer than that.

Teaching and learning activities – 2

2.1. The water cycle – an experiential learning activity

In this activity students are invited to act as water molecules and act out the processes of evaporation, condensation and precipitation in the water cycle.

Starter activity
Call four students up to the front and stand them in a line with their left arms on the next person's right shoulder. Then ask four more students to stand in a row behind them with their right arms on the right shoulder of the person in front and their left arms on the next person right shoulder. (Figure 2.1)

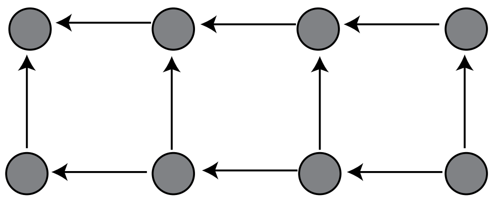


Figure 2.1

Now line up the class behind these two rows. Ask the students if they know what they represent. If not, explain that they are molecules of water in an ice crystal. Then ask the following questions.

- Are you moving? *(If they don't know then demonstrate how they are shivering while staying joined together. Link being cold and shivering with the actions of the molecules.)*
- What is in the spaces between the molecules? (*Air is in the spaces between the molecules. This is important for later when they discuss melting ice but it is better not to go into details at this time.)*
- What will happen if we add energy in the form of heat? *(Find out if they know the bonds will break and they will move apart. Draw a line on the floor or use desks as the boundary of their container and pretend to add heat and 'melt' the ice.)*
- What do water molecules do? *(Have them move relatively slowly, bouncing off the walls of the container and each other.)*
- What will happen to the molecules when you add more heat? *(Introduce/remind them about evaporation. Talk about water vapour rather than steam, then add the energy.)*

Note: Students will be running around the room at this stage – and could escape out of any open doors.

Now explain they are going to act out the entire water cycle as water molecules in all three states, liquid, solid, gas.

The water cycle activity

For 20 students, you need a space about half the size of a classroom. This can be inside the classroom or outside on concrete or grass.

- Draw a line on the floor or concrete about two metres from the wall or edge. The sea is behind the line.
- Draw the outline of a cloud shape above the sea – large enough for four or five children to stand in.
- On the other side of the space, draw the outline of a mountain and a river leading to the sea. Draw a sun in a corner or place a chair for a student to stand on. (Figure 2.2)
- If you are on grass, use a rope for the sea and mountain and a smaller length of rope or a large cloth for the cloud.

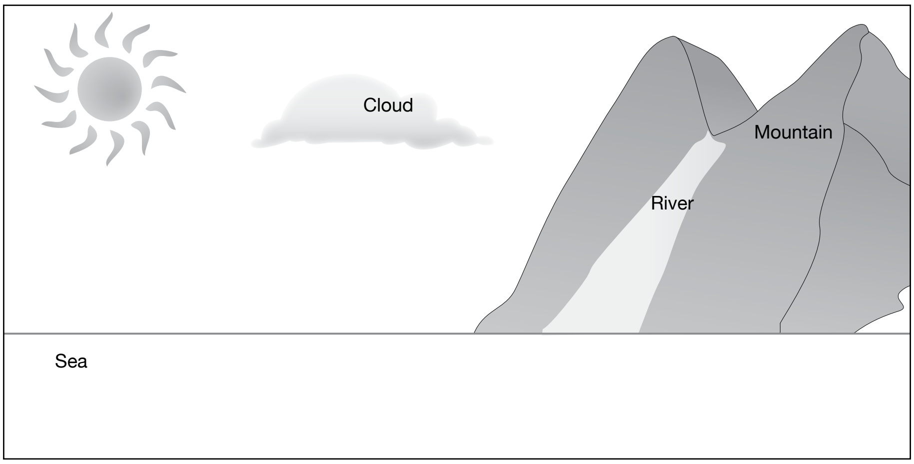


Figure 2.2

Organise the students as shown below. The numbers are given for a class of 20 (Figure 2.3) and a class of 30. Adjust the numbers proportionately if there are more or fewer students in the class.

Class of 20	Class of 30	
2	4	children stand in the cloud
4	6	children stand on the mountain
4	6	children stand in the river
9	13	children stand in a line in the ocean
1	1	child is the sun

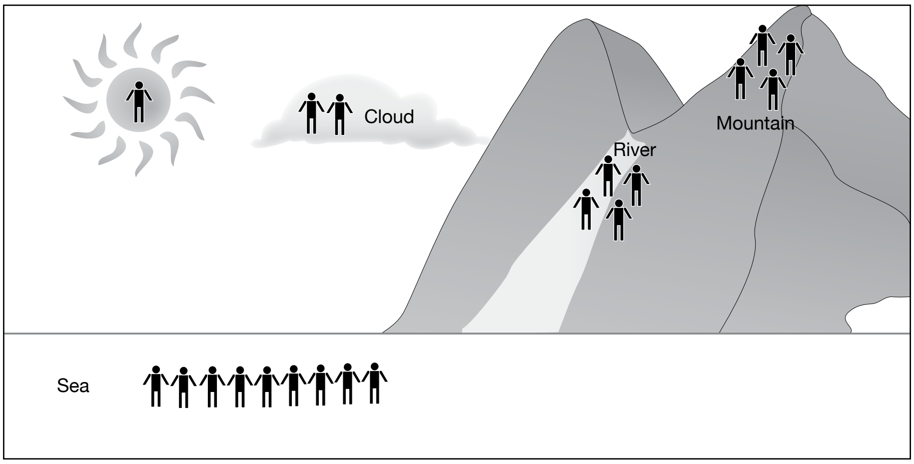


Figure 2.3

The 'sun' beats his/her arms up and down slowly. This is the sun providing heat energy to warm up the ocean.

At each beat of the sun, and at the same time:

- the students in the sea take one step to their left and the student at the left end moves towards the cloud;
- the students on the mountain take one step towards the river;
- the students in the river take one step towards the sea.

When there are six students in the cloud, four of them move to the mountain, leaving two in the cloud. These two wait until the cloud has built up to six again and repeat the process. (Figure 2.4)

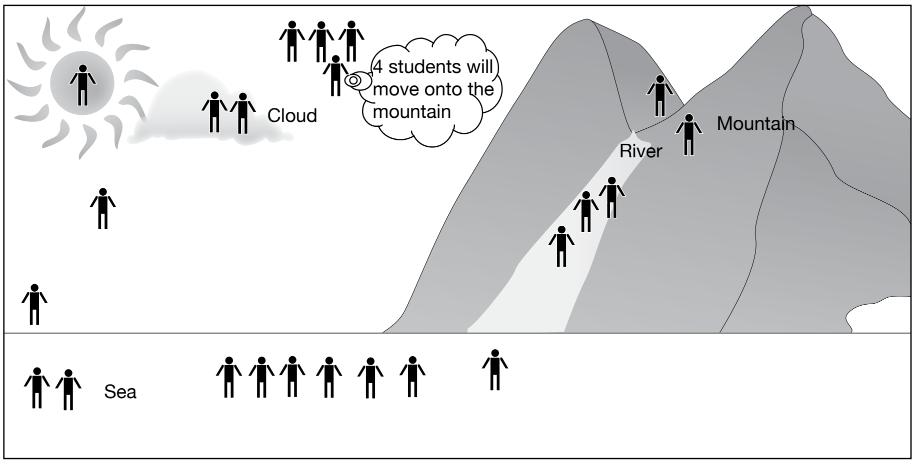


Figure 2.4

Keep this going until all the students have been around the cycle several times and know what to do. The cloud is the hardest part to keep accurate.

Now add the sounds – for each step, students need to say what they are doing – evaporating, condensing, precipitating, melting and flowing.

Next step – introduce the actions of the molecules – fast with lots of energy when evaporating, shivering for condensing, raindrops – floating down, swimming down the river and slowing down in the sea.

Keep the sounds going at the same time as the actions. The final cycles will be very noisy and have lots of student action which they will enjoy.

Questions

1. Where did the energy for the water movement come from?
2. Where did the water molecules spend most of their time?

Something extra to try

Try the same activity with the sun being brighter – bigger movements – relate this to the seasons with the sun directly overhead. Ask the students what changes will occur.

- Will evaporation speed up? *Yes – so need to move faster.*
- Will precipitation speed up? *No – there will be more clouds, perhaps*
- Will melting speed up? *Yes – move faster*
- Will the flowing of the river speed up? *Tricky – not because of the heat from the sun but maybe because of more water. This is where some discussion might need to happen on the use of the floor model. In nature, the distance and time over which this occurs are huge so we cannot be entirely accurate in a model. Use your professional judgement about your students for this.*

Suggestions

- The students in the sea take two steps per beat.
- The cloud fills to four, then loses two.
- The students on the mountain take two steps per beat.
- The river movement stays the same.

Similarly, the action can be slowed to represent cloudy conditions.

This could be followed by students drawing their own water cycle diagram.

2.2. Water cycle picture dictation

Another way to refresh students' understanding is to use the picture dictation strategy.

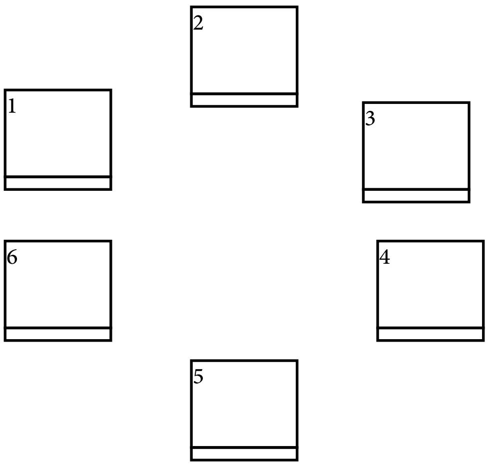


Figure 2.5

How to use this strategy

- Ask the students to draw six numbered boxes in a circle, one box for each statement. Leave a space for a caption underneath (Figure 2.5).
- Read out each of the steps of the water cycle below, and ask the students to draw their own simple picture for that section. Tell the students that a perfect picture is not required and they don't have much time to draw.
- Tell the students to connect Step 6 to Step 1 with an arrow, to show that the cycle is repeated. Then they can connect the other boxes with arrows to show the cycle.
- In pairs, the students take it in turns to translate each picture back to words.
- Individually, the students write a caption for each picture and then read their caption to their partner.

STEP 1:	Heat from the sun warms the liquid water that is on the earth's surface. Most of this water is in the oceans.
STEP 2:	The liquid water is turned into an invisible gas, which we call water vapour. The water vapour rises into the air. This is evaporation.
STEP 3:	As it gets higher the water vapour cools, and changes back into tiny drops of liquid water, which start to crowd together. This is when they form a cloud. This is condensation.
STEP 4:	The clouds are blown over the ocean by wind. When they reach land they are forced higher into the sky. The higher the clouds go the colder it gets.
STEP 5:	As the clouds get colder the tiny droplets of water join together and become so heavy that they cannot stay up. They fall down to the ground as rain, hail or snow. This is precipitation.
STEP 6:	When the water reaches the ground, it soaks into the soil. A lot of the water ends up in streams, which flow into rivers, which then flow into the oceans.

Why use this strategy?

- It uses all the communication modes (listening, speaking, reading and writing).
- Children have to listen carefully to the statements.
- It takes what is said and transforms that information into pictures.
- It orally puts the pictures back into words.
- The children have to write captions to match.
- They have to read the captions.
- They learn about sequence in a process.
- They have to focus on key ideas.

Depending on the students' level of prior knowledge, you may need to do some simple experiments on evaporation and condensation to reinforce their understanding. It is important to emphasise that the water vapour does not 'disappear'.

2.3. Investigating evaporation

Do this activity on a sunny day. Ask your students to get two containers – beakers are fine but any clear plastic or glass container will do. Fill the containers half full of water and mark the level on the outside. Place the containers on a window sill in the sun or outside. Put a lid on top of one container or cover the top with foil.

Ask the students:

- What will happen to the water level in each container?
- Why do you think this will happen?

Once the water has significantly evaporated, ask further questions:

- Why has the water gone down in the container without a lid?
- Where has the water gone?
- Can we get it back?
- Why has the level not changed in the container with the lid?
    - If the students do not come up with the word 'condensation', bring out several cold cans or bottles from a fridge. Place them where the students can see and ask them about the water droplets on the outside of the cans.
    - Where did this water come from? (Students have been known to say it has seeped through from the inside of the can. If you use a coke or lemonade can, they can taste the condensed water to disprove that idea. What happens: Water vapour from the air condenses when it gets in contact with the cold can or bottle.)
- Where else do they see condensation? (Can they link this to the condensation in clouds?)

2.4 The water cycle song

This would be a good time to introduce the water cycle song. If you know the tune of 'Clementine' use that, or make up your own tune.

Évaporation, Condensation, Précipitation tout autour, Accumulation, Évaporation, Répétition du cycle d'eau	Velasia Suavaia Timuia Fa'asoloatoa Fa'atupulaia toe Velasia Ta'amiloga ale vai	Te buanerake Te nimatenten Te baka ni karau ni katobibi Te bwarikoriko Te buanerake Butin te ran ni katobibi	Evaporation Condensation Precipitation all around Accumulation Evaporation The water cycle goes round and round

Students can do the actions for each line:
Evaporation – lifting arms with palms out from knee level to above their heads
Condensation – arms wrapped around themselves, shivering
Precipitation – fingers wriggling, arms going up and down as rain
Accumulation – arms outspread, crouching down then gathering together
Evaporation – rising up again
Water cycle – arms circling

2.5. Investigating what happens to water when it is heated

What we want children to learn:

- When water gets warm it expands because the water particles have more energy so they need to occupy more space as they move around more.

Predict: Ask the students: What do you think will happen to the level of the water in a bottle when it is heated? (They can discuss their ideas in a group and write down their group explanation.)

This experiment may help them answer the question and confirm their ideas.

Experiment (another sunny/hot day experiment)

Materials: A flask or clear plastic drink bottle with a lid or stopper, a stopper, a glass tube or straw, food colouring, some Blu-Tack or plasticine.

What you do

Take off the stopper or lid and make a small hole in it.

Put the tube or straw through the hole and seal it carefully in place underneath and on top with a small amount of Blu-Tack or plasticine.

Fill the flask almost to the brim with water and add a drop of colouring.
Put on the stopper/lid. Seal it on carefully with Blu-Tack if necessary (Figure 2.6).

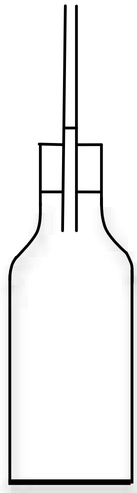


Figure 2.6

Result
Water should rise up the tube.
When it has stopped rising, mark the water level on the tube/straw with a marker pen.
Put the flask out in the sun. After ten minutes, show the students the flask.

Measure: How far up the tube is the water level now?

Explain: Why has the water moved in this way?

Something to think about: Can you redesign the experiment to measure how far the water travels for every 2°C?

2.6 Investigating the effect of melting floating ice on sea level

What we want children to learn:

- When an iceberg or floating ice melts it will not increase the amount of water in the oceans as the water that originated from the ice merely takes up the volume originally occupied by the ice.

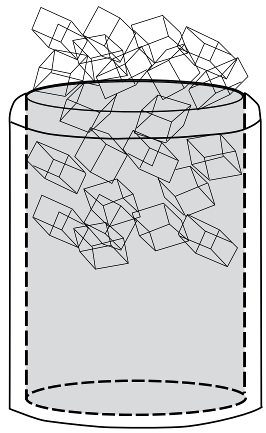


Figure 2.7

What you will need: A polystyrene or paper cup or tumbler, some ice cubes

What you do:

Fill the container with water.
Add 10–12 ice cubes.
Dry the side of the container after the water has spilled over.
Now let the ice cubes melt.

Predict: What do you think will happen?

Measure: Has the height of the water changed since the ice cubes melted?

Explain: Was there as much change as you expected? Can you explain what has happened?

Question: We know that the greenhouse effect is warming the oceans and melting land-based and floating ice caps.

What do you think will have the greater effect in your lifetime on sea levels? (The melting of land-based ice and thermal expansion as a result of global warming cause the sea-level to rise. The melting of floating ice has no effect on sea level. You can find more information on oceans in Picture 7.)

What evidence do you have to support your answer? (Refer back to your experiment.)

Extension

Fill a big basin three-quarters full of water. This represents the ocean. Place a large block (e.g. a rock) inside the basin of water. This represents a land mass. Mark the level of the water on the side of the basin once the water is still. On the block place a large number of ice cubes. (This represents an ice sheet such as the one that covers Antarctica.) Let the ice melt.

Does the water level rise?

What would be the effect on the oceans if all of the ice on the Antarctic land mass melted?

(The sea-level is now rising because of melting ice coming from the land-based ice sheets in the Antarctic, Greenland and Northern Canada, and also from land-based glaciers.)

(Adapted from SEREAD)

Picture 3 – Climate in the Pacific

The picture shows the typical position of important climate features from November to April: trade winds, the South Pacific Convergence Zone (SPCZ) and the Intertropical Convergence Zone (ITCZ), a warm pool over Papua New Guinea, high pressure zones and the West Pacific Monsoon (between Australia and Papua New Guinea). Climate graphs are shown for a number of Pacific Island countries. The climate graphs contain two pieces of information: precipitation (the amount of rainfall) and the temperature at a certain location in each country over the course of a year. The blue rods show the amount of rainfall per month (in millimetres). Three of the graph lines show the average temperature of the air: red is the maximum, black is the mean and blue is the minimum. The green line is the sea-surface temperature. The figures for the climate graphs are calculated as an average over 29 years (1961–1990).

Possible student learning outcomes **Students will be able to….**	**Teaching and learning strategies**
• differentiate between weather and climate; • describe the climate of Samoa using local language; • link seasonal changes in Samoa to growing and harvesting of crops and collection of seafood.	Picture interpretation with guiding questions Seasons in our country Rainfall and mountains Say-it grid

Discussion

You need to decide how much detail you want to discuss with your students. As a first step, ask your class what this picture shows.

Check that they can locate their country and island on the map, see the trade winds (yellow arrows), the high pressure and the climate graphs for each country, and the years for these statistics.

Pictures 3 (Climate in the Pacific), 4 (Global climate) and 5 (ENSO and climate variability) could be used together as they all contribute to information about climate in the Pacific and the factors that influence weather patterns. Start talking about weather, climate and climate variability from the start as it is important that the students understand the differences.

Ask your students to look at or copy the climate graph for their country and answer the following questions:
- Which month has the highest maximum temperature?
- Which month has the lowest minimum temperature?
- Is the sea-surface temperature warmer or colder than the mean temperature?
- Which month has the highest amount of rainfall?
- Which month has the lowest amount of rainfall?
- Which countries have similar climate graphs?

It is important to talk with the students about traditional ways of describing climate patterns. You can ask the students as a whole class or in small groups:
- What are the local terms for the wet and dry seasons?
- When do they start and end?
- Does the climate graph for our country show the seasons?
- What changes happen during those seasons?
- Are there differences in available fresh water? And in available food on the land and in the ocean?
- What is your favourite season? Why?
- What influences the climate in our country?

Perhaps you can make a class excursion to a weather station, if there is one close by.

Explain to the students the key difference between weather and climate: Climate is a long-term description of weather patterns of usually 30 years, whereas weather describes the current situation or predictions for the next few days (what is happening today).

Weather: The effects of atmospheric conditions, at a specific time and place, in terms of variables such as temperature, rainfall and wind. Compared with climate, which is a long-term description, weather describes the current situation or predictions for the next few days. Apart from daily weather, also seasonal and annual weather patterns are described and sometimes referred to as the 'prevailing climate'.

Climate is a term used by scientists as a **long-term description** of the weather (usually over at least 30 years) in terms of variables such as temperature, rain and wind.

(SPREP 2012)

The Pacific climate on a large scale

The climate of the Pacific Island region is tropical and humid. As the sun is almost directly overhead the amount of incoming solar radiation (energy – heat and light – emitted from the sun in rays or waves) is high and changes only very slightly throughout the year. That means temperatures also vary little throughout the year. On the islands, air temperatures are also strongly influenced by the temperatures of the surrounding Pacific Ocean because land areas are very small.

Ocean and atmosphere strongly influence each other in the region. While large-scale atmospheric circulations drive the ocean currents and greatly influence temperature, the ocean in turn strongly affects rainfall, winds and temperature as well. This results in significant variations in temperature and rainfall patterns within the region as a whole.

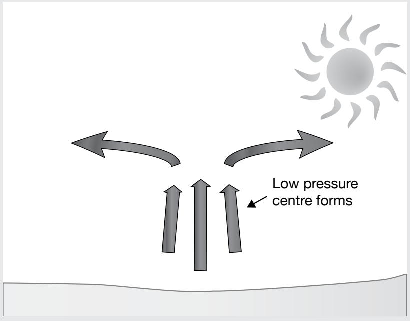
Westerly ocean currents, for example, result in warmer waters in the western Pacific, the Philippines and Indonesia, while the eastern Pacific is significantly cooler. Further differences in temperature exist between countries close to the equator and those closer to the sub-tropics.

While most countries experience only slight temperature variations throughout the year, seasonal changes in rainfall are considerable, resulting in pronounced wet and dry seasons. Regions of particularly high rainfall during the wet season are the ones under the influence of the West Pacific Monsoon (WPM) over the West Pacific Warm Pool (e.g. Papua New Guinea and Solomon Islands), the South Pacific Convergence Zone (SPCZ), stretching from Solomon Islands to Cook Islands, and the Intertropical Convergence Zone (ITCZ), just north of the equator (see Picture 3). Significant rainfall also comes from storms and tropical cyclones that are mostly occurring between the latitudes of 10° and 25° North and South. Locally, islands with higher mountains usually have drier and wetter sides, according to the main wind directions. Other influences on the climate of the Pacific Island region include subtropical high-pressure systems and the trade winds (see Table 3.1).

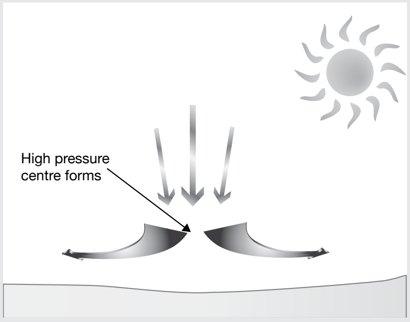
The regularity of these seasons has a large impact on life in the region and has led to long-held traditional knowledge of the seasons, reflected in the languages of the peoples of the Pacific. Each country has one or several names for the two seasons (see Table 3.2), which usually refer to the wet and dry periods, the time of planting and harvesting crops, or the changes in the prevailing winds between the seasons.

(ABM-CSIRO 2011 Vol 1)

If you decide to explain all the climate features shown in Picture 3 you first need to explain **atmospheric pressure, wind, the trade winds and convergence**:



The sun heats up some areas of the planet more than others. Where the land or ocean becomes hot, air is warmed and becomes less dense (fewer air molecules per m^3) and rises, creating an area of low **atmospheric pressure**.



Where the land or ocean is cold, air sinks and there is high atmospheric pressure because there are more air molecules per m^3.

The differences in atmospheric pressure from place to place give rise to **wind**. Air moves from areas of high pressure to areas of low pressure to try to maintain a balance or equilibrium.

Wind direction is also affected by the spinning of the earth. For example, the **trade winds** south of the equator blow from a south-easterly direction and north of the equator from a north-easterly direction – both towards the west and towards the equator.

A **convergence zone** is an area where winds flow from different directions toward each other, thus meeting at one point or along one line (like the ITCZ or SPCZ). Convergence zones could be called '**cloud meeting places**' (ABM- CSIRO-RCCCC 2013).

After this you can introduce the following climate features:

The **West Pacific Monsoon** (WPM) moves north to mainland Asia during the Northern Hemisphere summer and south to Australia in the Southern Hemisphere summer. The seasonal arrival of the monsoon usually brings a switch from very dry to very wet conditions. It affects countries in the far western Pacific.

The **South Pacific Convergence Zone** (SPCZ) is a band of high rainfall stretching approximately from the Solomon Islands to the east of the Cook Islands. It is a persistent and greatly elongated zone of low-level convergence. It is strongest in the Southern Hemisphere summer and affects most countries in the South Pacific.

The **Intertropical Convergence Zone** (ITCZ) is a band of high rainfall that stretches across the Pacific just north of the equator. It is an East-West band of low-level wind convergence near the equator where the southeast trade winds of the southern hemisphere meet the northeast trade winds of the northern hemisphere. ITCZ is strongest in the Northern Hemisphere summer and affects most countries on, or north of, the equator.

(ABM-CSIRO 2011 Vol 1: 37)

Table 3.1: Main climate features and influences for selected Pacific Island countries

Country	Main climate features and influences
Cook Islands	SPCZ, subtropical highs, trade winds, tropical cyclones, topography
East Timor	WPM, topography
Federated States of Micronesia	ITCZ, WPM, trade winds
Fiji	SPCZ, trade winds, subtropical highs, tropical cyclones, topography
Kiribati	ITCZ, SPCZ, trade winds
Marshall Islands	ITCZ, WPM (in some years), tropical cyclones
Nauru	ITCZ, SPCZ, trade winds
Niue	SPCZ, trade winds, subtropical highs, tropical cyclones
Palau	WPM, ITCZ, trade winds
Papua New Guinea	WPM, ITCZ, topography
Samoa	SPCZ, trade winds, subtropical highs, tropical cyclones, topography
Solomon Islands	SPCZ, WPM, tropical cyclones
Tonga	SPCZ, trade winds, subtropical highs, tropical cyclones, topography
Tuvalu	WPM, SPCZ, trade winds, subtropical highs, tropical cyclones
Vanuatu	SPCZ, trade winds, subtropical highs, tropical cyclones, topography

(Adapted from ABM-CSIRO: 2011 Vol; 1:41)

Table 3.2: Local terminology for wet and dry season

Country		Wet season	Dry season
Cook Islands		*tuatau mauu*	*tuatau maro*
East Timor		*udanben*	*bailoron*
Federated States of Micronesia	Chuuk	*nukuchochun*	*pwas*
	Yap	*nuw*	*yale*
Fiji	i-Taukei	*suasua*	*mamaca*
	Fiji Hindi	*gila mausam*	*ihura mausam*
Kiribati		*ameang*	*aumaiaki*
Marshall Islands		*mejleb*	*anńeneanń*
Nauru		*luai*	*aré*
Niue		*vahä mafana*	*vaha mokomoko*
Palau		*kemtimt*	*sechal el ongos*
Papua New Guinea	Pidgin	*taim bilong ren*	*taim bilong san*
	Motu	*medu ena nega*	*dina ena nega*
Samoa		*vaipalolo / tau susu*	*vaitoelau / tau mugala*
Solomon Islands		*komburu*	*ara*
Tonga		*fa'ahita'u 'uha*	*fa'ahita'u la'ala'a*
Tuvalu		*'tau 'moko*	*tau yela*
Vanuatu (Bislama)		*ren taem*	*san taem*

(Adapted from ABM-CSIRO: 2011 Vol 1:36)

The climate of Samoa

Samoa's climate is tropical. Temperatures in Samoa are generally consistent throughout the year, with only very small seasonal differences. Average temperatures are coolest in July, when the cool, dry south-east trade winds are strongest. The warmest month is March. The country has two distinct seasons – a wet season from November to April and a dry season from May to October. On average, 75% of Samoa's total annual rainfall occurs in the wet season.

Samoa's rainfall is greatly influenced by the position and strength of the South Pacific Convergence Zone. This band of heavy rainfall is caused by air rising over warm water where winds converge, resulting in thunderstorm activity. It extends across the South Pacific Ocean from Solomon Islands to Cook Islands and lies between Samoa and Fiji during the wet season. Samoa's mountains have a significant effect on rainfall distribution. Wetter areas are located in the south-east and relatively sheltered, drier areas are in the north-west.

Samoa's climate varies considerably from year to year due to the El Niño Southern Oscillation. This is a natural climate pattern that occurs across the tropical Pacific Ocean and affects weather around the world (See Picture 5). In Samoa, El Niño events tend to bring wet seasons that are drier than normal, while La Niña events usually bring wetter and cooler than normal conditions.

Droughts and flooding associated with the El Niño Southern Oscillation have affected the socio-economic livelihoods of the Samoan people on many occasions in the past. Flooding associated with tropical cyclones and strong La Niña events has caused widespread damage in Samoa in the past, particularly in Apia. In early 2008, and again in 2011 and 2012, for example, transportation infrastructure and water supplies were severely damaged during cyclones. Cyclone Evan in 2012 resulted in severe damage when the heavy rainfall caused several rivers to completely change course, flooding roads and houses.

Drought impacts are most notable in the north-west regions of the main islands and at times are associated with forest fires. In Asau, there were major forest fires during the dry seasons of 1982–1983, 1997–1998, 2001–2002 and 2002–2003.

Teaching and learning activities – 3

Teachers – it would be useful to ask the Meteorology Office for rainfall graphs or statistics from different centres so schools could have students analyse data relevant to where they live (www.mnre.gov.ws/index.php/divisions/meteorology). This could then be compared to Apia data.

3.1 Seasons in Samoa

1. Ask your students to draw a circle and divide it up into 12 sectors, each representing one month of the year. They then shade their diagram in two colours, one to represent the warm, wet season, and the other to represent the cooler, drier season in their country.

2. Ask your students the following questions:
   - What does 'drought' mean? When might we have droughts in our country?
   - What problems do people face in a) the warm, wet season, and b) the cooler, drier season?
   - When are different crops planted?
   - When are the crops harvested?
   - When are different seafoods in season?
   - When are different fruits harvested?

3. Ask your students to draw or write (in their circle) the crops, fruits and seafoods in the months when they are planted, harvested or gathered.

3.2 Rainfall and mountains

1. Ask your students to draw a large picture of your island. They can then label the following on their diagram: windward side, leeward side, prevailing south-east trade winds, reef, heavy rain. Tell them to add places where they might find thick rain forest.

2. Ask them: Which side of the island might experience more droughts?

3.3 Say-it grid

Say-it grids can be applied to any context, as an interactive way of processing information that has been discussed.

Say-it grids can also be an effective lead into writing, because the students have had time to process the information before they begin writing.

	A	B
1.	You are 15 years old. You live in an area where there are no public water pipes. Explain how you will help your family during a drought.	You are a police officer. Explain how you will help people during a flood.
2.	You are a grandparent who looks after the family garden. Explain how you will look after your garden during a drought.	You are a politician. Explain to the local community how spending money on a new drainage system will protect them from floods.

- Divide the class into groups of four.
- Divide students into A and B and then into 1 and 2 in each group so they know their speech topic.
- Students are given time to research and note the main points of their argument.
- Next, students take turns to speak in their group, one box at a time.
- This could be followed up by a piece of writing.

Picture 4 – Global climate

The picture on global climate shows global climate zones in a very simplified way, taking into account global temperature patterns only. Children from different countries in a specific climate zone are shown wearing different clothing. Also typical plants and animals are shown as examples for some countries.

Possible student learning outcomes **Students will be able to….**	**Teaching and learning strategies**
• label a diagram of climate zones of the globe correctly; • link temperature ranges on the earth to the angle of incident sunlight.	Picture interpretation with guiding questions The heating effect of the sun on earth's surface Climate zones An alternative activity on climate zones Practical investigation: What is air pressure?

Discussion

You can ask the students to describe what they see and to develop some questions on the picture on global climate. Discuss the picture with your students. See how much they know about the different climate zones, help them out with your knowledge and label each zone in the globe correctly. Talk about the different clothes the children in the picture are wearing. Do they know the basic principles of how the earth is divided into degrees of longitude and latitude?

You can ask the students the following questions:

- In which latitude is your country located and what climate zone do you live in? (See box below.)
- Which climate zone has the coldest climate? (cold zone)
- What difference would you be likely to notice if you went from a tropical zone to a temperate zone in clothing?... in housing?... in vegetation?
- Which zones have a climate that changes very little during the year? (tropical and cold)
- Which zones have the most variation in their climate over a year? (temperate)
- Between which latitudes is the Southern Hemisphere? ($0^{0,}$ the equator, to 90^0, the South Pole)
- Which zone has the longest days in its hemisphere's summer and the longest nights in its hemisphere's winter? (cold zone)

Note that the climate zones shown in Picture 4 are simplified. In the picture, Fiji, Vanuatu, Samoa and Tonga seem to be in the subtropical zone, but they are in fact tropical countries, since they are located between the equator and the Tropic of Capricorn.

Climate zones
Scientists have divided the earth into zones as a means of describing different climates found in these areas. Climate refers to the average weather conditions over a long period of time, based mainly on measurements of temperature and precipitation. It is affected by latitude, altitude and proximity to the ocean. The following simplified categories shown in Picture 4 are based solely on latitude patterns.

Tropical zones from 0°–23.5°: In the regions north and south of the equator (between the two tropics) the solar radiation reaches the ground nearly vertically at noontime during most of the year. Therefore, it is very warm in these regions. Because of the high temperatures, more water evaporates, so the air is often moist. The resulting frequent and dense cloud cover reduces the effect of solar radiation on ground temperature and can help keep temperatures cooler.

Subtropical zones from 23.5°–40°: The subtropical zones receive the highest radiation in summer (in the northern hemisphere in July, in the southern hemisphere in December), since then the sun's angle at noon is almost vertical, whilst the cloud cover is relatively thin. These regions usually receive less moisture from evaporation and trade winds, which increases the effect of radiation. Therefore, most of the world's deserts are situated in this zone. In the respective winter seasons the regions' radiation decreases significantly and it can be temporarily very cool and moister.

Temperate zones from 40°–60°: In the temperate zones, the solar radiation arrives at a smaller angle, and average temperatures are much cooler than in the subtropical zones. The seasons and day-lengths differ significantly over the course of a year. The climate is characterised by less frequent extremes and a more regular distribution of precipitation over the year: hence the term 'temperate'.

Cold zones from 60°–90°: The subpolar and polar areas between 60° latitude and the poles receive least heat through solar radiation, since the sunlight is spread over a very flat angle to the ground. Because of the changes of angle of the incident sunlight, the day-lengths vary most in these zones. In the respective winters the sun shines very briefly – and in the regions closest to the poles for some time not at all. On the contrary, in the respective summers polar days of 24 hours of continuous sunshine occur. Plant growth is possible during only a few months per year and even then often sparsely. The conditions for life in these regions are very hard.

Climate zones influence flora and fauna, our local sources of food, the way we build our houses and the way we dress ourselves.

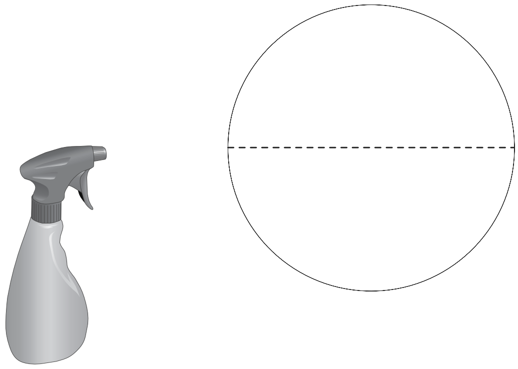
Teaching and learning strategies - 4

4.1. The heating effect of the sun on the earth's surface sources

This activity will help your students understand the heating effect of the sun on the surface of the earth and why some places are warmer than others.

What you will need: A large ball, such as a soccer ball, covered in white paper or a white balloon. (This will represent the surface of the earth.) You will also need a tin of yellow spray paint, or hairspray.) A torch will also work for this activity if your classroom can be made dark enough.

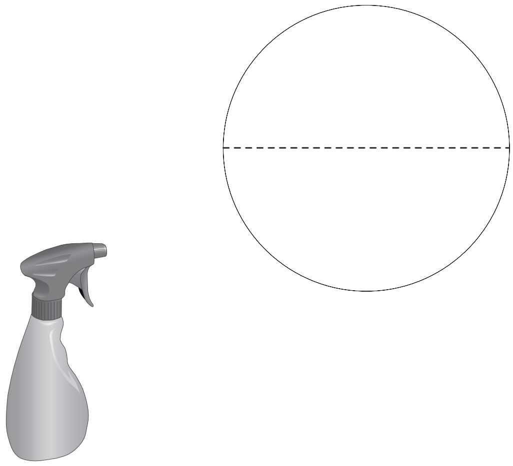
What to do:
Draw a line around the middle of the ball. This represents the equator.
Hold the spray can about 20 cm from the ball and point the nozzle at the equator, just as the picture shows.
Squirt just enough paint to cover an area. (A short burst should do!)



Mark with a pen and measure the area the paint covers.

Predict: Ask your students: What do you think would happen if I did exactly the same thing but holding the can below the equator?

Now hold can of spray lower down, just as the picture shows.
Spray the area for the same length of time and from the same distance as before.

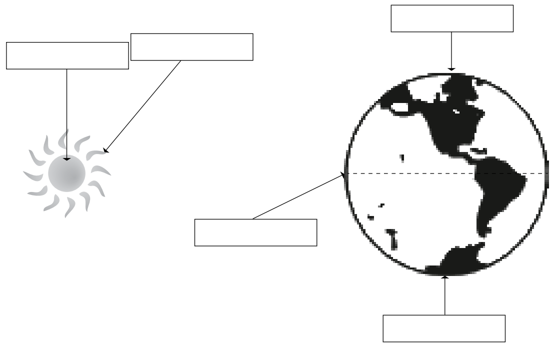


Observe: Tell the students to observe how big an area the paint covers this time. Measure it.
Help your students to explain why there is a difference in the area that the paint covers;

Discuss these questions with your class.

- Can you compare the yellow colour of the paint to the distribution of heat from the sun?
- How do you think this shows how much heat the earth receives from the sun?
- Why do you think it is warmer around the equator than further south towards the polar regions?
- Which areas of the planet have the warmest seas?
- What difference do you think the warmer temperature makes to the amount of water that evaporates from the surface of the sea?
- Which parts of the planet do you think have the highest rainfall and the highest temperatures?

4.2. Climate zones

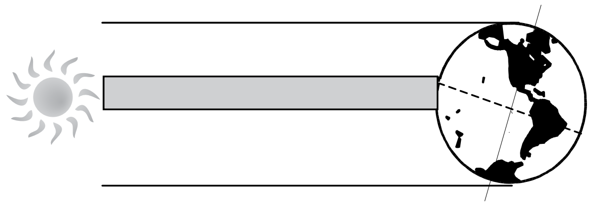


Draw the diagram on the right on the blackboard or a large piece of paper. Draw just the globe and equator, if you can't draw the map. Use the words below to label it:

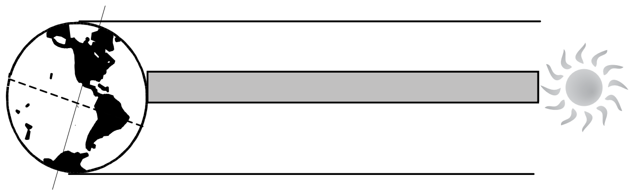
sun	North Pole	sun's rays
South Pole	equator	

Colour the coldest areas of the globe blue.
Colour the hottest areas red.

A step further: We recognise that the weather changes at certain times of the year. We call these seasons. Some places have a wet and dry season, others have four seasons: spring summer, winter and autumn.
Why do we have different seasons?



The earth actually goes around (orbits) the sun on a tilt.
Draw the diagram on the right on the blackboard or a large piece of paper. Draw just the globe and equator, if you can't draw the map.
Colour the coldest areas of the world blue. Colour in the hottest areas red.
How different is it from the first picture you coloured in?
Write summer, south of the equator, and write winter, north of the equator,



Now six months later the earth is half way around the sun in its orbit. The picture on the right shows the earth in its new position as it travels around the sun. Draw the picture on the board or on paper for your students.
Colour the coldest areas of the world blue. Colour in the hottest areas red.
How different is it from your first picture you coloured in and the second picture?

Can you explain why there are differences in the hot and cold areas of the earth?
What is the result?

4.3. An alternative activity on climate zones

What you want your students to learn:

The position of the sun over the earth's surface changes through the year. This change occurs because the earth rotates on a 22.5 degree angle as it orbits around the sun.

One complete orbit of the sun is equivalent to one year.

The movement of the sun over the earth's surface creates seasonal weather patterns and climatic regions on the planet.

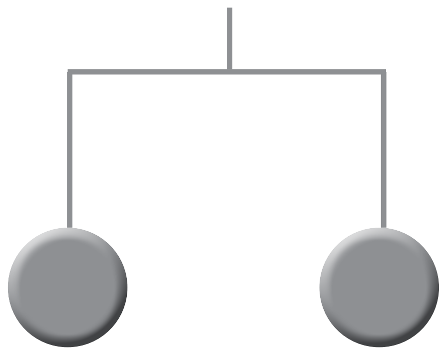
Tell your students to copy Picture 4, including the equator and latitudes, and put their country on the map. Using the pictures they drew in the previous exercise, they can colour the different zones: red for tropical, orange for subtropical, green for temperate and blue for polar.

4.4. Practical investigation: What is air pressure?

These activities will show students that air has mass and exerts pressure.

Activity to find out if air has weight

What you will need: two balloons, a stick or length of bamboo about 45 cm long, string, a piece of Sellotape, a measuring cylinder, a piece of tubing



What to do:

Blow up the balloons so they are about the same size.

Suspend the stick from the piece of string by tying it in the middle.

Carefully put a piece of Sellotape on each balloon.

Tie the balloons onto the stick. Move the balloons so they balance each other.

Prick one of the balloons carefully through the Sellotape – this takes care and practice but can be done so that the air just seeps out.

As the air moves out of one balloon, it gets lighter so the other balloon goes down.

Ask the students what they observe: What has changed? Did they expect this to happen? Can they explain why it has happened?

(Adapted from SEREAD)

Picture 5 – ENSO and climate variability

The picture shows the ENSO — El Niño Southern Oscillation — as an important variation of climate in the Pacific. There are three illustrations showing the weather conditions that are associated with normal years, El Niño years, and La Niña years.

Possible student learning outcomes Students will be able to....	Teaching and learning strategies
• describe the expected weather patterns in their country during El Niño and La Niña; • link these weather patterns to changes in wind and current strength and direction.	Picture interpretation with guiding questions Make your own El Niño

Discussion

Ask your students to look at the three illustrations and ask them the following questions:

- What are some differences in the three illustrations?
- What do El Niño and La Niña mean in your own language?
- Have you ever heard someone talking about El Niño or La Niña? If yes, in relation to what?
- What happens during El Niño and La Niña years in your country?
- Where can you get weather forecast information?
- How can you prepare for an El Niño and La Niña year?

Climate variability describes variations in the mean state of climate occurring over months, years and decades (SPREP 2012).

Warm and cold, wet and dry seasons are not the same from one year to the next. This natural phenomenon is called climate variability. When the observed differences are more than what has been commonly observed and create a long-term trend, this is called **climate change**.

Explain to the students what the difference between climate variability and climate change is. You could show Picture 5 together with Pictures 2 (The water cycle), 3 (Climate in the Pacific) and 6 (Causes of climate change).

It is not at all easy to explain ENSO. One way of doing it is by building on the answers of your students and going with them through the three illustrations one by one (see box below). And, if possible, try to link El Niño and La Niña events to personal experiences.

Don't expect your students to be able to describe exactly what happens. What matters is that they find out typical weather patterns in their country during the different events. Depending on where they are located, their island can experience very wet or very dry conditions. These can result in floods or droughts with accompanying effects on food and water supplies, houses, bridges, roads and health. The resource text for Pictures 9 (Pasifika after a cyclone or severe storm) and 10 (Pasifika during a drought) provide many ideas.

If you have a computer or laptop you can show the film *The climate crab* that helps in communicating the science of El Niño and La Niña and the effects. (You can find it at www.pacificclimatechangescience.org/climatecrab or on a DVD.) A second short film called *Cloud Nasara* focuses on Vanuatu www.pacificclimatechangescience. org/animations/cloudnasara/. (ABM-CSIRO-RCCC 2013)

El Niño and La Niña
A very important variation (or variability) in the Pacific region is **ENSO – El Niño Southern Oscillation**. ENSO has always been a feature of climate in the Pacific and typically has a three to seven year cycle. The name 'El Niño' comes from Peruvian fisher folk, who noticed that sometimes the anchovy fishing was very poor just before Christmas with an associated large-scale climate pattern, so they named it in Spanish El Niño after the Christ child. The opposite climate pattern brought very good fishing – La Niña or little girl.

ENSO affects the weather worldwide, as changes in sea temperature of a few degrees take place over a large area, resulting in big changes to global weather patterns. ENSO is known as a 'coupled' phenomenon, as it involves strong interaction between the ocean and the atmosphere.

Under neutral conditions
In the western Pacific, a pool of warm water goes deep into the ocean; the heat makes the water molecules spread farther apart, increasing the water volume. Since the extra volume cannot go through the floor of the ocean, it expands upward, causing the sea-level to rise in the western Pacific (close to the equator). Strong equatorial trade winds blow east to west and keep the water piled up.

The warm pool also puts a lot of warm, moist air into the atmosphere (evaporation, see cloud with rain in the illustration, also Picture 2 for evaporation and the warm pool in Picture 3). This leads to the development of thunderstorms and cyclones in the western Pacific (Gombus, Atkinson and Wongbusarakum 2011).

El Niño conditions
El Niño occurs when there is a weakening of the easterly trade winds blowing along the equator. Normally, these winds blow from east to west, but sometimes they weaken or even change direction and blow from west to east. The South Pacific Convergence Zone (SPCZ) moves to the north and east of its normal position. Weaker trade winds slow down the movement of warm water being pushed across the Pacific towards the west. It also prevents the upwelling of cold water along the western coast of South America. In effect, the 'pile' of warm water that would normally be in the western Pacific moves back east across the Pacific, and some of it stays along the west coast of South America. The result is a cooler western Pacific, with droughts in Australia and western Pacific islands, and warmer, wetter weather for the central Pacific and the west coast of South America, which may experience severe storms and floods. In some years, usually when El Niño is very strong, the SPCZ moves a long way from its normal position and sits almost along the equator, having serious impacts on many Pacific Island countries.

La Niña conditions
La Niña is the cool phase of ENSO, when the eastern Pacific Ocean is cooler than usual. The trade winds are stronger and blow more warm water into the western Pacific. The SPCZ moves back to the south and west, so that there are wetter conditions in tropical Australia, New Zealand and the western Pacific Islands, with more cyclones and flooding and an increase in the mean height of sea levels on their shores. On the other side, fisher folk in South America have a very good fishing season.

By using existing climatic records and predicting future changes with the aid of computers, climate scientists believe that these events may occur up to twice as often by the end of the 21st century than in the 20th century

(ABM-CSIRO 2011 and SPREP 2012)

Teaching and learning strategies – 5

5.1. Make your own El Niño

Purpose: You can set up a demonstration of what happens to the trade winds in an EL Niño cycle and the effect it has on ocean 'upwelling'. This is best done when the students have a basic understanding of El Niño.

Materials:
Clear plastic oblong container such as an aquarium (approx. 45 cm x 10 cm x 10 cm) (if not available, a clear plastic food container will do), water, cooking oil (something like clear turps or mineral oil will also work), blue food colouring, a hair dryer, a map of the Pacific Ocean

How to set the demonstration up:
Fill the tray with water to within 2 cm of the top.
Add blue food colouring to the water to give the effect of a blue ocean.
Do not stir the food colouring but allow some to settle on the bottom to give a darker colour. This will show the upwelling.
Gently pour the oil over the surface of the water. Allow it to settle so that you have two layers.
Mark one end of the container west (Indonesia) and the other end east (South America.)
Plug in the hair dryer.
Note: keep it away from any water spills.

Explain to your students that:

- the liquids in the plastic container represent a slice across the equatorial southern Pacific Ocean;
- the oil represents the warm layer of surface water that has been heated by the sun;
- the blue water represents the colder water below the surface warm layer which has travelled through from the colder southern regions;
- the hair dryer represents the trade winds.

Can the students predict what you are going to do?

What to do:
Turn on the hair dryer, so giving a strong blast of air (no heat needed) and direct the 'wind' across the surface of the oil-topped water from the east (South America) to the west (Indonesia) (Figure 5.1).

After the wind has been blowing for a period of time, add a few drops of food colouring to the 'west' end of the tank. (It should sink to the bottom.)

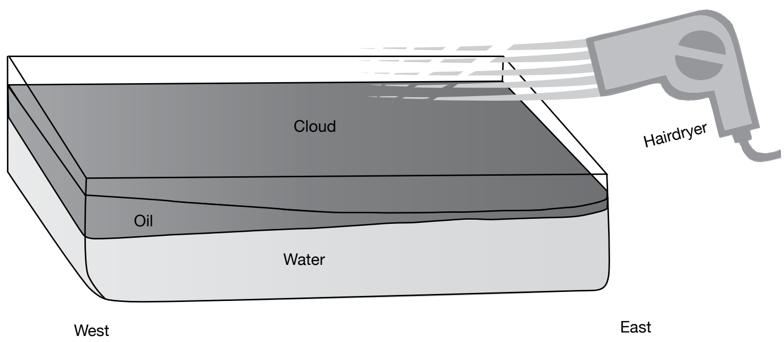


Figure 5.1

Keep the wind blowing.

Question: Ask your students: What effect does this have on the 'warm' and 'cold' water? Discuss their answers. Ask your students to draw what is happening.
(It should be possible to show the upwelling of cold water to the surface.)

Predict: What would happen if the 'trade winds' do not blow or are not as strong?

Turn off the 'trade winds'.
Do this by turning down the speed of the hair dryer or moving it further away from the surface of the 'ocean' to represent weaker winds.
What is happening when the trade winds are not as strong?

Do the observations fit the predictions?
Ask your students to draw what is happening.

El Niño: the explanation
If necessary, tell the students what is happening as you do this demonstration. The 'warm' water is pushed across the Pacific and piles up in the west (Indonesia) as it is blown by the 'trade winds' (hair dryer). This is what we would normally expect to happen in the equatorial Pacific Ocean.

The blue food colouring represents the cold water and your students may notice that the bottom moves upwards towards the surface at the eastern end (South America). This is upwelling which, in the Pacific Ocean, brings nutrient-rich bottom waters to the surface. Plankton feed on the nutrients and, in turn, fish feed on the plankton, so these areas tend to be rich in fish and other sea life.

When the trade winds do not happen or are weaker, the 'warm' water moves back across the 'ocean' from the west (Indonesia) to the east (South America). This movement of warm water is what happens in the ocean during an El Niño condition. (You may need to do this several times to observe the movement.)

This stops the upwelling and prevents the nutrients flowing to the plankton. The result is poor fishing.
The warm water also deflects up and down the coastline of South and North America, and this creates other problems.

Extension: Some more questions to discuss with your students
How do you think the warm water is moved across the world's oceans?

What do you think will happen to the air above the warm water in terms of how much moisture the air can hold? (The air warms and holds more moisture from the evaporation of seawater – the water cycle.)

If the body of warm water spreads across the Pacific Ocean, what will happen to the number of cyclones that could occur in our region?

(Adapted from SEREAD)

Picture 6 – Causes of climate change

This picture shows the enhanced greenhouse effect and has been drawn to focus on a Pacific perspective. In the picture you can see a range of sources of greenhouse gas emissions. Factories, trucks, boats, planes and cars are emitting carbon dioxide and some of them also nitrous oxide as they burn fossil fuels. There is a forest fire and an open landfill, and trees have been cut down – all of which release carbon dioxide. The rice fields and ruminants (cows, goats) emit methane.

The greenhouse gases are shown as little molecules. Globally, including in the Pacific, the main source of emissions is the burning of fossil fuels for energy. Organic waste, deforestation, agriculture and livestock, and volcanic eruptions also contribute to emissions.

Possible student learning outcomes **Students will be able to....**	**Teaching and learning strategies**
• name the major greenhouse gases; • describe some significant causes of climate change; • explain why the term 'greenhouse' is used.	Picture interpretation with guiding questions How well does the sun heat the earth?

Discussion

Ask your students to look at the picture and describe what they see. Ask if they have heard about the atmosphere and solar radiation. Do they know what a factory is and what combustion is? Have they ever thought about where electricity in their homes comes from? What is fossil fuel? What is carbon dioxide? What is a greenhouse? And what are greenhouse gases? You can explain these things, if necessary, using the background information in the next few pages.

When their questions are clarified and the basic concept of the greenhouse effect is understood, you can refer them to the picture and ask them the following questions:

- What is producing the emissions of greenhouse gases? (Distinguish between human causes and natural causes, such as bush fires and volcanoes.)
- What parts of the world are they coming from?
- What is the consequence of the enhanced greenhouse effect? (global warming)
- How can we stop or slow down this process (reduce emissions/mitigation) …individually? …as a country? ...all over the world?

Suggest to your students that they ask their parents and grandparents what changes they have seen in weather patterns over the years. The responses will probably be informative.

The greenhouse effect

The mix of gases in the atmosphere allows a portion of solar radiation directed at the Earth to reach the surface, as well as limiting the amount of long-wave radiation that escapes back into the atmosphere. This heat-trapping function is known as the 'greenhouse effect' and it has kept the temperature suitable for life for millennia. Without these gases, the temperature on the surface of the earth would be $-18^{O}C$. The greenhouse gases (GHGs) keep the average temperature at $15^{O}C$.

The term 'greenhouse' is used to describe this phenomenon, since these gases act in a similar way to the glass of a greenhouse that is used for growing vegetables and flowers in cooler places. The idea behind the greenhouse, which is actually a glasshouse, is to trap heat and maintain higher interior temperatures than occur outside. It is like the inside of a car that is left in the sun with all the windows closed. However, it is important to mention that the effect in a greenhouse or car is different from the atmosphere: the car or the glass of a greenhouse traps heat by preventing convection, whilst the greenhouse effect in our atmosphere reduces radiation loss.

This is how you can explain the greenhouse effect step by step, following the arrows in Picture 6 from left to right:

1. Solar radiation comes in (incoming solar radiation 343 Watt/m^2)·
2. Some of the solar radiation gets reflected by the atmosphere and the Earth's surface (outgoing solar radiation 103 Watt/m^2).
3. Solar energy is absorbed by the Earth's surface and warms it (169 Watt/m^2).
4. Solar energy is converted into heat, causing the emission of long-wave (infrared) radiation back to the atmosphere.
5. Some of the infrared radiation is absorbed and re-emitted by the greenhouse gas molecules. The direct effect is the warming of the Earth's surface and the troposphere.
6. The Earth's surface gains more heat and infrared radiation is emitted again.
7. Some of the infrared radiation passes through the atmosphere and is lost in space (net outgoing infrared radiation: 240 Watt/m^2).

(Rekacewicz 2005)

Enhanced greenhouse effect leads to global warming

What creates a lot of concern now is the fact that, over the past 250 years, humans have been raising the concentration of greenhouse gases in the atmosphere at an ever-increasing rate, mostly by burning fossil fuels, cutting down forests without replanting, and increasing agriculture emissions. Extra greenhouse gases have enhanced the greenhouse effect and resulted in global warming, leading to climate change.

Emphasise to your students that these gases are very important and need to be present. They are natural gases that we depend on to keep our planet habitable. The problem of global warming is caused by **excess** amounts of these gases and the **enhanced** greenhouse effect. The increase in temperature is also leading to other effects on the climate system. Together, these effects are known as anthropogenic (human caused) climate change.

The main greenhouse gases (GHGs) (WMO):

Carbon dioxide (CO_2). This is actually only a small component of atmospheric gases, but it is one of the most significant. CO_2 is released naturally into the atmosphere through volcanic eruptions, natural fire, and animal and plant respiration. It is also released through human activities such as deforestation and the burning of fossil fuels for energy. CO_2 spends a long time in the atmosphere, increasing its effect. CO_2 is the largest single contributor to global warming, accounting for three-quarters of emissions today. Since the industrial revolution, humans have increased the atmospheric CO_2 concentration by 40% (EPA 2010). CO_2 contributes around 60% of the overall warming.

Methane (CH_4). The second most important GHG is produced both naturally and through human activities. The most significant source of methane is from the decomposition of organic matter, e.g. in landfills and in agriculture, especially in the production of rice. Another large source is from the digestion of ruminants (cows, goats, etc.). Methane is a stronger GHG than CO_2 because it can absorb more heat. However, it is much less abundant in the atmosphere.

Nitrous oxide (N_2O). A very powerful greenhouse gas produced in massive quantities by the agriculture sector, specifically in the production and use of chemical fertilisers. It is also produced when burning fossil fuels and treating waste.

Chlorofluorocarbons (CFCs). These man-made compounds were produced for industrial use, mainly in refrigerants and air conditioners. They are now regulated under the Montreal Protocol due to their adverse affect on the ozone layer.

Water vapour (H_2O) and aerosols influence the greenhouse effect:

Water vapour (H_2O) is the most abundant gas. It has the same effect as a GHG but is not considered as such, because it spends only a short time in the atmosphere, and human activity has very little influence on the amount of water in the atmosphere.

An aerosol is a suspension of fine solid particles or liquid droplets in a gas. Examples are clouds, and air pollutants, such as smog and smoke. Aerosols can scatter or absorb solar radiation. The scattering of solar radiation acts to cool the planet, while absorption warms the air directly. Human activity contributes to the amount of aerosols in the atmosphere. For examples, aerosols are formed from dust particles released by agricultural activities, and organic and soot particles from burning biomass (e.g. wood). In addition, industrial production processes and exhaust emissions from transport generate a mix of pollutants that are either aerosols, or are converted by chemical reactions in the atmosphere to form aerosols.

Emission: The release of a gas into the atmosphere (SPREP 2012).

Global warming and climate change

Throughout its long history, Earth has warmed and cooled several times. The climate changed when the planet received more or less sunlight due to subtle shifts in its orbit, when the atmosphere or surface changed, or when the energy of the sun varied (NASA 2013).

Since the beginning of the 20th century, **industrial activity has grown forty-fold, and the emission of greenhouse gases has grown ten-fold**. Transportation, electricity, heating and industry rely mostly on burning fossil fuel. The amount of CO_2 in the atmosphere was 280 parts per million (ppm) at the beginning of the century. This year, 2013, it has nearly reached 400 ppm (Dr Pieter Tans, NOAA/ESRL & Dr. Ralph Keeling 2013). The upper limit for CO_2, according to scientists and climate experts, is 350 ppm.

Similarly, methane (CH_4) rose from a preindustrial atmospheric concentration of around 700 parts per billion (ppb) to about 1,789 ppb by 2007 (see Figure 6.1).

Global warming is the unusually rapid increase in the Earth's average surface temperature over the past century, primarily due to the greenhouse gases released as people burn fossil fuels. The global average surface temperature rose 0.6 to 0.9 degrees Celsius (1.1 to 1.6° F) between 1906 and 2005, and the rate of temperature increase has nearly doubled in the last 50 years. Temperatures are certain to go up further.' (See Figure 6.2; NASA 2013)

Climate change is a term used by scientists, politicians and experts to describe changes in the Earth's climate due to human activities (anthropogenic climate change) or natural processes that are already occurring or predicted to occur. These include increasing air and sea-surface temperatures, changing rainfall patterns, sea-level rise, ocean acidification, and changes in frequency and intensity of extreme events such as droughts, floods and tropical cyclones. Anthropogenic climate change is expected to happen much more rapidly than natural changes in the climate, posing an enormous challenge to both natural and human systems (SPREP 2012).

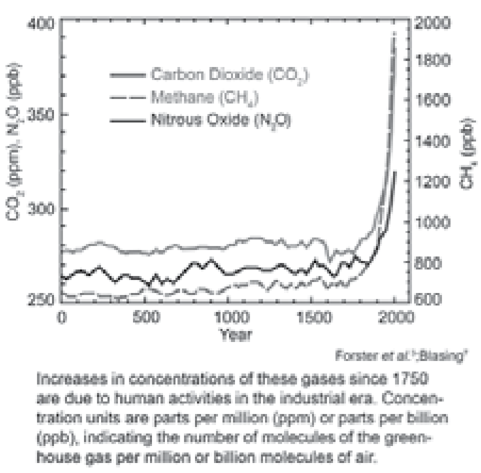


Figure 6.1: Increases in GHGs since 1750 (Forster et al. 2007; Blasing 2008)

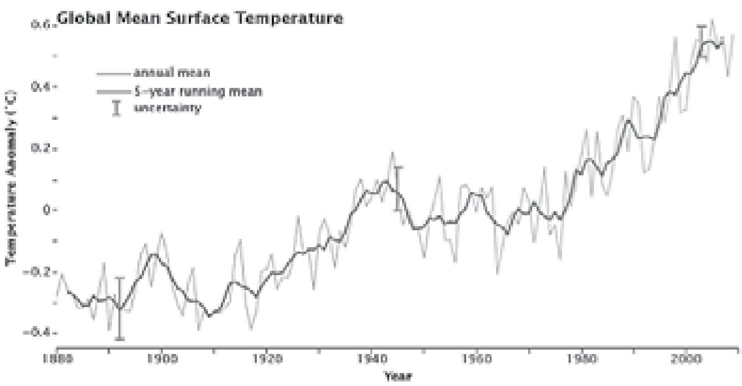


Figure 6.2: Global mean surface temperature (NASA/ Earth Observatory 2013)

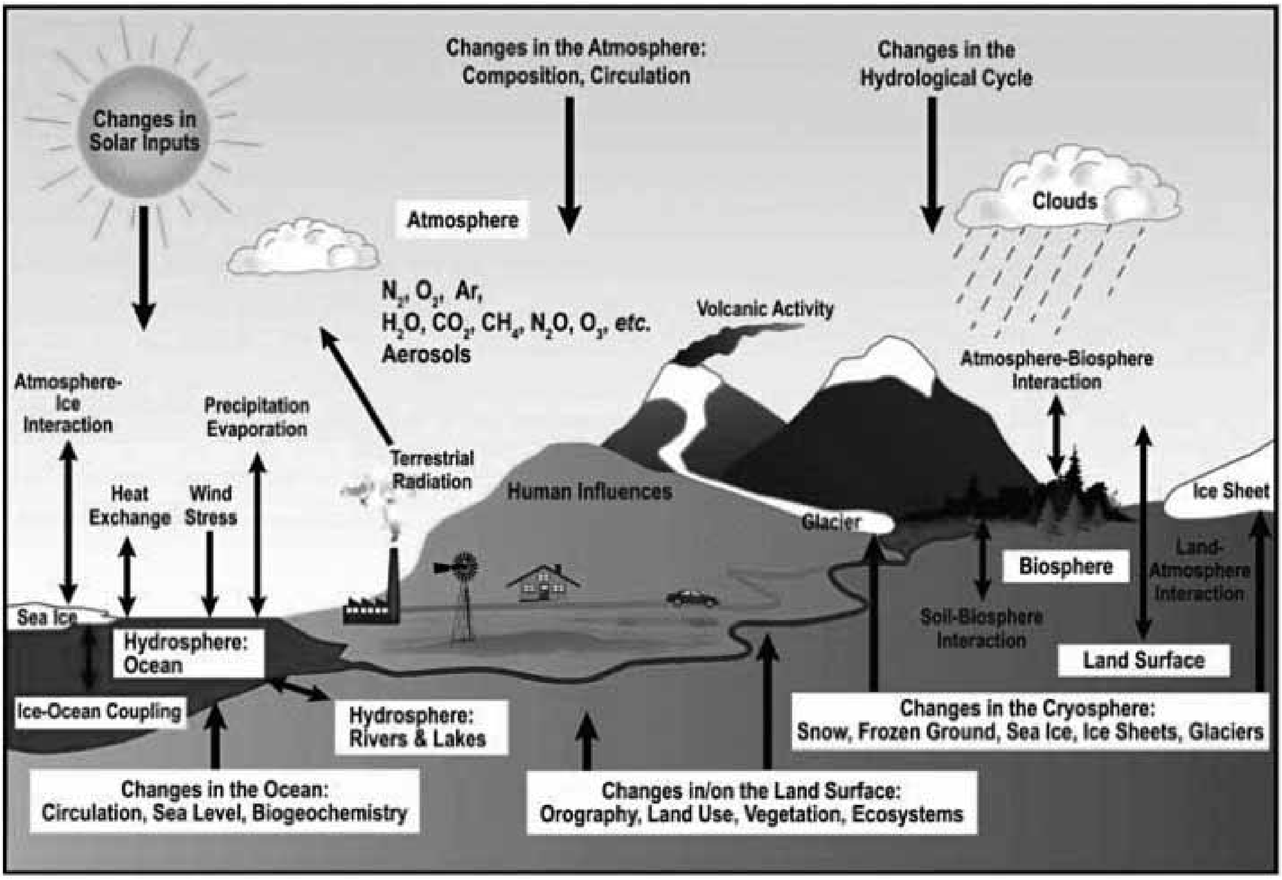


Figure 6.3: Diagram to show factors that affect climate change (IPCC 2007)

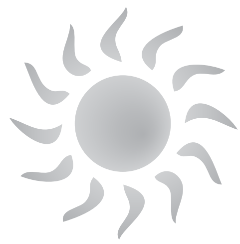
Figure 6.3 shows some of the complexity and interconnectedness of the factors that contribute to climate change. If possible, photocopy this for your students. It can be used in conjunction with Picture 6.

Teaching and learning strategies – 6

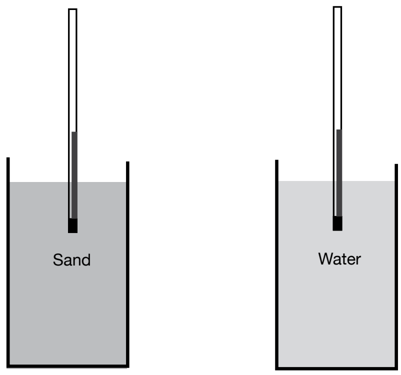
6.1. How well does the sun heat the earth?

What we want children to learn:

- Water can hold more heat energy than sand or earth.
- This is why it heats up more slowly and cools more slowly.
- The oceans hold a lot of heat energy. (In fact the amount of heat energy in the top three metres of ocean is roughly equivalent to the same amount of heat energy in the whole of the atmosphere.)
- What might this mean for the earth if more ice melts and there is more ocean to warm up?



What you will need for each group: two jars, sand, water, two thermometers.



Method for each group:

1. Fill up the two jars; one with sand, the other one with water ('land' and 'sea')

2. Put a thermometer into the jar of sand. The bulb of the thermometer should be 3-4 cm into the sand.

3. Put the thermometer into the jar of water. The bulb of the thermometer should be held 3-4 cm into the water. A piece of cardboard with a small hole in the centre, Sellotaped to the jar will do this if you don't have a clamp stand.

4. Place both jars in the sun.

Predict: Which jar will heat up the fastest – land or sea?

Observations

1. Ask each group to record the temperature at the start.

2. Make a grid on the blackboard so each group can record their numbers.

3. Ask them to record the temperature after 10 minutes.

4. Do this until you end up with the temperature after 40 minutes for each group.

Question: Was your prediction correct?
Which jar had the greatest increase in temperature?
Students can graph these figures – their own group's figures compared to the average for the class.
What effect do you think this has on our climate, particularly places by the sea?

Extensions
Predict: If the jars are moved into the shade or somewhere cool, which one would show the greatest drop in temperature?

Observe: Move them to a shady place and record the temperature of the two jars, and then leave them for 10 minutes. Measure the temperature. Do this again two more times, so they have been left for 30 minutes.

Question: Was your prediction correct?
Can you explain what happened and why?
What effect do you think this has on our climate, particularly places by the sea?

What would happen if we wrapped the 'earth' in a blanket?
Find two big, clear plastic bags. Place the jars inside them and tie the tops so that they are airtight. Now repeat the experiment.

Predict: What do you think will happen to the temperature rise this time? Why?
What do you think will happen when the jars are moved to the shade? Why?

Observe: Record the measurements as before, and discuss the result.

(Adapted from SEREAD)

Picture 7 – Interrelationships

This may be one of the most difficult pictures to interpret with students, yet it is possibly the most important. It shows some of the interrelationships between the land, the atmosphere and the ocean. It shows the fresh water lens being contaminated by improper sanitation, cemeteries, and animal and solid waste. With higher sea levels and a higher consumption of water, salt water intrudes into the fresh water lens. The taro pit shows some healthy plants and some affected by salt-water intrusion. On the shore, the picture shows how the mining of beaches causes coastal erosion. Also, sea-level rise will contribute to coastal erosion. Carbon dioxide molecules are shown being emitted by the burning of waste and cutting down of trees, but also being used by plants for photosynthesis and being absorbed by oceans. On the right-hand side, the carbon dioxide and carbonic acid molecules in the ocean indicate ocean acidification. The ocean temperature symbol and whitening coral indicate the effect of higher sea-surface temperature on coral reefs (leading to bleaching). In the ocean on the left-hand side, the effects of contamination and waste disposal are shown.

Possible student learning outcomes Students will be able to….	**Teaching and learning activities**
• identify some interrelationships between the ocean and land; • identify some of the possible effects of climate change and unsustainable practices on those interrelationships; • identify some of the possible effects of climate change and unsustainable practices on carbon pathways.	Picture interpretation with guiding questions Ocean acidification exercise Build a tree What makes sea water different? Comparing the behaviour of warm water to cold water

Discussion

Ask the students to explain what they can see in the picture.
Possible questions you can ask, with answers after each question:

- What can you see happening in the picture?
- How do you think this affects the land and ocean and the plants and animals that live there?
  (Throwing rubbish into the ocean results in high levels of nutrients, particularly nitrogen, entering the ecosystem and promoting algal growth, which can kill plankton and some small fish and shellfish. It also introduces bacteria into the water, such as e-coli, which are harmful to people.
  Burning rubbish causes more carbon dioxide emissions and can also affect health.
  Fetching drinking water is important and has no adverse effect if water is managed properly, but pollution can contaminate drinking water, droughts and/or overuse can reduce the amount of fresh water available in the water lens, and salt water can intrude due to a shrinking water lens or wave over topping during storm surges.)
- What do you think the thermometers show?
  (Temperature rises in the atmosphere and on the surface of the sea because of climate change or climate variability. In the ocean, the higher temperature causes corals to bleach. That means fewer coastal fish.)
- Where do the carbon dioxide molecules go from the air?
  (*Those above the plants go into the leaves – photosynthesis. Those above the ocean go into the ocean water. Both plants and oceans are carbon sinks.)*
- Where do the plants get what they need to grow?
  (*Besides light and water and nutrients from the ground, plants take carbon dioxide from the air and convert it into solid material – starch.)*

- What happens to carbon dioxide molecules in the ocean water?
  (*Some remain as they are, some dissolve in sea water: carbon dioxide molecules combine with water (H_2O) to form carbonic acid (H_2CO_3). The carbonic acid reduces the available amount of calcium carbonate that corals and molluscs need to build their skeletons and shells. That affects molluscs and corals negatively, as they need calcium carbonates to build their skeletons.)*
- What do you think causes sea-level rise and coastal erosion?
  (*Many things, as described below. For example, tides, ENSO, seasons. One of them is climate change – thermal expansion due to higher ocean temperatures and an increase in volume because of melting land-based ice. But also our own actions, such as mining sand on our beaches, lead to coastal erosion.)*
- Where does the fresh water come from on the land?
  (*The water lens. Correct answers could also be: rainwater, tap, etc.)*
- What happened to the taro-pit? Why do some plants look healthy and others not?
  (*Taro plants that get water that is too salty will die.)*

Specific topics

1. Coastal changes and sea-level rise
   Many naturally occurring processes cause coastal and sea-level changes. Soft shores (sand and gravel beaches) are dynamic and change all the time. Ask the students to interview older people in their community to find out what they remember.
   - Has the beach changed over time and how?
   - Are there places where land has been washed away (erosion)?
   - Is there land in places where there was none before (deposition or accretion)?
   - Have they seen sea water flooding the coast?
   - Was it during a storm or during calm weather?

> **Vulnerability** is the level of susceptibility of an individual, a community, an organisation or a system to adverse conditions, emergencies or disasters; a measure of its ability, or inability, to cope.
>
> **Resilience** is the capacity of a community, society or natural system to maintain its structure and functioning through stress or change.
>
> (SPREP 2012)

2. Food security
   Discuss the students' experiences of:
   - drought, when water is prioritised for drinking and washing;
   - salt infiltrating the fresh water lens, making it unsuitable for drinking;
   - salt infiltrating soil, making it unsuitable for growing plants;
   - coral reefs damaged by storms and/or bleaching, and hence supporting fewer lagoon fish;
   - extreme storms damaging and uprooting plants such as bananas, coconut and breadfruit.

3. Human actions
   Be sure that the students appreciate that wherever humans live, they have an impact on the environment. Pictures 9 to 14 provide more information and discussion on drought, fresh water and terrestrial and marine environments. Human actions can increase the vulnerability of our ecosystems to climate change. If we manage our natural resources in a sustainable way, our ecosystems are more resilient to the effects of climate change. Ask your students if they can give some good and bad examples from their own community.

> If we protect our environment from pollution and waste, we reduce the stress on ecosystems and increase their resilience to climate change.

Coastal changes and sea-level rise

Global warming leads to higher ocean temperatures because the oceans act as a heat sink and absorb heat energy (See Picture 2, The Water Cycle). This results in the (thermal) expansion of the water. The melting of land-based snow and ice also contributes to sea-level rise (IPCC Synthesis Report Glossary).

In the Pacific region, most people live in low-lying coastal areas. Low-lying atoll islands, such as Kiribati, Republic of the Marshall Islands and Tuvalu, and coastal communities on higher islands are most vulnerable to sea-level rise, surges and associated coastal erosion. Today, many coastal vulnerability and flooding problems are made worse when structures are built without fully understanding how this might affect the coastal environment and by removing mangroves and mining beaches. These are already big environmental and social problems. However, climate change and sea-level rise will make these problems far worse.

Soft beaches and sea levels have always been subject to change. This is caused by various natural processes, listed below.

- The positions of the Earth, moon and sun change periodically, causing daily tides, monthly spring and neap tides and changes on an annual basis. In the Pacific Island region, tides are often higher in the early part of the year.
- Changes in the ocean-atmosphere system (such as ENSO, see Picture 5) can also cause large-scale changes in sea level. For example, during El Niño events, sea levels can rise up to 20–30 cm (ABM and CSIRO 2011).
- Longer-term seasonal temperature changes can also cause expansion or shrinking of the ocean waters, leading to higher and lower sea levels.
- Sinking or lifting of land masses because of geological events (plate tectonic processes) changes the relative height of the sea in relation to land.
- Seasonal changes in ocean currents, waves, wind and rain can also cause sandy shores to change (natural erosion and accretion of sediments). Some islands in Federated States of Micronesia , Kiribati and Tuvalu have been shown to increase in size over the last 19–61 years.
- Extreme waves caused by storms or tsunamis change sea levels briefly but significantly and affect shorelines.
- Many sandy shores in the tropical Pacific islands are protected by coral reefs, and the sand on the beach is also made from once-living reef material. Any change in the reef systems can affect beaches by either less or more sediment supply and the way the reef blocks wave energy.

Ocean acidification and coral bleaching
The ocean absorbs 25% to 30% of the additional carbon dioxide (CO_2) produced by human populations. As this additional CO_2 dissolves in sea water it reacts in such a way that in the end the amount of calcium carbonate that corals and molluscs need to build their skeletons and shells is not sufficient. The smaller the organism, the less protection it has, so many species of plankton are already being badly affected.

(In more detail: As additional CO_2 dissolves in sea water it forms carbonic acid (H_2CO_3), which in turn breaks down into bicarbonate (HCO_3^-) and hydrogen ions (H^+). The hydrogen ions then combine with carbonate ions (CO_3^{2-}), which means that there are fewer carbonate ions available in sea water to combine with calcium to form the calcium carbonate that corals and molluscs need to build their skeletons and shells.) (Bell, Johnson and Hobday 2011)

Also changes in ocean temperature create big problems for coral. Coral reefs are made up of millions of very small animals called coral polyps which are related to, and look like, miniature jellyfish. These polyps live in huge colonies and create complex skeletons (using calcium carbonate as described above), which are the building blocks of the coral reefs. Each coral polyp has microscopic algae living inside it, which give the coral its colour and use energy from the sun to provide the polyp with the sugars it needs to grow. When the sea temperature rises, the corals become stressed and spit out the algae. This turns the corals white in a process known as 'coral bleaching'. The coral that have turned white cannot survive for very long without their algae, and will slowly starve to death if the water temperature remains too high for too long (Findlay and Hinge 2010: 98).

Global warming increases ocean acidification and coral bleaching, thus degrading coral reefs. This will reduce the reefs' capacity to support the fish that are so important to the people of the Pacific Islands.

Carbon sequestration : The removal of carbon dioxide from the atmosphere and its long-term storage in reservoirs.
(SPREP 2012)

Carbon sink: A carbon sink is a natural or artificial reservoir that takes up and stores carbon. Trees, plants, oceans, rocks and soils are natural sinks, while landfills are artificial sinks (SPREP 2012).

Salt water intrusion
It is important to understand that the way we manage water has considerable effects on its availability and quality. Where the sea-level has risen, salt water enters the underground freshwater lens (salt water intrusion). When large quantities of fresh water are removed for human use, seawater seeps in from the bottom of the lens and eventually mixes with the freshwater to form brackish water, which is unfit for humans to drink and for plants to survive.

The carbon cycle and photosynthesis
The carbon cycle describes the circulation of carbon between living organisms and the atmosphere, oceans and land. Plants take in carbon dioxide from the atmosphere and build more complex compounds (sugars and starch). When animals eat plants, the carbon is used to build different compounds and carbon is stored in the body. Some of the carbon is released back to the atmosphere as carbon dioxide during respiration (breathing), and more is released when plants and animals die and decompose. When dead plant and animal matter is buried, carbon is stored in the earth. Humans can use this material as an important source of energy (fossil fuel). Burning fossil fuels releases carbon back to the atmosphere
(SPREP 2012).

Teaching and learning strategies – 7

Simple experiments students can do to show the effects on sea-level from heating water and melting ice can be found in the Teaching activities for Picture 2 – the Water Cycle. These are worth considering as they use empty drink bottles, straws and cardboard cups – not laboratory equipment.

7.1. Ocean acidification exercise

The effects of ocean acidification can be shown easily if students collect small pieces of shell or coral and wash them carefully. Tell your students to do the following.

1. Wrap a piece of Sellotape closely around part of the shell.

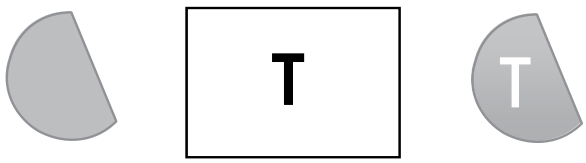
2. Make a 50% solution of vinegar and water or squeeze some lemon or lime juice into the water – make sure it tastes 'sour'. (Students could also make carbonic acid in water by blowing into the water through a straw, but this will take a while.)

3. Place the wrapped shell in the acid solution and leave it overnight.

4. Unwrap the shell – it should look white and smooth on the part that was not covered and, under the Sellotape, it should be the original colour and roughness.

You may need to experiment beforehand to get the right strength that will erode the shell or coral. Shells vary in their hardness. If you want to make it very effective use eggshell – it may disappear altogether! This is what can happen to plankton skeletons in acidic water.

If you have the sheets of plastic covering used for covering exercise books and shelves, students can cut themselves a piece and then cut out their initial inside the square. When they put their plastic over a shell and leave it in the acidic water overnight, their initial will appear on the surface of the shell, etched by the acid.



7.2. Build a tree

This activity works best with at least 15 students.

What do trees need? What do trees do?
Brainstorm with students – trees need sunlight, water, soil, oxygen (air).
They need roots, leaves, branches, flowers.
They grow tall, make their own food, provide food and shelter for humans and other animals, and transpire.

Explain that the students are going to 'build' a tree by becoming parts of the tree and acting out their roles. This is best done somewhere where students won't mind lying on the ground. The numbers are based on a class size between 18 and 30 and can be flexible.

1. ***What do you see when you look at a tree?*** Ask for a volunteer to be the trunk – they may need to stand on a chair. They need to stretch their branches (arms) high, and move their leaves (fingers) in the sun.

2. ***Where is the sun?*** Ask for a volunteer to be the sun standing a few metres away from the trunk. The volunteer may also need to be on a chair.

3. ***What keeps the tree up?*** Students will say roots so ask for three or four volunteers to lie on their stomachs facing out from the trunk.

4. ***What do the roots do?*** When they refer to getting water from the soil, ask the roots to wriggle their root hairs (fingers) and make slurping noises to show they are taking in water.

5. ***How does the water get up the stem?*** If they know what a xylem is or mention tubes or pipes ask for three to five volunteers to be xylem. They stand around the trunk, facing outwards and holding hands. They need to crouch down, then make a sipping noise as they rise – lifting their hands up to carry water to the leaves, then back down again for the next load.

6. ***What are the leaves doing with the water?*** Making food. How does the food travel around the plant and down to the roots? Four to six volunteers will be needed for the phloem, facing in towards the xylem, holding hands. They will make a 'whish' noise as they carry food downwards, then rise again to repeat.

7. ***What protects these tubes?*** Bark – Five to seven volunteers stand facing outwards, holding hands. When danger approaches they will 'bark' and try to repel them.

8. ***What do the trees do with carbon dioxide (CO_2)?*** *The leaves absorb carbon dioxide and release oxygen. The branches, trunk and roots store carbon.*

9. ***What do trees need protection from?*** The answer may well be humans but look for birds and insects, some of which are harmful to trees. Two or three students can be invaders.

The tree now needs to 'come to life'. The sun starts to 'beat' and actions start. Everyone needs to make his or her noises and move accordingly. The tree should be very active and noisy.

Processing

- Why does the tree need so many parts?
  - Lots of different things need to happen. Water and food are going in different directions – they need different paths.
- What happens if one part doesn't work properly?
  - The rest won't work properly either.
- Which part is the most important?
  - None – they are all important – students will usually claim the part they acted. This is good as they have a deeper understanding when they have an emotional attachment.
- What stops the bark being effective?
  - Being cut or damaged.

Extension

What will happen if the roots are damaged due to erosion?

- Remove one root. What happens to the trunk?

What happens if there is very little water in the soil?

- Each root has to hold one hand still against their side. What effect does this have on the xylem? It makes them move more slowly.

What effect will this have on the leaves?

What happens if there is salt in the soil?

- The roots go 'Phhhhhgh' and curl up.
- The xylem sinks down as water flows out.
- The phloem crumples with no water or food.
- The trunk collapses.

What would happen if all the trees in the world were cut down?

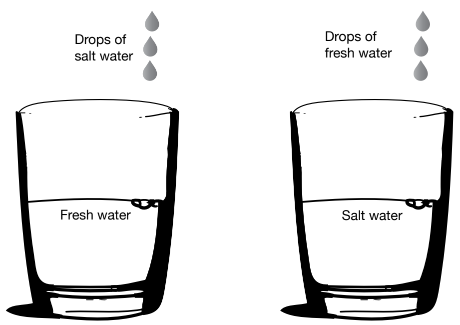
- There would not be enough oxygen for humans and animals to breathe, because trees are most important in photosynthesis.
- Carbon would not get stored and oxygen would not be released any more by trees. Instead, carbon dioxide would accumulate in the atmosphere and the oceans, so the greenhouse effect would be greater – it would get hotter and hotter and the oceans would become even more acidic.

7.3 What makes sea water different?

What we want children to learn:

- Sea water is denser, and therefore heavier, than fresh water.
- When it rains, the fresh water reduces the salinity of the salt water on the surface.

Predict: Will sea water and fresh water mix?



What you will need: 2 x 250 ml beakers or large glass jars, salt, blue and green food colouring, two small clear containers, about 50 ml will do, two droppers, a tablespoon, a marker pen.

What to do:

Pour water into the large glass containers so they are half full.

Put a tablespoon of salt into one of the containers and stir until the salt has dissolved.

Write salt water on this container.

Write fresh water on the other container.

Pour some of the salty water into one of the small containers so it is 3/4 full.

Add green colouring to this salty water until it is dark green.

Label the small container 'Salt Water.'

Pour some fresh water into the other small container until it is 3/4 full. Add the blue food colouring so that the water turns light blue. Label it 'Fresh Water.'

Use a dropper and gently add some drops of the 'green' salt water to the large container of clear fresh water.

Observe: Draw what happens to the green salt water. Does it mix with the fresh water? Does it float or sink? Use colours in your drawing to show what is happening.

Now use a clean dropper and add some drops of blue fresh water to the clear salt water in the large container.

Observe: Draw what happens to the blue fresh water. Does it mix with the salt water? Does it float or sink? Use colours in your drawing to show what is happening.

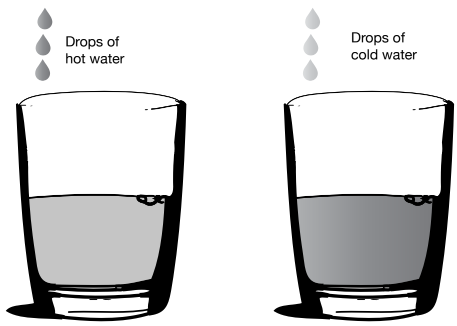
Explain: Can you think of a reason for what you see happening when fresh water and salt water come together?

Questions: What do you think happens when it rains out at sea? Do the rain water and sea water mix straight away?

7.4 Comparing the behaviour of warm water to cold water

The temperature of sea water varies all over the world. The ocean waters near the Arctic and Antarctic will be considerably colder than the water near the equator. The temperature of water affects its density. This in turn affects how water moves in the ocean, and the way deep ocean currents move.

What we want children to learn:
Cold water sinks below warm water. It is more dense.
Warm water will sit on top of cold water.
Wind will mix up the layers of warm and cold water.



Predict: What do you think will happen when warm and cold water meet each other?

What you will need: iced water, very hot water, a large clear container (500 ml beaker), two small containers (30 ml beakers), red and blue food colouring, two droppers.

What to do:
Fill the large container 3/4 full with tap water and place it on a table to allow the water to reach the same temperature as the room.
Pour some hot water into one of the small containers so that it is half full.
Put some drops of RED food colouring into the hot water to make it dark red.
Pour some iced water into the other container.
Put some drops of BLUE food colouring into the iced water to make it dark blue.
Using the dropper, gently add some drops of hot red water to the water in the large container. Then add drops of blue iced water to the same large container of water.

Observe: What happens to the hot and cold water? Do they mix? Draw pictures using red and blue colouring pencils to show what happens to the water. You may need to do several pictures over a period of time.

Explain: What happens to the cold water? Why do you think this happens?
What happens to the warm water? Why do you think this happens?
What do you think will happen when cold water from the polar regions meets up with warmer water from the equator?

Extension: Hold a straw at the edge of the top of the beaker so that it is parallel to the water surface. Blow gently through the straw. What happens to the water?

(Adapted from SEREAD)

Picture 8 – The changing climate of Samoa

The top part of this picture has photos showing the destruction of buildings and flooding as a result of a cyclone, and coral bleaching as an effect of ocean acidification and rising sea-surface temperatures. The lower part shows how climate patterns in Samoa have changed in the past and will change in the future. There are two charts, one that shows how temperatures in Apia have increased and one that shows how the average rainfall in Apia has been changing considerably from one year to the next because of ENSO. The symbols show what is predicted for the future.

Possible student learning outcomes **Students will be able to….**	**Teaching and learning activities**
• describe the observed and predicted changes to Samoa's climate; • describe some effects of climate change in Samoa.	Interpretation of the climate data with guiding questions Web of life and sustainability

Discussion

Ask your students to describe the effects of a cyclone, flooding and drought, using the photographs in Picture 8 and their own experiences.

Charts of temperature and rainfall in Apia

Check that your students can 'read' the charts. If necessary, explain that in the temperature chart, the dots show the average yearly temperature – red dots in an El Niño year, orange dots in a La Niña year and grey dots in a normal year – and in the rainfall chart, the bars represent the average annual rainfall – the light blue bars in an El Niño year, the dark blue bars in La Niña year and the grey bars in a normal year. In both charts, the red line shows the trend.

Ask your students to use the charts to answer the questions below. They can work in small groups. (See Picture 5 for background information.)

1. What was the average annual temperature in Apia in 1950 and in 2005?
2. In general, what do you notice about Apia's average temperatures during an El Niño year (red dots)?
3. In general, what do you notice about Apia's average temperatures during a La Niña year (orange dots)?
4. Does an El Niño year have more or less rainfall in Apia than usual?
5. Does a La Niña year have more or less rainfall in Apia than usual?
6. What do you think happens to the South Pacific Convergence Zone during an El Niño year, and during a La Niña year?
7. If Samoa's temperatures are increasing, suggest three things that may happen as a result.

The symbols

Now look at the symbols. In pairs or groups, your students can discuss and note down at least one likely effect on your island of the change shown by each symbol.

It would be useful to ask the Samoa Meteorology Division for rainfall and temperature graphs or statistics for different parts of the country so that students could analyse data relevant to where they live. These data could then be compared to the Apia data. (www.mnre.gov.ws/index.php/divisions/meteorology).

Samoa's changing climate

- Records show that annual maximum and minimum temperatures have increased in Samoa since 1950 (see left hand graph in Picture 8). The mean temperature has risen approximately 0.6°C in the last 60 years, with lower temperatures during La Niña cycles.
- There are no clear trends in annual or seasonal rainfall for Apia since 1950. The average annual rainfall has stayed constant during this time, with El Niño often being associated with times of drought (see graph in the middle of Picture 8).
- There has been big variation in rainfall from year to year. El Niño events usually bring wet seasons that are drier than normal. Li Niña events bring wetter and cooler conditions than normal.
- Because of rising temperatures worldwide, ocean waters have expanded, and there is evidence that the sea level in Samoa has risen by about 4 mm a year since 1993. This is more than the global average of 2.8–3.6 mm a year.
- Since the 18th century the level of ocean acidification has been slowly increasing in Samoa's waters, following a worldwide trend of increasing levels of carbon dioxide in the atmosphere. Such acidification is likely to affect the growth of coral and other organisms that build their skeletons out of carbonate minerals.

(ABM and CSIRO 2011: Vol 2 & Samoa Country Brochure)

'Samoans see their climate changing. Their traditional knowledge and observations over the years show incremental changes to their landscape, affecting food crops and their livelihoods. They know instinctively that it's happening. And now the government is working hard to integrate climate change adaptation programmes into all sectors. We cannot continue to think of it as just an environmental issue.' Anne Rasmussen (Ministry of Natural Resources and Environment)

A century of meteorological data collected by the Samoa Meteorology Division supports the anecdotal evidence of the community. Temperatures have increased by 0.59°C on average; annual precipitation has decreased by almost 50 millimetres; sea level at Apia has risen by 4.6 millimetres a year for the period 1993–2009.

Samoa's future climate

These projections are presented along with confidence levels based on expert judgement by Pacific Climate Change Science Program (PCCSP) scientists. Over the course of the 21st century:

- **Air temperature and sea-surface temperature will continue to rise** (very high confidence). If greenhouse gas emissions remain high, air temperature is projected to increase in the range of 0.4 to 1.0°C by 2030.
- **There will be more very hot days** (very high confidence): The increases in average temperatures will also result in a rise in the number of hot days and warm nights and a decline in cooler weather.
- **There will be more extreme rainfall days** (high confidence).
- **Wet season and annual mean rainfall is projected to increase** (moderate confidence). Dry seasons might have less rain than in the past.
- **The annual mean rainfall will increase** (moderate confidence).
- **Tropical cyclones will be fewer in number** but might become more intense in the south-east Pacific Ocean basin (0–40°S, 170°E–130°W) (moderate confidence): Category 4 and 5 or possibly higher. The maximum wind speed will rise by up to 11% and the rainfall intensity will increase by 20%.
- **Mean sea-level will rise** (very high confidence, see Figure 8.1) to a possible 59 cm by 2090 under the high emissions scenario.
- **Ocean acidification will continue** (very high confidence): Evidence suggests that the process of ocean acidification will continue in Samoa waters. This will clearly lead to the deterioration of reef ecosystems.

ABM & CSIRO: 2011 Vol. 2

Putting these predictions together, what does this mean for Samoa over the next 50 years? The temperature will rise, with very hot days and warm nights becoming more common. There is likely to be a decline in cooler weather. Cyclones, storms, flooding and drought are all forms of extreme weather that have been happening in the Pacific for thousands of years. Scientists' predictions for the future, as a result of climate change, are for extremes to become more common and/or more severe.

Storms will be more severe with storm surges more likely (an increase in the height of the tide of 2 to 12 metres due to a deep low pressure at the heart of the storm and strong winds driving the waves). Because the storms are more violent there will be increased rainfall in a shorter time, which is more likely to induce flooding.

The ocean will get warmer, higher and more acidic, which is likely to mean more bleaching and damage to coral and reef ecosystems. This will lead to storms coming onto unprotected beaches and causing more erosion.

The Samoan community has critical concerns about the effects of climate change: fluctuating food production, impacts of drought and flooding on water quality and availability, more vector-borne and water-borne diseases, higher risk of forest fires, damage to low-lying infrastructure, and land loss. Impacts on energy supplies and tourism are further concerns. The Government of Samoa formulated a National Adaptation Programme of Action, which sets out a coordinated countrywide response to these climate-change risks. The community consultations identified nine priority projects, including a climate early warning system, designed to help the country respond quickly and effectively to adverse climate events and, in the longer term, to adapt to changes in the climate, particularly where they affect agriculture and health.

Teaching and learning strategies - 8

8.1 Web of life and sustainability

Issues of sustainability affect many aspects of life. To make sustainable decisions and actions we need to consider four things: the environment, food sources, society and the economy.

Purpose

- To demonstrate the links between the four aspects of sustainability

Instructions

- Ask each student to divide their page into four squares and label each square with the words: environment, food sources, society and economy.
- Tell the students to think of words that relate to these labels. Perhaps give a few examples. Give students a few minutes to write down their words in the right section of their page.
- Divide the class into four groups: environment, food sources, society and economy. Tell each student to choose one word from their list and write it on a card in large writing. Make sure you have words from each of the groups, and that everyone has a different word.
- Get the whole class to stand in a circle and hold their word in front of them. As the teacher, you can stand in the middle of the circle with a ball of wool or string.

Food sources	Environment
Society	Economy

- Ask a student to describe a link between the word on his/her card (e.g. **resources**) and another word in the circle (e.g. **products**). The response might be: You need **resources** to make **products** to sell.
- Join the cards together by linking the string to the fingers of the two students holding the cards.
- Ask the student holding **products** to link to another word (e.g. **garden**) in the circle with another sentence. For example: The **products** we make can come from our **garden**.
- Link the **products** string to **garden** and continue to make links until all the words in the circle are linked together. Some words may be linked more than once.

Reflection: Ask the students these questions:

1. What have we created with our string? (a web)
2. Could we continue to make more links and connections? (yes)
3. If we continued, what would happen to our web? (make it stronger)
4. What happens when you pull a string? (it affects many others)
5. What happens when you let one string go?
6. How does this activity help us to understand sustainability?
7. What connections have you learnt from this activity?
8. What did you like about this activity?

Can you write an explanation for sustainability? And for sustainable living and sustainable development?

This activity also works very well in other contexts. When studying an ecosystem, students can make cards with all the plants and animals and words such as **eats, weather, birds** and make a complex web from them.

(Adapted from SEREAD)

Picture 9 – Pasifika after a cyclone or severe storm

The picture shows Pasifika after a cyclone or severe storm. Roofs have been ripped off, trees have been blown down, the river is flooding, and there are queues of people at the health clinic.

Possible student learning outcomes Students will be able to...	Teaching and learning activities
• identify probable outcomes of a cyclone or severe storm; • identify possible risks in their own community; • identify some measures that their community could take to reduce the likelihood of damage.	Picture interpretation and discussion Y-charts Sequencing

Discussion

You can use the following questions:

- What has happened to the people?
- What happened to their food sources – gardens, livestock?
- What happened to their houses?
- Is their water source or supply affected?
- What damage would there be to cash crops, such as coconut, vanilla, sugar-cane or squash?
- What other damage can you see?
- What seems to have caused the most damage – wind or rain?
- Can they make links to their own village and talk about similar consequences?
- What are some of the long-term and short-term effects of a cyclone or severe storm?

Once they have established the effects, students could work in groups and discuss how Pasifika could have prepared itself for the cyclone/storm and prevented some of the damage. Is there anyone they could talk to about this? Is there a local disaster management committee or police officer or Red Cross specialist who could visit your class?

Short-term effects: trees blown down, buildings destroyed, injuries, loss of life, roofs blown off, severe flooding, rivers changing course, power lines down, seawalls destroyed, boulders swept into the lagoon, erosion of coastal and river bank land.

Longer-term effects: lack of power for cooking and lighting; lack of fresh water for drinking and cleaning, causing food loss and likelihood of disease; lack of shelter, causing people to leave their homes; gardens and fruit trees destroyed, causing ongoing food shortages; silt, debris and possibly sewage being washed onto roads and into houses

What is a tropical cyclone?

A tropical cyclone (also known as a typhoon or hurricane) is a violent rotating windstorm that develops over tropical waters warmer than 26.5ºC and located between 5º and 15º latitude.

There are times when the air rising over the warm regions of ocean form areas of extreme low pressure. The convection currents start spiralling around this low-pressure centre, causing rotation. Cyclones begin as thunderstorms. The winds spiral clockwise (southern hemisphere) and anticlockwise (northern hemisphere) in towards the centre of the low-pressure area. They pick up more moisture from the sea. At the centre, the air rises upwards, with the water vapour condensing to give high cloud formations and heavy rainfall. As the cyclone becomes organised, a calm clear area called the 'eye' forms at its centre. As long as the low-pressure centre remains over the warm ocean, there will always be energy to continue feeding the system (see Figure 9.1).

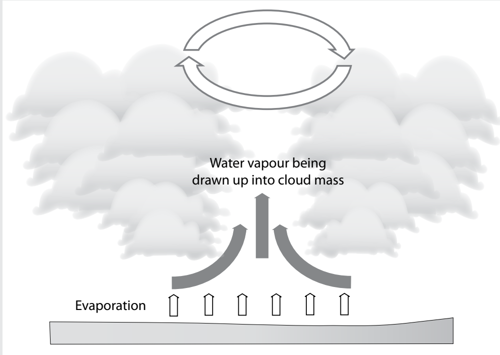


Figure 9.1

These storms rise up to 10 km into the atmosphere and can be up to 2,000 km across. The eye is typically 10–50 km wide and is surrounded by a dense ring of cloud known as the eye wall, which marks the belt of strongest winds. When the tropical cyclone moves over land or cooler water, there is no energy to feed the system and the cyclone dies away. In the meantime the amount of energy and rain can do a great deal of damage.

The cyclone season in the southern hemisphere runs from October to May and in the northern hemisphere from May to October but some cyclones do occur outside the season. (SEREAD and SOPAC 2006)

With climate change, cyclones and storms are likely to become less frequent but more severe, but there is uncertainty in predictions (ABM-CSIRO 2011 Vol 1). The types of damage from severe storms or cyclones, particularly when associated with king tides, are very similar.

Cyclone and storm warning

There is a well established network of cyclone warning centres throughout the region. The Regional Specialised Meteorological Centre (RSMC) in Nadi, Fiji, monitors, tracks and names tropical cyclones and severe storms, as well as providing warning services to Pacific Island countries. Similar services are provided for Papua New Guinea and Solomon Islands by the Australian Bureau of Meteorology's Tropical Cyclone Warning Centres. French-speaking countries are looked after by Meteo-France, and American affiliated states by the National Oceanic Atmospheric Administration.
(SOPAC 2006)

CYCLONE SEVERITY: SAFFIR-SIMPSON HURRICANE SCALE

Cate-gory	Wind speed (km/h)	Damage	Storm surge (m)
1	119-153	Minimal: No real damage to buildings. Coastal road flooding and minor pier damage.	1-1.5
2	154-177	Moderate: Damage to roof, window, door. Piers, shrubs damaged, trees felled. Coastal and low-lying escape routes flood. Craft break moorings.	1.5-2.5
3	178-209	Extensive: Structural damage to houses, utility buildings. Shrubs stripped, large trees felled. Low-lying escape routes cut off. Terrain less than 1.5 m above sea-level flooded. Coastal evacuation.	2.5-3.5
4	210-248	Extreme: Extensive curtainwall failures, roofing failures on small houses. Extensive damage — doors, windows. Low-lying escape routes cut off. Major damage to lower floors of nearshore structures. Terrain lower than 3 m above sea-level may flood. Massive evacuation up to 10 km inland.	3.5-5.5
5	> 250	Catastrophic: Complete roof failures, some complete building failures, utility buildings blown away. Severe and extensive window and door damage. Low-lying escape routes cut off. Major damage to lower floors of all structures less than 4.5 m above sea level. Massive evacuation up to 16 km inland.	>5.5

Figure 9.2: Cyclone Severity: Saffir-Simpson Hurricane Scale

Before

Prepare for a severe storm or cyclone

- Be aware of warnings about cyclones or storm surges (local radio, TV, etc.).
- Know which areas are prone to flooding and evacuate to safer ground if necessary (in the case of flooding).
- Fix any loose parts of the school and home.
- Cut off old branches from trees near buildings.
- Identify the safest room in your house or school, or a safe area, (e.g. high ground).
- Clear the school/house compound of loose objects.
- Prepare an emergency kit for the family and the school containing: a portable radio with spare batteries, a torch, kerosene lamp, candles, matches, water containers, canned food with opener, spare clothes, masking tape for windows, plastic bags, first aid necessities, etc.
- Clear all drains and waterways.
- Ensure the school / house has proper protection against lightening strikes.
- Make sure everyone is safe. The elderly, very young, and people with disabilities may need special care. (Have emergency plans in place, which everyone is aware of.)

During

Remain as safe as possible during a severe storm or cyclone

- Disconnect all electrical appliances but listen to your battery-powered radio for further information.
- Open louvres/windows on the side away from the wind to reduce the pull force of the wind on the roof.
- Remain calm, stay indoors but clear of doors and windows. Remain in the strongest part of the building.
- Use the telephone for only very urgent calls.
- If the building breaks up, protect yourself with rugs or mattresses under a strong table/ bench or hold onto a solid fixture (e.g. a water pipe).

After

After the severe storm or cyclone has passed

- Don't go outside until officially advised it is safe (listen to the radio).
- Don't attempt to drive and don't allow children to roam around outside.
- Beware of fallen power lines, damaged buildings, trees and flooded waterways.
- After a flood take extra care in washing hands.
- Check drinking wells for contamination.
- Boil drinking water if possible.

(SOPAC 2006)

BEWARE THE EYE OF THE STORM!

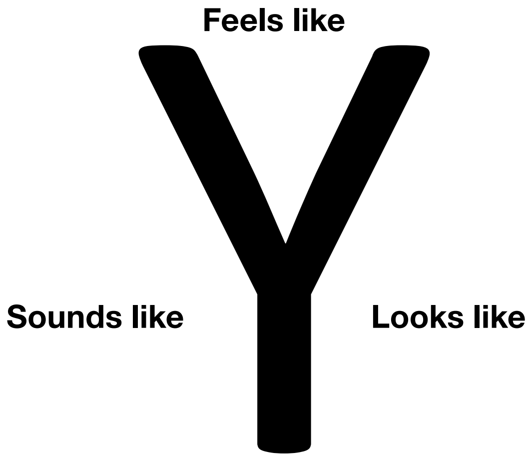
When the cyclone eye passes over, there is a calm period, a lull, which may last up to two hours. The other side of the cyclone then hits and winds resume with equal strength but blowing from the other direction. It is vitally important to remain inside during and after the eye passes.

Teaching and learning strategies – 9

Students could brainstorm the types of damage likely to occur in their village or town.

9.1. Y-charts

Some students will have experienced a cyclone, most of them will have experienced a severe storm. Ask students in groups to draw a large Y on a piece of paper and label it as in the diagram.



Students can write in the gaps what they think they would / did see, hear and feel during a cyclone or severe storm. They could use another colour pen to then add what they might see, hear and feel when they step outside after the cyclone or storm.

Each group can then talk about their responses with the class.

9.2. Sequencing

Putting a jumbled set of steps into the correct order requires students to read for meaning. The sequence of a cyclone is given below. The steps could be written on the board in the incorrect order or copied onto recycled paper and cut into single sentences or printed out with double spacing between the lines and then cut up and each set placed in an old envelope. Whichever method you use, ask the students to put the sentences in the correct order.

Sentences for sequencing: Cyclones

- There are times when the air rising over the warm regions of ocean can form areas of extreme low pressure.
- This happens when the sea temperatures are above $26.5^{o}C$.
- The convection currents start spiralling around this low-pressure centre, causing rotation.
- The winds spiral clockwise towards the centre of the low-pressure area, picking up more moisture from the sea.
- At the centre, the air rises upwards, with the water vapour condensing to give high cloud formations and heavy rainfall.
- As long as the low-pressure centre remains over the warm ocean, there will always be energy to continue feeding the system.
- The amount of water in the system builds up and wind and rain intensify and the system becomes a tropical cyclone.
- When the tropical cyclone has moved over land or cooler water, there is no energy to feed the system and the cyclone will die away.
- In the meantime, the amount of energy and rain can do a great deal of damage.

(Adapted from SEREAD)

Picture 10 – Pasifika during a drought

This picture shows Pasifika during a drought. What are the effects of the drought? Can they make links to their own village and talk about similar consequences?

Possible student learning outcomes: Students will be able to….	Teaching and learning activities
• identify probable outcomes of a drought; • identify possible risks in their own community; • identify some measures that their community could take to reduce the likelihood of damage.	Picture interpretation with guiding questions Consequence wheel

Discussion

Once the students have established the effects of a drought, they can discuss how the village could have prepared itself for the drought and prevented some of the damage.

- What are some of the effects of the drought that you can see in the picture?
- Do you think all people are affected in the same way by the drought? (Get your students thinking about gender, age and disability.)
- What could have been put in place to reduce the risks and be better prepared?

Ask students to think about the consequences of a drought in their village. What measures could they take to counteract or prepare for the expected effects? Make a list. Have the groups compare lists.

Drought

A drought is a long period with no rain during a time when rain would be expected. It results in reduced groundwater, and a shortage of water for drinking, sanitation and watering plants. It is a slow-onset phenomenon – which means it does not happen suddenly, caused by one single event like a storm or cyclone, but emerges gradually over time. People might notice it too late and early warnings are not always issued.

The consequences of a long drought vary in different regions. Crops always suffer, causing food shortages that continue after the drought has ended. In some places, forest fire is a likely consequence of a drought. Lack of fresh water is the most serious issue for small Pacific islands. Keeping sufficient water clean in water tanks can be a problem. Many houses do not have their own water tanks and are dependent on well water which may become brackish or run dry.

Bottled water and desalinator plants can be flown in but that is costly and increases waste. Desalinator plants mostly use diesel fuel.

Predictions for the future suggest there are likely to be more periods of drought in many countries because the rainfall is likely to come in more severe events rather than being spread throughout the year. Much of the water coming from heavy rain will flow into the sea rather than being stored on land. More days of excessive heat – higher temperatures for longer periods – will cause water from the land to evaporate. The availability of water and the likelihood of forest fires depend to a large extent on people behaving responsibly.

(SPREP 2012 and IFRC 2013)

How to prepare for a drought and reduce possible effects

- Be aware of weather forecasts (radio, newspaper, television, traditional knowledge).
- Cover wells and keep rubbish and livestock away to prevent evaporation and contamination.
- Protect water catchment areas: do not litter; If you cut trees down, make sure you re-plant; don’t build in these areas, if possible.
- Ration water during a drought (two litres/adult person/day) and food (2,100 calories/adult person/day).
- Preserve and store food (a combination of a basic staple such as rice, taro, wheat flour; a concentrated source of energy (oil or another fat) and a concentrated source of protein, such as legumes (beans, peas, lentils) or preserved fish. Fruits and vegetables can be preserved as well.
- Inspect pipes and outdoor taps for leaks, and repair them.
- Harvest rainwater from suitable roofs in tanks and keep roofs, gutters and tanks clean. (Note: the water may need purification treatment before it is safe to drink.)
- Use alternatives to water (e.g. sand for washing the dishes).
- Recycle household ‘grey water’ (used water, such as the washing-up water) for the toilet, and for irrigation and home gardens.
- Look after livestock (especially females and their young).
- Conserve water at home, for example:
    - ➢ turn off taps when brushing teeth or shaving;
    - ➢ take shorter showers;
    - ➢ clean vegetables in a basin rather than under running water;
    - ➢ install composting toilets or low-volume toilets;
    - ➢ wash dishes using two basins rather than doing it under running water;
    - ➢ in washing machines, match the load setting to the amount of laundry, or wash full loads only.

(IFRC 2013)

Teaching and learning strategies – 10

10.1 A consequence wheel

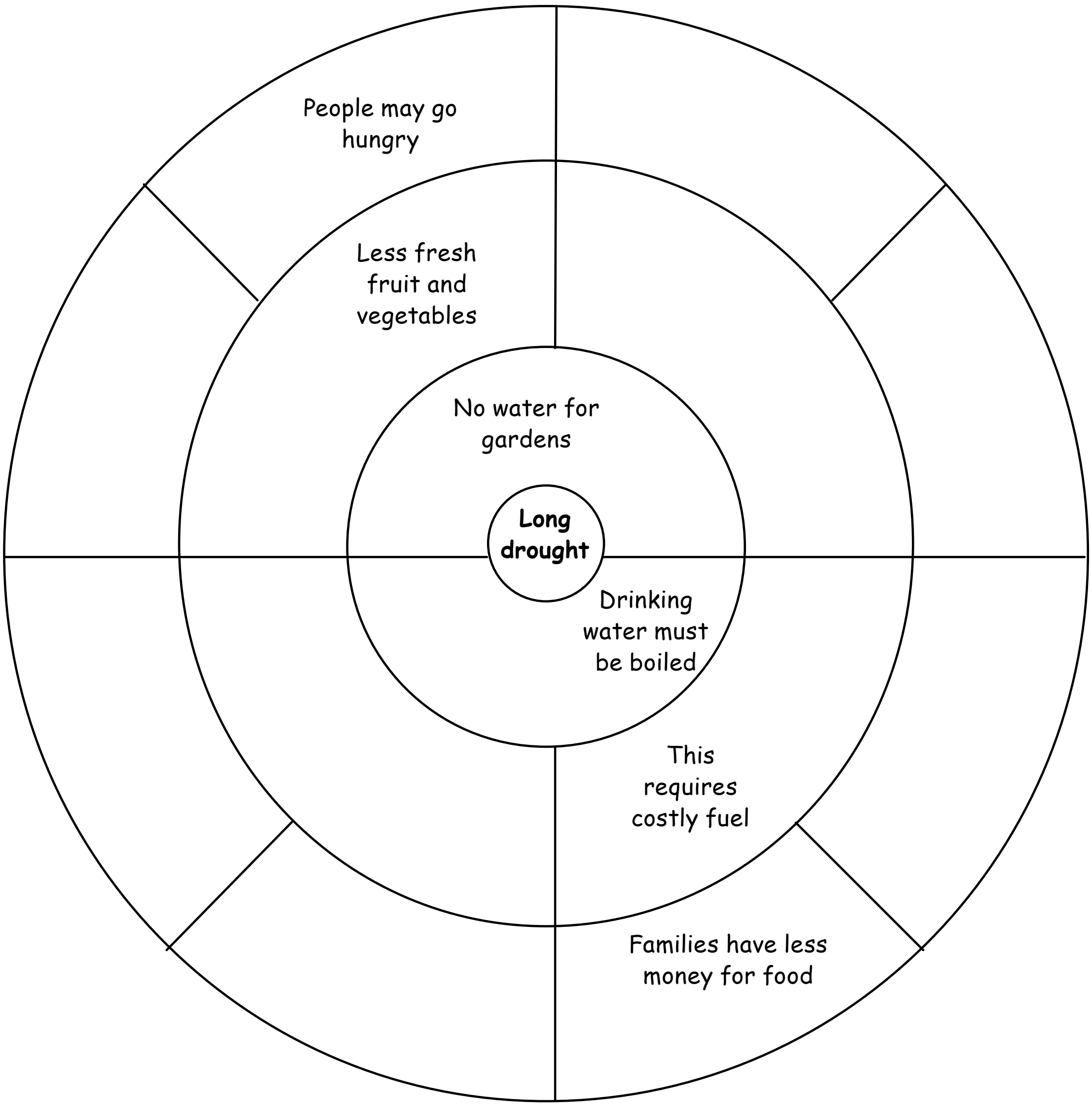
Students use a consequence wheel by writing an event in the centre, and then writing consequences of this event in the surrounding two spaces. Consequences arising from these go in the next four spaces and so on until the wheel is complete. More layers may be added. Students can draw their wheels on scrap paper to start with. They could then make good copies as posters.

If the centre was filled in with **Long drought,** there will be many consequences.

- Drinking water must be boiled ➔ This requires costly fuel for boiling the water ➔ Families have less money for food
- No water for gardens ➔ Less fresh fruit and vegetables ➔ People may go hungry

This exercise can be put into local context by asking the students to think about the consequences in their own community.

This exercise can be used for other events. Where appropriate, you can make each consequence lead to a positive and a negative consequence; this helps students focus their thoughts.



(Adapted from SEREAD)

Picture 11 – Adaptation and mitigation

The pictures show actions that are mitigating, actions that are adaptive and actions that fit into both categories. **Mitigation** refers to efforts to reduce the levels of greenhouse gases in the atmosphere, either by limiting the sources or by enhancing the sinks. **Adaptations** are actions that are taken to moderate harm or explore potential benefits of climate change for sustainable development. Students will need to use these terms in several different activities to be confident in their meaning.

Possible student learning outcomes **Students will be able to….**	**Teaching and learning activities**
• differentiate between adaptation and mitigation actions; • work in a group to plan a possible adaptation or mitigation action; • implement a group or individual action.	Discussion based on picture interpretation Planning an action

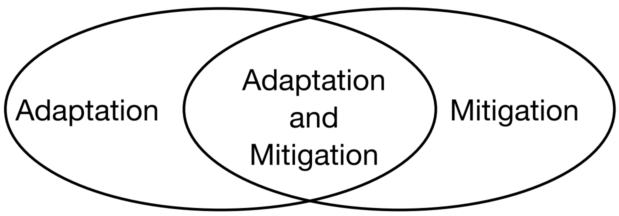
Discussion

Questions for your students:

- Can you name all the actions in Picture 11?
- Can you explain how each mitigation action reduces the levels of GHGs?
- Can you explain how each adaptation reduces the effects?
- Can you explain the actions that are in the centre of the picture?

In groups, ask students to brainstorm some ideas about adaptation and/or mitigation activities at a personal, community and national level. You can then get them to categorise their ideas and introduce a Venn diagram as an effective tool.

Remind them of the cyclone and drought pictures – what could be done to reduce the effects? You can also introduce them to pictures 12 to 16 that all show adaptation and mitigation in different contexts: gardening, livestock, forestry, fishing and living in the town.



Remind students about reduce, reuse, recycle. Ask them to come up with other re-words about actions they could take (e.g. refuse, redesign, repair). Are they adaptation or mitigation actions? Or both? Reinforce the idea that the first steps start with each individual. What could students do to reduce, reuse or recycle? This can lead to taking action for climate change – individual and/or group. The reduction, reusing and recycling of what would otherwise be thrown away as waste is a mitigation action because it reduces emissions of carbon dioxide (CO_2), nitrous oxide (N_2O) and methane (CH_4). Composting organic waste improves the retention of carbon in the soil profile. If we protect our environment from pollution and waste, this is an adaptation. We reduce the stress on ecosystems and increase their resilience to climate change.

We can reduce our carbon dioxide emissions by using less fossil fuel through such measures as walking or riding instead of travelling by car, and saving electricity by using energy efficient appliances and lights, closing windows and doors of rooms being air-conditioned, and turning out the lights when no longer needed.

Adaptation: Making changes in order to reduce the vulnerability of a community, society or system to the negative effects of climate change, or make the most of potential positive effects. It includes building skills and knowledge, as well as making practical changes, such as strengthening coastal infrastructure, adjusting farming systems, and improving water management (Adapted from SPREP 2012).

Mitigation of emissions: Efforts to reduce the levels of greenhouse gases in the atmosphere, either by limiting the sources or by enhancing the sinks. Examples include using fossil fuels more efficiently, switching to renewable energy sources such as solar energy and hydro-power, and expanding forests and other sinks to remove greater amounts of carbon dioxide from the atmosphere (Adapted from SPREP 2012).

Teaching and learning strategies - 11

11.1 - Planning an action

Students can usually come up with ideas but working out how to put them into practice is harder. In groups, students list some actions the whole class could take. These could be **mitigation activities** (turning off lights, walking instead of going by car, planting trees), **adaptation actions** (planting a garden, using cloth shopping bags instead of plastic) or **risk reduction actions** (planting mangroves, develop an emergency plan for the school).

Then they need to consider how they can prioritise their ideas to come up with one action that is possible and will have an effect.

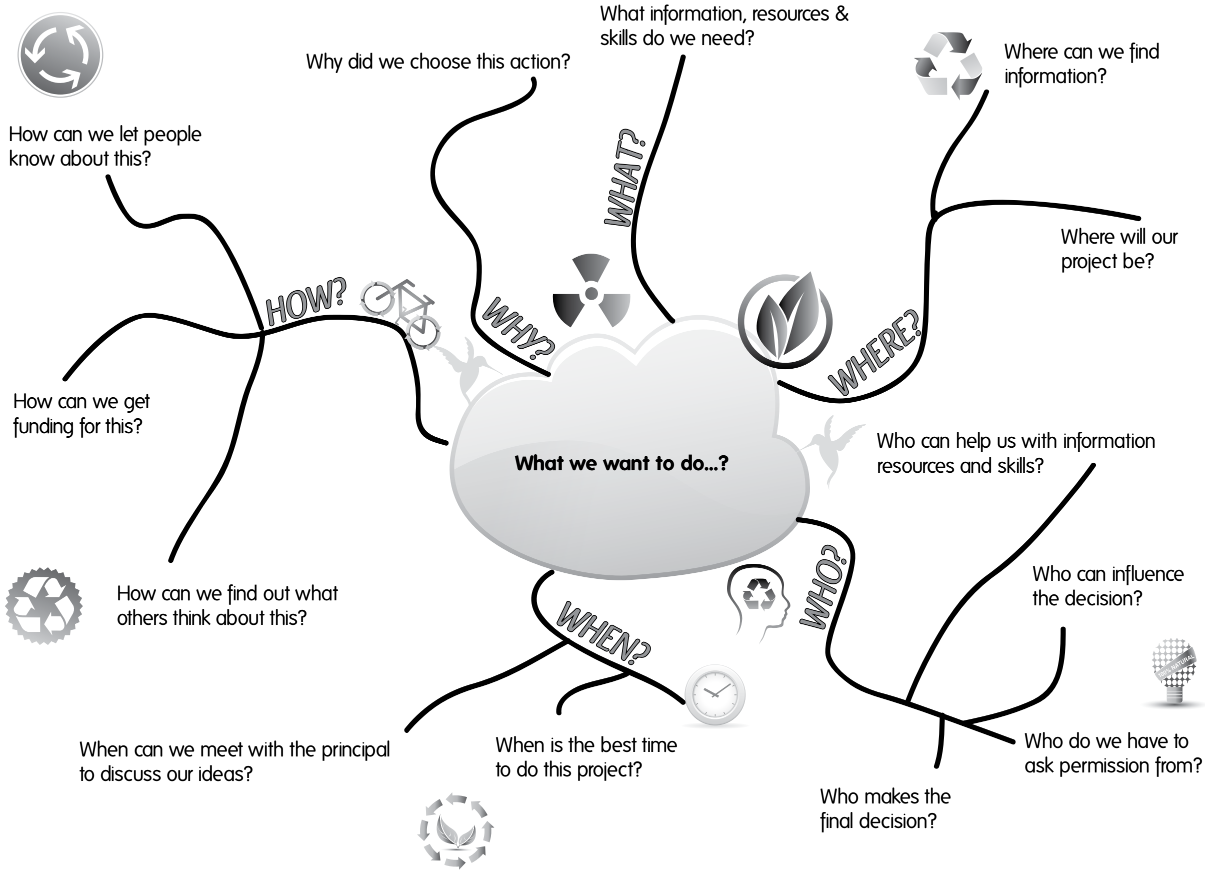
- Whose permission would they need?
- Who should be involved?
- What resources are needed (funds, materials, labour, equipment)?
- Who could help them with funds, materials and equipment?
- What skills would they need?
- Is there anyone in their community who could help?
- Who would benefit? (Try to get your students to consider all groups in society, e.g. the elderly, men and women, persons with disabilities.)
- Are there any risks involved in taking this action? Would it be safe in cyclone or drought conditions?
- Is there any potential harm to someone or something when the idea is put into practice? (This can help in prioritising ideas and ensuring no harm is done unintentionally.)
- How long would it take?
- What else do they need to research about their action?

Give students time to research answers in their groups, before making a decision on a class action.

It can be helpful to allocate values to the actions:
1 = very difficult (expensive, needs lots of skills, there's no help, etc.)
2 = moderate
3 = easy/best (cheap, low skills, etc.)

If each group does this for each proposed action, they can use the scores to decide which action to carry out. Different roles can then be allocated to each group or to students with specific skills, (e.g. research, fund-raising, writing letters, planning, and measuring out land). These will depend on the action, such as planting a vegetable garden, putting in a water tank, putting on a play for the community, etc. Picture 12 may give some useful suggestions.

Action planning template: Example 1



(Adapted from TKI)

Action planning template: Example 2

What's the issue?
(the effects of climate change)

What do we want to achieve?
(something to bring about adaptation, mitigation or risk reduction)

ACTION

What are we going to do?

Plan:
What?
When?
Where?
Who?

What skills and resources will we need?

What information do we need and where will we find it?

How will we find out what people think and feel about the issue and action?

How can we make people aware of the benefits of our action?

How will we get support for our action?

Evaluation
How successful was our action?

Picture 12 – Gardening and livestock

This picture has people carrying out gardening and livestock care practices – planting a wide range of crop varieties that are tolerant to drought, salt, heat or heavy rain, using sustainable practices such as conserving water, composting, using traditional tools and methods, and providing protection for their crops and animals against drought and cyclone or severe storm.

Possible student learning outcomes **Students will be able to….**	**Teaching and learning activities**
• identify a range of sustainable agricultural and horticultural practices; • explain one sustainable practice in detail.	Discussion and picture interpretation Home and expert School gardening

Discussion

You can ask the students to look closely at Picture 12 and answer the following questions.

- What crops, fruits and livestock do they recognise?
- What practices can students identify that they know and that they don't know?
- Are the practices different from what they know?
- Why might it be better to grow different species of banana or taro, for example? (Some species are more salt tolerant; others need less water. Some can withstand wide ranges of temperature and will withstand the extremely hot days. Some are more flexible and will bounce back after cyclone winds.)

This picture could be used with Pictures 13, 14 and 15 as the stimulus for a 'Home and expert' activity so students can research the changes. Discuss how these activities can be actions for both adaptation and mitigation.

Gardening and livestock in the Pacific Island region

Many families depend on growing roots crops in their gardens and smallholdings – the roots and leaves provide valuable energy, nutrients, fibre, calcium, iron, Vitamins A, C,and B1.

- Taro *(Colocasia esulenta)* – known as *dalo* in Fijian*, te taororo* in Kiribati*, talo* in Samoa and Tonga and *aelan taro* in Vanuatu
- Giant swamp taro *(Cyrtosperma chamissonis)* – known as *via kan* in Fiji, *te babai* in Kiribati, *pulu'a* in Samoa and *navia* in Vanuatu
- Giant taro *(Alocasia macrorrhiza)* – known as *via* in Fiji, *te kabe* in Kiribati, *ta'amu* in Samoa*, kape* in Tonga and *pia* in Vanuatu
- Tannia *(Canthosoma sagittifolium)* - known as *te tannia* in Kiribati, *talo palagi* in Samoa, *dryland taro* or *talo futuna* in Tonga and *taro Fiji* in Samoa
- Cassava *(Manihot esculenta)* – known as *tapioca* or *tavioka* in Fiji*, manioka* in Samoa and *manioc* in Vanuatu
- Sweet potato *(Ipomoea batatas)* – known as *kumala* in Fiji and Tonga, *umala* in Samoa and *kumwara* in Kiribati
- Yam (Dioscorea family) – known as *uvi* in Fiji and *ufi* in Samoa.

In many countries, taro is one of the most common and popular root crops and a mainstay of Pacific Island cultures. It is considered a prestige crop and is used for traditional feasts, gifts and for fulfilling social obligations. Other important ground crops include sugar cane, hibiscus spinach, pumpkin, pineapple, maize, chilli peppers, cabbages and beans. For traditional practices kava *(Piper methysticum)* and tobacco are grown. To weave traditional mats, produce tapas, jewellery and other handicrafts, paper mulberry *(Broussonetia papyrifera)*, coconut and various Pandanus cultivars are very important species.

Livestock production is important for protein and income. Throughout the Pacific region, chickens and pigs are raised for small-scale consumption. In larger countries like Fiji, Samoa, Tonga and Vanuatu, pigs and poultry, as well as cattle, sheep and goats, are produced commercially. The quality of pasture is usually poor as it is unimproved and poorly managed.

Agriculture, harvesting wild growing fruits, nuts and crops, and livestock are crucial for subsistence and commercial use – agriculture is also the backbone of many economies (e.g. copra and sugar production).

(FAO 2010)

How climate change affects gardening and livestock

- Increases in the intensity and frequency of droughts and floods are posing a risk to livestock and crops.
- Productivity declines due to heat stress, drought conditions, water-logging, increased flooding and/or soil erosion and accelerated nutrient loss.
- Higher temperatures and changes in rainfall patterns and wind direction can lead to outbreaks of pests and diseases (even those that were not known previously).
- Sea-level rise, combined with drought and potential overuse of fresh water, results in salt water intrusion. The water gets brackish and eventually fresh water lenses are contaminated. If no proper sanitation and sewage systems are in place, this risk is even higher. This can result in a lack of fresh water for plants and animals and a decrease in yields and productivity.
- Increased temperatures and extreme rainfall patterns alter the soil structure, easily triggering erosion and accelerating the loss of nutrients – the productivity of soil decreases.

Some emission mitigation and adaptation actions that are being developed in Pacific countries and that everybody can contribute to:

- planting a range of different types of vegetables and food crops in your garden. If one crop or vegetable is destroyed, there are others to be eaten (adaptation);
- planting a variety of crops, including selected types of yam, taro, kumala and cabbage that can withstand very hot days, long periods of drought, salt-water and excessive rainfall that leads to flooding (adaptation);
- choosing varieties of yam, banana and kumala that can propagate quickly because they generate many shoots from the mother plant (adaptation);
- planting trees and shrubs along contour lines for better erosion control on slopes (adaptation and mitigation);
- making compost from leaves and vegetable and fruit remains, as this reduces emissions (mitigation) and makes the soil more fertile (adaptation);
- drying fruits and vegetables such as manioc, bananas and kumala using solar power. Such sun-dried produce can be sold to generate income (adaptation and mitigation);
- adjusting current methods and times of planting and growing water melon, cucumber, tomato and other species to a more variable, hotter climate (adaptation);
- making compost from crown of thorns starfish (threatens reefs), using this compost both as a fertiliser and in composting toilets (adaptation example from Vanuatu);
- protecting your livestock animals from heavy rainfall, flooding, storm, direct sun radiation and drought by providing them with shelter (in case of storm), shade (roof or trees) and fresh drinking water (adaptation);
- cross-breeding local pigs with foreign pigs to produce varieties that can withstand warmer, drier conditions and at the same time produce more meat (adaptation);
- improving the husbandry of honey bees so that they can flourish in warmer, more extreme conditions (adaptation example from Vanuatu);
- not using too much fertiliser and, if needed, opting for organic fertilisers (mitigation);
- using solar water heating, solar food driers and solar panels (PV) for lighting;
- using biogas instead of wood as fuel, or closed fire ovens instead of an open fire in villages (mitigation).

(FAO 2010; SPC/GIZ 2012; SPC/GIZ; Sansom 2012; VMGD 2013)

Teaching and learning strategies - 12

12.1. Home and expert

This strategy could be used with the individual pictures or with Pictures 12, 13, 14 and 15.

1. Number the students in the class 1, 2, 3, 4, 1, 2, 3 etc. until everybody has a number. Ask them to form themselves into home groups, each group containing one 1, one 2, one 3 and one 4.
2. Ask all the 1s to go to one corner at the back of the room, the 2s to the opposite corner, the 3s to a corner at the front and the 4s to the opposite corner.
3. Give the 1s picture 12 and the 2s Picture 13. Give them Picture 1 as well, so they can compare how it is different from their Picture 12 or 13.
4. Give the 3s Picture 14 and the 4s Picture 15.
5. Each group is to research the practices they can identify, discussing whether they are good or bad practices and why. Set them a reasonable time limit to have one A4 page of notes about their picture.
6. Each member of the group then has to become an 'expert' on the practices in their picture, so they will need to teach each other.
7. Students then go back to their home groups and teach each other about what is happening in their picture. They have become 'expert' about the recommended practices in one area and know some facts about recommended good practices in the other three pictures.
   (Adapted from SEREAD)

12.2. School gardening

Students can identify and plant crops and fruits on the school grounds, so they can harvest and eat them within a year.

1. Guide the students to an area in the school ground where they can create a garden.
2. Students can interview elders about what crops and fruits grow well. They can also approach an agriculture extension officer or the closest agriculture department for recommendations and sources of seeds.
3. Take a guided tour of a successful local garden to show practical ways of planting.
4. Students can be asked to list the crop and fruit species and collect additional information on a table like the one below.

Name of crop or fruit (local, English or French)	When is a good time for planting?	When is the fruiting and harvesting season?	Where can we get seedlings?	Were changes in fruiting and harvesting seasons observed?
Taro		.		
Coconut				
Etc.				

5. Seedlings can be donated, or purchased, or collected by students at home.
6. Students plant crops and fruits with advice on the best place, planting season and technique.
7. Plants need to be looked after and watered regularly. Students can organise themselves in shifts (three or four each day) or they can adopt certain plants or garden plots.
8. Students can harvest crops and plants and prepare their own food.

Picture 13 – Forestry and agro-forestry

This picture shows practices in forestry and agro-forestry that absorb carbon from the atmosphere (mitigate emissions), conserve resources, prevent erosion and make the forests, crop production and animal husbandry more sustainable (adaptation to climate change).

Possible student learning outcomes Students will be able to….	Teaching and learning activities
• identify a range of sustainable forestry practices; • explain one sustainable practice in detail.	Discussion and picture interpretation with guiding questions

Discussion

You can ask the students to look closely at Picture 13 and answer these questions:

- Which trees, fruits, crops and livestock can you identify?
- What practices can you identify that you know and that you don't know?
- Are any of the practices done in your community?
- Why might it be better to plant crops underneath trees? (Trees provide shade and reduce evaporation, thereby keeping more water in the soil. Roots can also help in retaining water. They protect the soil from erosion during heavy rain, so nutrients are kept in the soil.)
- How does planting trees help in reducing emissions? (Trees need carbon dioxide to grow/for photosynthesis and are an important carbon sink.)
- What other benefits can you identify from planting trees? (They provide shade for livestock and help to mimimise erosion on slopes and on coasts. They provide firewood, fruits and logs for building houses and furniture, etc. They are important for our islands' biodiversity, our birds, insects and plants.)

This picture could be used with Pictures 12, 14 and 15 as the stimulus for a Home and expert activity so students can research the differences. Discuss how these activities can be actions for both adaptation and mitigation.

Forests and biodiversity

Apart from releasing more carbon dioxide into our atmosphere and enhancing the greenhouse effect, the cutting down and burning of forests and trees also affects our environment.

- Trees and forests provide an important habitat for various plant and animal species. Cutting down forests reduces this variety and number and contributes to a loss of biodiversity.
- Forests play a vital role in water catchments, as they help keep fresh water in the soil, they reduce evaporation and they prevent soil erosion.

How forests help reduce greenhouse gases in our atmosphere

Plants, particularly trees, need carbon to grow. When we plant new trees (through afforestation and/or reforestation) we remove carbon dioxide from the atmosphere (carbon sequestration), because forests take in a lot of carbon to build new cells.

When we cut down trees and leave them to decay, they emit gases, including two greenhouse gases —carbon dioxide and methane. The accumulation of these two gases in the atmosphere contributes to the greenhouse effect and thus to global warming.

When we conserve forests, reduce deforestation and forest degradation, and manage our forests in a more sustainable way, we reduce the emissions of greenhouse gases.

Reducing emissions from deforestation and forest degradation
In forest-rich Pacific Island countries such as Fiji and Vanuatu, new forest and mitigation projects have begun, such as Reducing Emissions from Deforestation and Forest Degradation (REDD) and Clean Development Mechanisms (CDM) projects. Their basic idea is to reduce carbon dioxide emissions and increase the sequestration of carbon. The main activities that are promoted are to reduce emissions from deforestation and forest degradation, conserve forests, manage forests sustainably and enhance the carbon stock.

Table 13.1: Typically utilised species in agroforestry systems

Agroforestry crops		Fruit tree species		Tree crops and other trees
Taro Giant taro Xanthosoma taro Cassava Sweet potato Pineapple Sugarcane Hibiscus spinach Pumpkin	Maize Chili peppers Cabbages Beans Kava Tobacco Coffee Cacao	Banana Citrus trees Pawpaw Mangoes Avocado Papaya Soursop Sweetsop	Carambola Pandanus Malay/ mountain apple Vi-apple Edible figs Dragon plum Oceanic litchi	Breadfruit trees Coconut palms Sago palms Nut trees Betelnut (Areca) other palms

FAO 2010

Forests and food production
Many Pacific communities harvest and plant tree species, both for subsistence and commercial use.

'In the Pacific region, farmers who practise agroforestry grow crops … with fruit trees … and tree crops. This provides them with different kinds of food throughout the year. Planting crops and trees together keeps the soil healthy and prevents it from being washed away into the sea or rivers, where it muddies the water and destroys the homes of the fish and other creatures that live there.

'An agroforestry farm has fewer pests and diseases than a farm with only one crop. If only one crop is planted, the insects feeding on this crop spread very fast. But if there are many different crops and trees planted together, it is more difficult for the pests to find the crop they want to feed off. Farmers can also get firewood and other wood products from an agroforestry farm so they do not need to cut down the forests unnecessarily' (Sansom 2012:20).

Also, pigs and chickens or other livestock can be kept underneath trees to protect them from sun radiation, heavy rain or other severe conditions (typically under coconut plantations).

How climate change affects forests

- Higher temperatures will make forests more vulnerable to fires.
- Changes in water levels in the soil, temperature and CO_2 concentrations can affect photosynthetic efficiency and tree growth.
- Higher temperatures and changes in rainfall patterns may lead to increased occurrence of invasive species and pests.
- Forest health could be damaged by salt water intrusion, coastal and river bank erosion and exposure to salt water sprays and heat stress on soils.
- Floods, droughts and cyclones may physically damage forest plantations, natural forest and associated infrastructure.
- Loss of arable land due to climate change places added deforestation pressure on forest areas.

Pacific Island countries promote agroforestry, afforestation and erosion control to help our forests adapt to the effects of climate change and to remove carbon dioxide from the atmosphere. On slopes, the roots of plants help to prevent possible landslides as a result of heavy rain and cyclones (that are related to climate), and also due to earthquakes or volcanic eruptions (that are related to tectonic processes inside the earth).

Some emission mitigation and adaptation actions that are being developed by Pacific countries and that everybody can contribute to:

- preventing the conversion of forestland to other land use types (like completely clearing a forest for agriculture);
- reducing the degradation and destructive utilisation of our forests, (e.g. practising fewer destructive logging practices);
- conserving old and high value forests;
- practising agroforestry by growing crops and vegetables with different kinds of trees;
- planting strong-smelling vegetables such as onion, garlic and coriander, and strong-smelling flowers and plants such as marigold, basil, lemon grass and island musk (*uhi* in Tongan, *uci* in Fijan and *usi* in Samoan) to help protect your trees and crops against pests and harmful insects;
- Practising alley cropping – alternating belts of forest and fruit tree species and root crops;
- planting and replanting trees;
- when planting on slopes, removing as little vegetation as possible;
- eliminating invasive weeds to reduce forest degradation;
- planting selected tree, shrub and grass species on slopes and coasts, (e.g. mangroves in suitable areas);
- promoting more forest nurseries in rural areas;
- not burning wood, roots and leaves. using leaves for composting purposes instead. Additional benefits such as better soil outweigh the increase in carbon dioxide originating from decomposition;
- promoting sustainable agriculture and forestry practices and sustainable land management technologies to ease the pressure off forest areas.

(GoF2012;FAO2010;SPC/GIZ2012;Sansom2012;GoT2010.)

Teaching and learning activities – 13

13.1 Home and expert
Students form groups and do the same exercise as for Picture 12.

13.2. Identify and plant trees, shrubs and/or grass
Students can identify and plant trees, shrubs or grass species as a practical outdoor exercise (either as part of the classroom syllabus or as an extra-curricular activity).

1. Ask the students to identify an area in which the class or school wants to plant trees, shrubs, grasses and perhaps crops. This could be the school compound, a hill slope or a coastal area.
2. Ensure that the community gives permission for the planting project.
3. Students can interview elders about what plant species grow well in the selected area. They should also approach a forestry extension officer or the closest forestry department for recommendations. Look for a local expert who is keen to provide a guided tour to learn more about local trees and forests.
4. Students can be asked to list the species and collect additional information in a table like the one below/

Name of tree/ shrub/grass species (local, English or French)	Where does it grow best? (e.g. hill slope, plains, lagoon side /ocean side, forest)	What part of the tree/shrub/grass can be used and for what purpose?	Planting time	Fruiting and harvesting time, where applicable
Breadfruit	Can grow well in our village and gardens	Breadfruit for eating Wood for construction of houses		
Coconut	Lagoon side and ocean side	Coconut for eating its flesh and coconut milk Coconut shells for jewellery and *kava* bowls Leaves for mat weaving Wood for construction of houses Bark for.... Etc.		

5. Seedlings can be donated or purchased, or students can collect them. (On Tarawa, for example, the seedlings for mangrove planting were collected by students themselves in a dense mangrove area. In Tonga, the Department of Forestry advised what species to plant and climate change programmes donated seedlings.)
6. Students plant seedlings. Perhaps the forest officer or local expert can volunteer to advise them on the best place, planting season and technique.
7. Check on the well-being of the newly planted trees on a regular basis, water them and protect them from damage. It is a good idea to ask students to adopt one of the trees (in pairs).

Picture 14 – Fishing

The upper right-hand corner of this picture shows traditional and modern practices of fishing that are sustainable and protect marine and fresh water ecosystems, (e.g. the hand collection of seafood during low tide, cast nets that are used commonly for bait fish, spearfishing). The lower left-hand corner shows unsustainable practices, such as dynamite fishing, the use of large nets inside the reef, and dumping rubbish and sewage into the reef area. Students living in coastal villages may have many questions about these things. Examples of aquaculture on land are also shown.

Possible student learning outcomes **Students will be able to....**	**Teaching and learning activities**
• identify a range of sustainable fishing practices; • explain one sustainable fishing practice in detail; • explain how climate change can affect reefs; • explain why one fishing practice is unsustainable.	Questions about fishing and seafood with picture interpretation Home and expert Who am I? One fish, two fish, red fish, few fish Discover marine species Protected area activities

Discussion

Marine ecosystems and fishing

- How often do you eat seafood?
- What type of seafood do you eat?
- Where does the seafood come from?
- What type of fishing techniques do you see in Picture 14?
- Do you go fishing yourself? With whom? (mother, father, friends) Where? (ocean, lagoon, reef, river, estuary...)
- How do you fish and what do you catch?

Ocean acidification and coral bleaching
Look at the background information for Picture 7. If you use Pictures 14 and 7 together, you can discuss the impacts of climate change on fisheries.

- Why are coral reefs important?
- How do you feel about the threat to coral reefs?
- What would change in your community if you didn't have coral reefs?
- What changes could your community make so that it could survive without coral reefs? (Findlay and Hinge 2010).
- What could your community do to keep the coral reef healthy?

What is seafood?
Sea food is food we eat that comes from the sea. There are, of course, also creatures in the sea that we would rather not eat. Scientists summarise them all together as 'marine life', shown in Table 14.1 and Figure 14.1.

Traditionally, seafood has been the most important source of protein for people living on Pacific islands. There are many different traditional fishing techniques, and men and women, as well as youth, are involved in fishing.

Seafood is one of the most important natural resources for commercial exploitation in Pacific Island countries, especially tuna fish, which is in great demand from foreign fishing fleets from the USA, Japan, the People's Republic of China, Korea and Spain. The governments of Pacific Island countries sell fishing licences that allow foreign fleets to fish in their exclusive economic zones (EEZs). Commercial fishing is done with vessels that catch the fish on long lines with many hooks or with enormously big nets (purse-seine vessels). The fossil fuel used by vessels and motor boats contributes to the emission of carbon dioxide; 2.3% of global emissions come from railways and shipping.

Mangroves and coral reefs
Mangrove forests are of great importance as fishing grounds for coastal communities, and coral, shells and pearls are used for jewellery. Tourists from all over the world are attracted to the beauty of coral reefs. At the same time, coral reefs and mangroves are of great importance for biodiversity because their diversity and density of species is very high. Both types of ecosystems are sensitive and it is important to protect them from pollution, damage and over-exploitation.

Volcanic islands, such as Fiji, Samoa, Solomon Islands and Vanuatu, have rivers and creeks in which men, women and children go fishing for freshwater fish, mussels and snails.

Fish farming
Recently, fish ponds have been built along fresh water streams on volcanic islands and in sandy areas on atoll islands. New species have been introduced; tilapia in many Pacific countries and trout in the highlands of Papua New Guinea are two examples. It is still under discussion whether the introduction of new fish species into fresh water streams is beneficial enough to outweigh the ecological costs. In Kiribati, for example, tilapia is not recommended but milkfish is. However, there is no doubt that fish raised and harvested from ponds is beneficial for generating income and food.

(Adapted from King 2004)

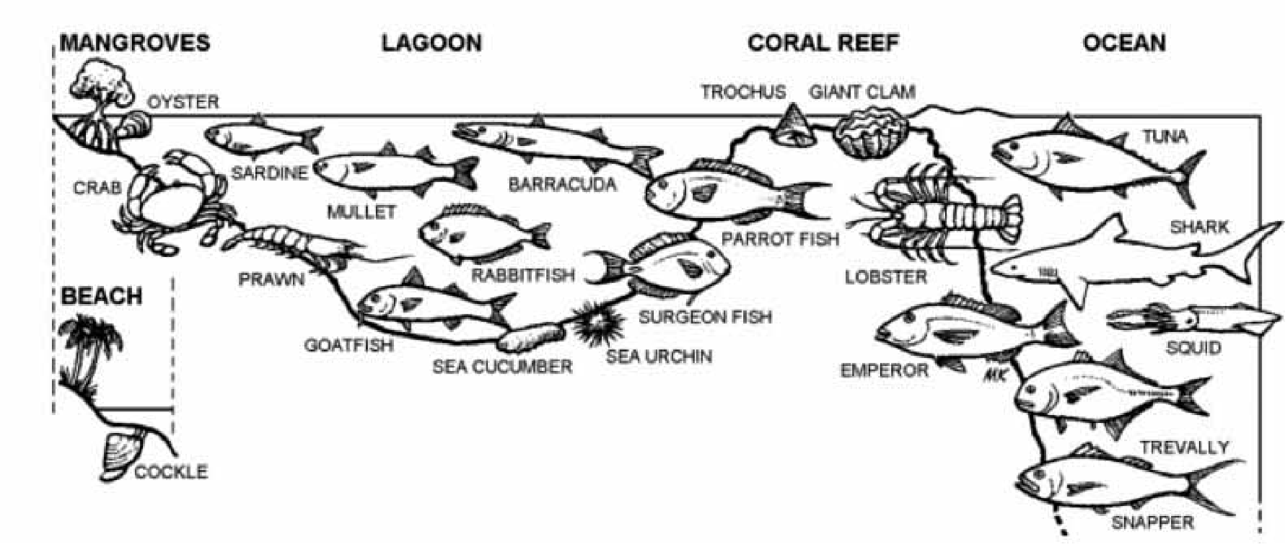


Figure 14.1: A profile of the coast of a high island showing the ocean, barrier coral reef, lagoon and either a mangrove forest (above) or a sandy beach (below) (King 2004)

Table 14.1: Forms of marine life

Forms of marine life (*phylum*)	Families
crustaceans	shrimps, prawns, lobsters, crabs
molluscs	clams, oysters, mussels, sea snails, octopuses, sea worms
echinoderms	sea urchins, sea cucumbers, sea stars
fish	inshore fishes (e.g. milkfish and rabbitfish), coral reef fishes (e.g. groupers or parrotfish) and offshore fish (e.g. tuna, mahi-mahi and trevally)
other marine vertebrates	snakes, turtles, dugongs, whales, sharks
plants	mangroves, sea lettuce
algae	seaweeds
birds	e.g. tern, noddy, frigate bird

Marine habitats
Different species usually have a preferred marine environment in which they live. In the Pacific islands, these environments are typically: mangrove forest, sandy beach, lagoon, barrier coral reef, sea grass, tidal flats and the open ocean (see Figure 14.1).

Mangroves and sea grasses are of special interest to coastal fisheries worldwide because of the role they play in providing nursery areas for commonly harvested fish and invertebrates, as well as providing feeding habitats for many species of adult demersal fish, some of which reside on reefs during the day and forage over sea grasses and intertidal flats at night. Sea grasses and intertidal flats are also permanent habitats for several species of sea cucumbers, the main group of invertebrates eaten and targeted as an export commodity in the region, and for a wide range of molluscs collected for subsistence.

Increases in the turbidity [muddiness] of coastal waters and higher rates of sedimentation, resulting from poor land management in the catchments of high islands, are reducing the area and health of sea grass habitats. Further losses are expected to occur as a result of greater heat stress, increased sedimentation and turbidity due to higher rates of run-off, changes in suitable sites for growth of mangroves and sea grasses due to rising sea levels, and possibly more physical damage from the combination of sea-level rise and more severe cyclones and storms.

(King 2004)

The effects of climate change
Climate change will have effects on coastal, ocean and freshwater fishing in many ways. The most important are listed below.

- Higher ocean temperatures will lead to more frequent coral bleaching.
- Increasing the acidity of ocean water will cause coral reefs, crustaceans and molluscs to have weaker or damaged skeletons and shells.
- More severe storms and cyclones will cause physical damage to coral reefs.
- Higher sea-surface temperatures will increase the risk of fish and invertebrates being exposed to diseases.
- Changes to coral reefs (more dead coral and seaweed) will increase the incidence of ciguatera fish poisoning.
- Alterations in ocean temperatures, currents and food chains are projected to affect the location and abundance of tuna species that will be increasingly required to support food security and livelihoods of coastal communities. (In Kiribati it is expected that there will be more skipjack tuna!)
- Higher water temperatures and ocean acidification are expected to reduce the efficiency of most coastal aquaculture operations.
- Increased rainfall will increase river flows and the extent of floodplain fish habitats, improving conditions for the life cycle of many freshwater fish species and increasing freshwater fish productivity in catchments where vegetation is well managed.

When coastal ecosystems degrade, the productivity of coastal subsistence and commercial fisheries declines. In countries with limited areas of reef per person and high rates of population growth, coastal fisheries based on coral reefs will not be able to supply the fish required for good nutrition, especially in Pacific Island countries.

(Bell, Johnson and Hobday 2011; SPC 2011; SPC/GIZ 2012; VMGD 2013)

Some adaptation and mitigation practices that are being developed in Pacific countries

- improving access to other sources of fish to reduce the pressure on coral reefs or to provide a substitute for coastal fish if a reef has bleached (adaptation). This includes:
  - ➢ catching oceanic fish such as tuna around near-shore fish aggregating devices (FADs);
  - ➢ harvesting small pelagic fish;
  - ➢ growing tilapia (or freshwater prawns) in pools fed by river water (not recommended in Kiribati);
  - ➢ farming milkfish caught from the wild as juveniles;
- replanting mangroves or other coastal vegetation in suitable areas (mitigation and adaptation; see also Picture 13 Forestry);
- stop cutting off shark fins and release sharks if caught (adaptation);
- building open causeways between islands to allow water exchange, and modify existing causeways to bring back lost marine and terrestrial resources (adaptation);
- preventing sediment entering rivers and oceans from coastal or hill erosion (caused, for example, by deforestation and poor land management practices) (adaptation);
- not destroying coral reefs: not using dynamite for fishing, not using coral for building and construction (adaptation);
- not dumping waste and sewage into rivers and the ocean (adaptation).
- establishing areas (or imposing taboos) to protect marine ecosystems (adaptation);
- managing fish resources in a sustainable way (adaptation);
- using canoes instead of motor boats or, when using outboard motors, use small economical ones (mitigation).

Teaching and learning activities – 14

14.1 Home and expert

Students form groups and identify what adaptations and mitigations they see in the picture to stimulate discussion. They could do the same exercise as for Picture 12.

14.2 Who am I?

This activity is designed to get students to ask accurate, focused questions. Put a card on the back of each student, with a word or a picture on it. You can use the list below to make the cards. Be careful not to let the student see the card. The cards can be pinned with safety pins or put on a string long enough to go around the student's neck so the card hangs down the back. Students have to find out who they are by asking questions of other students – but there are rules.

1. They may ask only one question at a time from a student. They then move on to the next student to ask their next question.
2. Students can answer ONLY Yes or No, so all questions must be able to be answered by Yes or No.

This is called the Suchman technique. It forces students to think carefully about their questions and remember the answers they are given. Discussions with students before the activity could focus on the types of questions to ask. For example, they can ask:

Am I an animal? (Not: Am I a plant or an animal? as this cannot be answered by Yes or No. You can suggest that students respond to a wrongly worded question by saying 'Invalid question'.)

It also requires concentration on the part of the listener – not to blurt out the answer to a wrongly worded question.

Here is a list of examples. If you are near a beach, you can do the activity before or after a visit to the beach. The list can be adapted to suit your class.

coral	turtle	sand	sea-grass	tuna	boat
rock	lobster	outrigger canoe	fishing trawler	waves	rubbish
coconuts	shark	mangrove	crab	clam	sea star
whale	rabbitfish	salt water	frigate bird	fish trap	hand line
tern	snail	dugong	mussel	trevally	mahimahi

You can opt for more generic family names such as 'shark' or more specific species such as 'white tip reef shark' or 'white shark'. Detailed information on species can be found at http://www.spc.int/coastfish/en/publications/technical-manuals.html.

SPC has provided manuals and identification cards for deep bottom, coastal and reef fish that can be downloaded for free.

(Adapted from SEREAD)

14.3 ONE FISH, TWO FISH, RED FISH, FEW FISH*
*with acknowledgements to Dr Seuss.

Objective
This experiential activity is designed to show students the effect humans can have on marine ecosystems. This is how we suggest you organise the activity.

- Explain clearly how they will play the game (see below).
- Facilitate the first run through of the game.
- Support students to reflect on the experience.
- Give students the opportunity to add to the game with new ideas and then trial them.
- You could use the experience to explain:
  - ➢ the difference between biotic (living) and abiotic (non-living) factors;
  - ➢ the influence of biotic and abiotic factors on a community;
  - ➢ the connections between living things within a community, particularly with respect to feeding relationships, energy flows and nutrient cycles.

Students will;
- listen to the instructions;
- participate in the experience;
- reflect on what happens and describe what that means;
- suggest new ideas to play the game to create more sustainable fisheries;
- play new versions of the game and compare the changes;
- reflect on the experience.

Aim of the game - To reach a level of sustainable fisheries.

Resources: netball court/playing field, four+ area-markers (cones) or a long rope, ten+ ice-cream container lids or pieces of card, two+ sponge balls, a picture of a longliner fishing boat, a turtle, hula hoops or loops of rope (for simulated marine reserves), arm bands, pegs.

What to do:

- Explain to the students that longliners sometimes catch more fish than they are licensed to catch. For this reason, Pacific governments employ observers to travel on the boats and monitor their fishing activities.
- Define the playing area: e.g. half a netball court for 20 pupils initially. Explain that the marked playing area represents the marine habitat.
- All except two students are fish, but these fish can walk (and ONLY walk! No running is allowed). If a fish leaves the playing area then they become longliners,
- Pick two volunteers as longliners. They wait outside the playing area ('in port') until the game starts. Then they chase fish and 'tag' them. The tagged fish then become longliners and must hold hands/link arms with the longliner that tagged them to form a chain, and together pursue the other fish.

  1. Start the game and play until there are no fish left. Usually, this takes only two or three minutes.
  2. Stop the game and gather in the students, still in their chains. Say, with a suitably horrified tone: *Look what you have done! You have just made all fish life extinct! How are you going to feed your families or provide for your village? This is not sustainable! How can we change the rules of this game so that we are more sustainable?*

Students come up with suggestions (see next page) and rules, and for each new rule, you play the game again. **Introduce only one new rule per round or it becomes too confusing.** At the end of each round, ask for a show of hands to see how many fish and how many longliners there are. Keep a record of this. Also, time each round to show how long it takes to catch the fish using different sustainable strategies.

Here are some suggestions the students might come up with.

a) **Make marine reserves or conservation areas.** Discuss with students how you could represent marine reserves with the items you can find, (e.g. hoops, pieces of string, sticks. What rule can we make? Rule: Fish are allowed in the marine reserve for 20 seconds only).
b) **Use the appropriate mesh size for nets or for fish hooks, so that small fish or breeding fish are not caught.** Select some students to be small fish and identify them with arm bands or pegs. Rule: these fish cannot be tagged.
c) **Use a quota system.** What rule can we create? Rule: After the quota has been tagged, no more fish can be tagged. For example, once a longliner has tagged three fish it must retire to a port, (i.e. outside the game area).
d) **Put observers on longliners.** One or two students act as Ministry of Fishery (MoF) observers. When they see the longliner catching too many fish, they make a report. This is acted out here by throwing a sponge ball or soft toy at the longliner. Rule: If hit, the longliner breaks from the chain and becomes a fish again. (The remaining longliners in that chain must join hands again). The MoF observer then retrieves the ball and does one complete lap of the playing area before being allowed to make another report. The game continues for four or five minutes or until all the fish have become longliners.
e) **Turtle impact.** Discuss how nets also trap turtles, and longlining hooks catch birds, so fishing at night, not throwing fish offal overboard, redesigning hooks or adding sinkers keep mortality down. Make up rules for sustainable fishing practices.

Reflection

- What happened to the longliner numbers during the game? What happened to the fish numbers? ('Hands up all the longliners, hands up all the fish.')
- Why did this occur? (Longliners keep increasing/fish decreasing.)
- How did the MoF observer feel? Why did the MoF observer have to do a lap before shooting? (Track down prey again.)

The students, with your help, can come up with some variations (e.g. longliner numbers, MoF observer numbers, fish numbers, area size, different MoF observer techniques) to control exploitation, and then play the game again. Some variations are shown below.

Variations

Run a trial using a larger area:

- What happened to the longliner numbers?
- How hard was it for longliners to catch fish? Why harder? (Resource distribution.)
- How was it different for the MoF observer? Why was this?

Introduce more MoF observers:

- What happened to the longliner numbers?
- How hard was it for the MoF observers this time?
- What did the MoF observers have to do to 'control' longliners effectively? (Cooperative strategies for MoF observers.)
- What other techniques do we use to control exploitation?

Discussion

Here are some question to stimulate discussion.

- How did the fish avoid being caught?
- What strategies did the longliners develop to catch fish?
- What strategies does the MoF observer develop to monitor and control the longliners' fishing activities?
- Are there any other resources in your country that are threatened by unsustainable practices (e.g. coral reefs, turtles, land, water....)?
- Are there any ways that you and I are contributing to this problem (e.g. buying unsustainably fished species, polluting the water, polluting the land)?
- Is there anything that we can do to reduce this problem (e.g. assist in replanting areas in mangroves and natives trees, minimise our resource use in general to lessen habitat destruction, buy local produce)?
- What is ecology? (The study of living things and their environment)
  (adapted from SEREAD)

14.4 Discover marine species

Students go on a small excursion to a fishing place (mangroves, coral reef, river or fish pond) they have identified and discover the marine environment. Provide them with a table and ask them to find and identify at least five marine or river plant and animal species. You could ask your students to design a poster showing one or several species in their natural habitat, with notes of their observations.

Local name of plant or animal	Scientific name of plant or animal	Found in which ecosystem (reef, mangrove, sea grass bed, river, estuary, or artificial pond)?	Is it originally from your home country or has it been introduced?

14.5 Protected area activities

Protecting marine areas is one of the most significant adaptations a country can make to protect breeding stocks and habitats. Each country has its own protocols and processes to set up these protected areas.

Possible activities for your students include:

- visit a protected area and a non-protected area to observe any differences;
- discuss changes in fish supply with local fisherman several years after an area has been declared a protected area;
- research national and /or local protected areas or protected species.

Picture 15 – The town

This picture shows two very different scenes in terms of modes of transport, the generation of electricity, waste generation, the products for sale, etc. Students can compare these, noticing such things as solar panels, the number of cars, people walking and cycling, and the amount of rubbish, particularly plastic. It may take some directing for students to notice the transport differences. The top half also shows the development of local markets, stocking produce not wrapped in plastic and shoppers with handmade bags walking to the shops.

Possible student learning outcomes **Students will be able to....**	**Teaching and learning activities**
• identify a range of sustainable practices in an urban environment; • explain one sustainable practice in detail; • explain one unsustainable practice.	Picture interpretation and discussion Media search Waste time line

Discussion

Ask the students to look at Picture 15 and identify different adaptation and mitigation actions. Perhaps they can identify good and bad practices from their country's towns.

Towns
A town/ urban centre is a human settlement, larger than a village, with the higher population living closer together. It is likely to have schools, a hospital, a harbour and roads. Most government institutions, as well as private sector services, are located in a town. All over the world and in the Pacific region, urban centres are growing, due to population growth and the fact that people from remote outer islands and rural areas migrate to towns for jobs and education. This causes problems with informal settlements developing, some in vulnerable areas, such as places too close to the sea or river.

The biggest town in the South Pacific is Port Moresby in Papua New Guinea (2000 census: population 254,158), followed by Suva in Fiji (88,271 in 2009). Other urban areas/towns are Port Vila in Vanuatu, Nuku'alofa in Tonga, Betio in Kiribati and Apia in Samoa.

In most towns, traditional culture is combined with modern culture.

Towns are usually the place where most greenhouse gas emissions from energy use are created – from the burning of fossil fuel in cars, buses, planes and motor boats.

Most Pacific Island countries get their electricity from burning diesel, which is imported at high cost. The consumption of electricity is highest in towns. Shops, offices, restaurants, manufacturing enterprises and factories, as well as private households, need energy for lighting, air-conditioning, production purposes, computers and radios, TVs, cooking and cleaning.

The effects of climate change on towns are complex, due to the linking of many different social and economic factors. One thing leads to another, as you can see in this example.

- Most towns in the Pacific are located near oceans or rivers and people have altered natural coastal features, making the towns more liable to be flooded (e.g. Nadi town in Fiji has been flooded several times recently). They are more vulnerable to high ocean waves during storm surges and cyclones. Sea-level rise and more days of extreme rain caused by climate variability or change will in future worsen the situation.
- This causes damage to infrastructure (bridges, roads, houses, hospitals, schools, shops, etc.) and power cuts that can affect the whole country.
- This leads to a situation where school children cannot access schools and, generally, communication and transport are affected.
- During flooding events, the risk of loss of life, injury and disease, such as typhoid or other water-borne diseases, increases.
- Shop owners and producers who provide commodities to the towns' markets lose income during extreme events.
- Tourists can get stuck if transport is not available.

Some adaptation and emission mitigation practices that are being developed in Pacific countries

- promoting low energy light bulbs in all retail stores (mitigation)
- using solar energy for water heating and electricity production (mitigation)
- using wind energy for the energy supply (mitigation)
- designing and building of low-energy buildings (mitigation)
- switching off lights, TV, etc. when not in use (mitigation)
- using more decomposable bags, such as local bags made from pandanus leaves, and enacting legislation against the use of plastic bags (mitigation and adaptation)
- avoiding water leakages and saving water, e.g. by turning off the tap whilst brushing teeth or taking short showers (adaptation)
- harvesting rainwater from roofs and collecting it in water tanks, keeping water tanks and gutters clean (adaptation)
- installing rain gauges (adaptation)
- constructing higher sea-walls, roads and bridges (adaptation)
- following the advice of town planners and not building in flood-prone areas (adaptation/prevention)
- having evacuation plans and following instructions during cyclone or flooding events (adaptation/preparedness)
- monitoring ground water (adaptation)
- breeding tilapia in water tanks in backyards (adaptation example from Vanuatu)
- growing fruits and crops in backyards (adaptation and mitigation)
- protecting old trees and planting new ones (adaptation and mitigation)
- trying to avoid uncontrolled or illegal sandmining (adaptation)
- buying more local produce to reduce imports that create emissions (mitigation)
- practising sports regularly and eating plenty of fruit and vegetables to be fit (adaptation)

Teaching and learning activities – 15

15.1 Media search
Students can do some research about sustainable practices or adaptation and mitigation activities in their local town/community.

They can find information from the radio, newspapers, television and local people, and write up what they have found out.

Some pointers
- What is the sustainable practice?
- Is it an adaptation or mitigation practice? Or both?
- Who is doing it?
- Who is making decisions?
- Who or what benefits from this practice?
- Does anyone oppose it? Why?
- Where did you find this information?

15.2 Waste time line

Objective: To give students a visual representation of the time it takes for various materials to break down so they understand that (a) rubbish stays in the environment for a long time and does not just go away, and (b) that people can reduce the amount of rubbish in the environment.

Materials for each group
- a piece of coloured string, 10 m long
- a metre ruler or tape measure
- some clothes pegs
- a variety of waste materials
- card with the real times (see next page)

Here's what you do
- Organise your students into groups of three or four and give each group a length of rope and some clothes pegs.
- Guide the groups to organise a time line using the rope, and ask questions to check they understand scale. They need to mark out every hundred years (1 m = 100 years) with the clothes pegs.
- Give out the waste materials and encourage the students to guess how many years they take to break down and then place them in the corresponding place on the time line.
- Now give each group the card showing the real times for the articles to break down so the students can compare their guesses with the right answers and move the items if necessary.
- Then ask the students to remove all the articles they can reuse and/or recycle.
- Ask the reflective questions (on the next page) to get students thinking about waste and what happens to it in the environment.

In groups, your students will:
- place a 10 m time line across the room or along one wall (or use chalk and draw a line along the concrete);
- mark out every 100 years on the time line (1 m = 100 years), using the clothes pegs;
- label the beginning of the line TODAY;
- discuss and decide how long they think it will take the waste items to break down and place them on the time line;
- compare their ideas with the times on the card and change their placement, if they all agree;
- remove the articles that can be reused or recycled;
- reflect on what they have learnt as they answer the reflective questions.

The real times

Article	Time to break down	Article	Time to break down
apple core	2 months (in water)	orange or banana peel	up to 2 years
aluminium cans	200–500 years	plastic bags	20–1000 years
cardboard box	2 months (in water)	plastic bottles	forever
cigarette butts	1–5 years	plastic-coated paper	5 years
disposable nappy	450 years (in water)	plastic film containers	20–30 years
fishing line	600 years (in water)	plastic	100 years
glass bottles	forever	styrofoam/ polystyrene	forever
leather	up to 50 years	tin cans	50 years
nylon fabric	30–40 years	clothes	1–5 years

Reflective questions

1. How long are most people expected to live?
2. How does this age compare with the total length of the time line?
3. What skills did you use to create the time line?
4. How did you estimate the time for the waste materials to rot?
5. When you learned the correct time, what surprised you?
6. What materials were left on your line after you removed all those you can reuse and/or recycle?
7. What could you do with these materials?
8. What did you learn from this activity?
9. How could you use this knowledge?

Your reflection / evaluation of the activity

1. What was the purpose of doing the activity?
2. What skills were practised and developed in the activity?
3. How could you modify this activity to use it:
   (a) with younger children?
   (b) with teachers or educators?
   (c) with other adults (community groups)?

(TKI)

Picture 16 – Pasifika with adaptations in place

This picture shows Pasifika from a slightly different angle with sustainable practices in place. These practices represent those shown in detail in Pictures 12–15.

Possible student learning outcomes Students will be able to….	Teaching and learning activities
• identify a range of sustainable practices; • explain one sustainable practice in detail.	Picture interpretation and discussion RIQ Strategy

Discussion

You can use this picture as the finale of the unit of work or it could be used at the beginning with Picture 1 to develop student questions about the reason for the changes. You can ask your students:

- Which picture would you prefer to live in? Why?
- Which part looks most like your village/town/island?
- What sustainable practices can you see that are also shown in Pictures 11 to 15?
- Can you practise any of them in your school or home?
- Do you know of any such practices in your community?
- Who makes decisions about new practices in your community?
- Can you provide information on climate change and the predicted consequences for your country to the local decision-makers?
- What are your next steps to support your community to put sustainable practices in place?

Teaching and learning strategies – 16

16.1 An RIQ (Recalls, Insights, Questions) strategy

Background
Since students can effectively process one-way lecture style information for only 8-12 minutes, time should regularly be set aside for students to process and make sense of new information. The 3:2:1 RIQ strategy assists students to process new information. After reading a poem, novel or short story or after watching a video or as a review of a lesson, a practical activity or a topic, a 3:2:1 RIQ is completed individually by students.

Teaching about climate change will have taken place over an extended time frame. This is a valuable tool to use at the end of a topic.

Process

Step 1 Ask each student to write on a piece of paper:

3 Recalls: Students write three important facts they can recall.

2 Insights: This can be such things as why the material is relevant or interesting, who it affects, the implications, how it relates to themselves/society/school, and identifying correlations, connections and patterns.

1 Question: For example

- What is the reason for…?
- How does this affect…?
- In the future, what will …?
- What is the relevance of …?
- How does this relate to…?

Step 2 Class recall (optional)

Ask for some recalls, insights, questions as a class. This may be effective feedback to ensure that students have recalled the main concepts, as well as to ascertain whether some concepts require re-visiting in order to facilitate better student understanding.

(Adapted from SEREAD)

Definition roll up

This is a useful activity for students to construct group definitions of difficult terms.

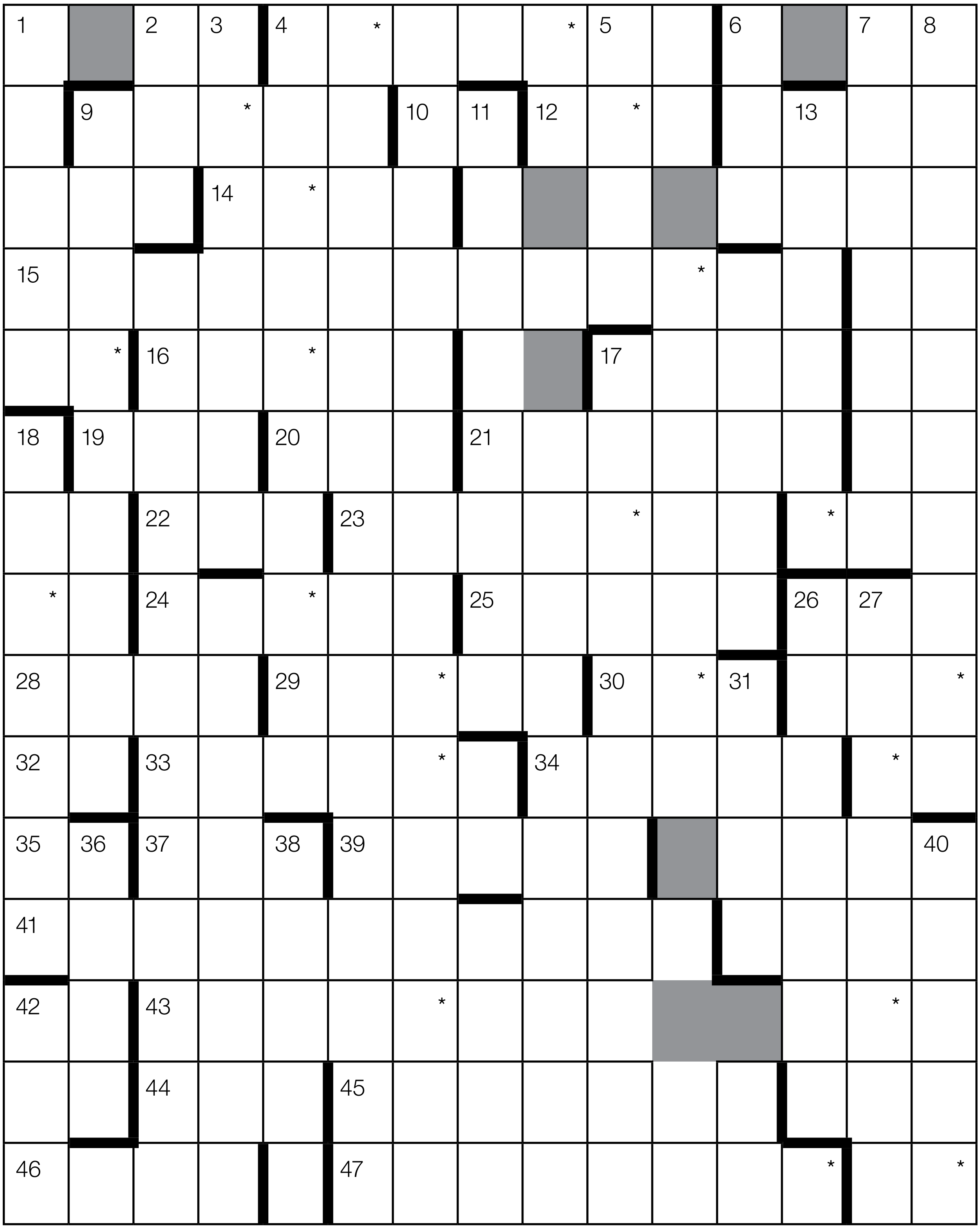
1. Draw up a set of words that are new to students or difficult to define. You can use the set below if it suits your class.
    a. Water cycle: evaporation, condensation, precipitation, accumulation, transpiration
    b. Climate zones: tropical zone, subtropical zone, temperate zone, cold zone
    c. Science of climate change: weather, climate, climate variability, climate change
    d. Greenhouse gas effect: greenhouse gas, emission, atmosphere, solar radiation, infrared radiation
    e. Impacts and responses to climate change: vulnerability, resilience, impact, adaptation, mitigation
2. Have one sheet of paper for each student. Write one word from your list at the top of each piece of paper. Go through the list once and then start again.
3. Seat the students in small groups of five or six, depending on the set of words and size of the class.
4. Give each student in each group a piece of paper, making sure that each student in the group has a different word.
5. The students each write a definition of their word at the bottom of the page, fold over the bottom of the page so their definition is covered, and pass it to another member of the group. This is repeated until each student in the group has defined each word.
6. When all words are defined, the students unfold the papers and in their group they decide on the best definition for each word from their group.
7. The groups then share their definitions with the class and the teacher helps in selecting the best ones.

(Adapted from SEREAD)

Win a small weather station for your school compound!

Crossword and Jumbled Words Competition

Crossword: Photocopy the grid on this page and the clues on the next page and ask your students to fill in all the squares (except the grey ones) by solving the clues. The black bars indicate the end or beginning of a word.
Jumbled words competition: The details for this are on the next page.



Clues across

4. A long period without rain where rain is expected
9. A mass of water droplets in the sky
10. Abbreviation for ante meridian
12. A large mass of water
14. Fresh water that has soaked through the ground and collected there
15. A scientific word for rain
16. The liquid form of hydrogen dioxide
17. A Pacific country
19. A heavenly body that radiates heat
20. A domestic animal, a favourite at Pacific feasts
21. Where householders plants crops, trees and flowers
22. The abbreviation for November
23. The current conditions of temperature, humidity and rainfall
24. A Pacific country
25. They give us shade, timber and food and protect slopes and shores from erosion
28. The solid portion of the Earth
29. We can get this from the sun, from wind, from water, from fuel, from nuclear reactors and muscles
30. The abbreviation of October
33. A time when fisherfolk in South America have very good catches whilst there are droughts the western Pacific and in Australia (2 words)
34. What you must not do in an emergency. Instead, you must try to keep calm
35. What you say when you give a negative answer
37. The abbreviation for West Pacific Monsoon
39. We have this when rivers burst their banks
41. The process of liquid water turning into gas
43. A tree that protects the coast and the fish and birds that live in that habitat
44. Part of our body that sounds the same as I.
45. A Pacific country
46. A structure that protects us from bad weather
47. If we have very warm and mostly moist weather throughout the year, our climate can be described with this word

Clues down

1. Making changes in order to reduce the vulnerability of a community to the negative effects of climate change, or make the most of potential positive effects.
2. This insect can spread disease
3. The eruption of matter and gas from underground in the form of lava and ash, which make fertile soil when cool
5. Make something warm
6. Frozen water
7. Weather patterns over long periods, 30 years or more
8. A house made of glass for growing plants that need warm temperatures; the term is now used to describe the effect that the gases in the upper layer of our atmosphere have on earth's temperature
9. Kiritimati Island's other name
11. To reduce or lessen something, such as the emission of CO_2.
13. El Niño's female counterpart, a little girl (2 words)
18. A violent tropical storm with wind blowing spirally
26. A tropical tree used for food and drink, shelter, handicraft and jewellery
27. A Pacific country
31. It rises and falls according to the position of the moon
36. Egg-shaped
38. Cash income
40. A Pacific country
46. A rule, decree, or regulation

Jumbled words competition

Twenty-one squares in the crossword grid have an asterisk (*). When you have completed the crossword, write down the letters in the squares with an asterisk and rearrange them to make three words. The first word has 7 letters, the second word has 6 letters and the third word has 8 letters.

Clue: Perhaps you are one.

JUMBLED WORDS COMPETITION **PRIZES**

First prize: a set of equipment to measure rainfall and temperature on the school compound and three volley balls
Second prize: three volley balls
Third prize: one volley ball

Terms and conditions of entry

- To submit an entry to the draw, write down your solution to the Jumbled Words Competition and the other details required (see below) and send this to:

  Education
  SPC/GIZ CCCPIR,
  Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH,
  PO Box 14041
  Suva
  Fiji

  OR

  Scan your submission and send it by email to hanna.sabass@giz.de

  Two draws will be held, one in 2014 and one in 2015. If your school submits an entry in 2014, it must reach SPC/GIZ by 31 May 2014. If submitting in 2015, your entry must reach SPC/GIZ by 31 May 2015. **Entries received after the due date will not be entered in the draw.**

Details required

1. Solution to the Jumbled Words Competition:

   _ _ _ _ _ _ _ _   _ _ _ _ _ _ _   _ _ _ _ _ _ _ _ _

2. School name
3. School Head Teacher/Principal's name
4. Postal address
5. Email
6. Telephone number
7. Lesson during which the crossword and jumbled words competition were attempted

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- To enter the draw, the correct words must be given for the jumbled words competition.
- Incomplete, indecipherable or illegible answers/entries will be deemed invalid.
- Only primary or secondary schools in Fiji, Samoa, Vanuatu, Tonga and Kiribati are eligible to submit an entry to SPC/GIZ CCCPIR.
- The competition must have been solved by students with no assistance from anyone else.
- Only entries sent by the school and signed by the Head Teacher/Principal will be accepted. Individual submissions will not be accepted.

- Each school can submit one entry only.
- The winning schools will be determined with a simple draw from correct entries – one draw for each country listed above, conducted by two staff members of SPC/GIZ CCCPIR. This will be done once in 2014 and once in 2015. The decision of SPC/GIZ is final.
- The winning schools will be notified by SPC/GIZ CCCPIR, by 30 June 2014 or 30 June 2015.
- The prize will be awarded to the winning school, not to an individual.
- The prize will be delivered to the address stated in the submission.
- SPC/GIZ CCCPIR will be responsible for delivering the prize to the schools.
- The responsibility for assembling the prize will be the sole responsibility of the winning schools and not SPC/GIZ CCCPIR.
- If, for any reason, the prize cannot be delivered to your school, it will be sent to the Curriculum Development Unit of the Ministry of Education in your country.
- SPC/GIZ CCCPIR is not liable for any delayed, damaged, lost or misdirected mail (both for entry submission and prize delivery).
- Solutions submitted after the due date will not be considered.

Important

The school's entry must be signed by the school Head Teacher/Principal thus:

I hereby confirm that I have read and understood the terms and conditions of entry and that I agree with them. I further confirm that the Jumbled Words Competition is the work of students in this school, and was completed without assistance.

Signed ....

School Head Teacher/Principal

Date..

Glossary

Accretion	A process where layers of materials, such as coastal sediments, are formed as amounts are added over time.
Adaptation	Adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities (UNFCCC 2013). Simplified definition: Making changes in order to reduce the vulnerability of a community, society or system to the negative effects of climate change, or make the most of potential positive effects. It includes building skills and knowledge, as well as making practical changes, such as strengthening coastal infrastructure, adjusting farming systems, and improving water management (adapted from SPREP 2012).
Aerosols	A collection of airborne solid or liquid particles, with a typical size between 0.01 and 10 micrometer (a millionth of a meter) that reside in the atmosphere for at least several hours. Aerosols may be of either natural or anthropogenic origin. Aerosols may influence climate in several ways: directly through scattering and absorbing radiation, and indirectly through acting as cloud condensation nuclei or modifying the optical properties and lifetime of clouds (IPCC 2007).
Afforestation	Establishment of forest through planting and/or deliberate seeding on land that, until then, was not classified as forest (FAO 2010).
Anthropogenic	Resulting from or produced by human beings (IPCC 2007).
Aragonite	A form of calcium carbonate that makes up the shells and skeletons of key organisms in reef ecosystems, including reef-building corals (ABM & CSIRO 2011 Vol. 1: 244).
Atmosphere	The gaseous envelope surrounding the Earth. The dry atmosphere consists almost entirely of nitrogen (78.1% volume mixing ratio) and oxygen (20.9% volume mixing ratio), together with a number of trace gases, such as argon (0.93% volume mixing ratio), helium and radiatively active greenhouse gases such as carbon dioxide (0.035% volume mixing ratio) and ozone. In addition, the atmosphere contains the greenhouse gas water vapour, whose amounts are highly variable but typically around 1% volume mixing ratio. The atmosphere also contains clouds and aerosols. (IPCC 2007).
Biodiversity or	The variability among living organisms from all sources including, inter alia, terrestrial,
Biological diversity	marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems (CBD 2013).
Carbon cycle	The term used to describe the flow of carbon (in various forms, e.g. as carbon dioxide) through the atmosphere, ocean, terrestrial biosphere and lithosphere (IPCC 2007).
Carbon sequestration	The process of removing carbon from the atmosphere and depositing it in a reservoir (UNFCCC 2013).
Carbon sink	A carbon sink is a natural or artificial reservoir that takes up and stores carbon. Trees, plants, oceans, rocks and soils are natural sinks, while landfills are artificial sinks (SPREP 2012).
Climate	Climate refers to the average weather conditions over a long period of time (usually over at least 30 years), based mainly on measurements of temperature, precipitation and wind (SPREP 2012). It is affected by latitude, altitude and proximity to the ocean.
Climate change	Climate change refers to a change in the state of the climate that can be identified (e.g. by using statistical tests) by changes in the mean and/or the variability of its properties, and that persists for an extended period, typically decades or longer. Climate change may be due to natural internal processes or external forcings such as modulations of the solar cycles, volcanic eruptions and persistent anthropogenic changes in the composition of the atmosphere or in land use. Note that the Framework Convention on Climate Change (UNFCCC), in its Article 1, defines climate change as: ‘a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods’. The UNFCCC thus makes a distinction between climate change

	attributable to human activities altering the atmospheric composition, and climate variability attributable to natural causes (IPCC 2013). Simplified definition: Changes in the Earth's climate due to human activities (anthropogenic climate change) or natural processes that are already occurring or predicted to occur. These include increasing air and sea-surface temperatures, changing rainfall patterns, sea-level rise, ocean acidification, and changes in frequency and intensity of extreme events such as droughts, floods and tropical cyclones. Anthropogenic climate change is expected to happen much more rapidly than natural changes in the climate, posing an enormous challenge to both natural and human systems (adapted from SPREP 2012).
Climate variability	Variations in the mean state and other statistics (such as standard deviations, the occurrence of extremes) of the climate on all spatial and temporal scales beyond that of individual weather events. Variability may be due to natural internal processes within the climate system (internal variability), or to variations in natural or anthropogenic external forcing (external variability) (IPCC 2013).
Convergence zone	A convergence zone is an area where winds flow from different directions toward each other, thus meeting at one point or along one line (like the ITCZ or SPCZ). Convergence zones could be called 'cloud meeting places' (ABMCSIRO-RCCCC 2013). Similarly, in oceanography, where water currents flow toward each other and meet. Horizontal convergence usually forces vertical motion to occur, such as convection (ABM & CSIRO 2011 Vol. 1: 245).
Coral bleaching	The paling in colour which results if a coral loses its symbiotic, energy providing organism (IPCC 2007).
Cyclone	A tropical cyclone (also known as a typhoon or hurricane) is a violent rotating windstorm that develops over tropical waters warmer than 26.5^{0}C and located between 5^o and 15^o latitude (SOPAC 2006).
Deforestation	The conversion of forest to other land use or the long-term reduction of the tree canopy cover below the minimum 10 per cent threshold (FAO 2010).
Deposition	Deposition is the process by which sediments, soil, rock and other matter are laying down / added to a landform or land mass such as a soft beach or coast.
Disaster	A serious disruption of the functioning of a community or a society involving widespread human, material, economic or environmental losses and impacts, which exceeds the ability of the affected community or society to cope using its own resources (UNISDR 2009).
Disaster management	Policy and administrative decisions and operational activities at all levels to ensure preparedness for, response to and recovery from potential disaster events (Pacific Disaster Net 2012).
Disaster risk management	The systematic process of using administrative directives, organisations, and operational skills and capacities to implement strategies, policies and improved coping capacities in order to lessen the adverse impacts of hazards and the possibility of disaster (UNISDR Terminology on Disaster Risk Reduction, 2009).
Drought	A period of abnormally dry weather long enough to cause a serious hydrological imbalance. Drought is a relative term, therefore any discussion in terms of precipitation deficit must refer to the particular precipitation-related activity that is under discussion. For example, shortage of precipitation during the growing season impinges on crop production or ecosystem function in general (due to soil moisture drought, also termed agricultural drought) and, during the runoff and percolation season, primarily affects water supplies (hydrological drought). Storage changes in soil moisture and groundwater are also affected by increases in actual evapotranspiration in addition to reductions in precipitation. A period with an abnormal precipitation deficit is defined as a meteorological drought. A megadrought is a very lengthy and pervasive drought, lasting much longer than normal, usually a decade or more (IPCC 2013). Simplified definition: A drought is a long period with no rain during a time when rain would be expected. It results in reduced groundwater, and a shortage of water for drinking, sanitation and watering plants. It is a slow-onset phenomenon – which means it does not happen suddenly, caused by one single event like a storm or cyclone, but emerges gradually over time (SPREP 2012 and IFRC 2013).

Ecosystem	A complex set of relationships of living organisms functioning as a unit and interacting with their physical environment. The boundaries of what could be called an ecosystem are somewhat arbitrary, depending on the focus of interest or study. Thus the extent of an ecosystem may range from very small spatial scales to, ultimately, the entire Earth (IPCC 2001). A community of plants and animals, and their relationships and interactions with each other and with their physical environment (SPREP 2012).
Emission	The release of a gas into the atmosphere (SPREP 2012).
ENSO	The term El Niño was initially used to describe a warm-water current that periodically flows along the coast of Ecuador and Peru, disrupting the local fishery. It has since become identified with a basin-wide warming of the tropical Pacific Ocean east of the dateline. This oceanic event is associated with a fluctuation of a global-scale tropical and subtropical surface pressure pattern called the Southern Oscillation. This coupled atmosphere-ocean phenomenon, with preferred time scales of two to about seven years, is known as the El Niño-Southern Oscillation (ENSO). It is often measured by the surface pressure anomaly difference between Darwin and Tahiti or the sea-surface temperatures in the central and eastern equatorial Pacific. During an ENSO event, the prevailing trade winds weaken, reducing upwelling and altering ocean currents such that the sea-surface temperatures warm, further weakening the trade winds. This event has a great impact on the wind, sea-surface temperature and precipitation patterns in the tropical Pacific. It has climatic effects throughout the Pacific region and in many other parts of the world, through global teleconnections. The cold phase of ENSO is called La Niña (IPCC 2013).
Erosion	Erosion is the process by which soil and rock are removed from the Earth's surface by wind or water flow, and then transported and deposited in other locations.
Evaporation	The conversion of water from a liquid into a gas.
Evapotranspiration	The combined process of evaporation from the Earth's surface and transpiration from vegetation (IPCC 2013).
Fauna	Animal life occurring in a specific region.
Flora	Plant life occurring in a specific region.
Forest	Land spanning more than 0.5 hectares with trees higher than 5 meters and a canopy cover of more than 10 per cent, or trees able to reach these thresholds in situ. It does not include land that is predominantly under agricultural or urban land use (FAO 2010).
Forest degradation	The reduction of the capacity of a forest to provide goods and services (FAO 2010).
Fossil fuels	Carbon-based fuels from fossil hydrocarbon deposits, including coal, peat, oil, and natural gas (IPCC 2007).
Global warming	The increase in average global temperature that has occurred since industrialisation, due to increased levels of greenhouse gases in the atmosphere. Since the early 20th century, the average surface temperature of Earth has increased by 0.8°C, and it is predicted to continue to rise, with the actual amount depending on mitigation measures taken in the coming years (SPREP 2012).
Greenhouse	A greenhouse is a glasshouse in which plants are grown. It is usually used in colder climates to trap heat and moisture for plants, especially vegetables and flowers, to grow better than outside.
Greenhouse effect	The infrared radiative effect of all infrared-absorbing constituents in the atmosphere. Greenhouse gases, clouds, and (to a small extent) aerosols absorb terrestrial radiation emitted by the Earth's surface and elsewhere in the atmosphere. These substances emit infrared radiation in all directions, but, everything else being equal, the net amount emitted to space is normally less than would have been emitted in the absence of these absorbers because of the decline of temperature with altitude in the troposphere and the consequent weakening of emission. An increase in the concentration of greenhouse gases increases the magnitude of this effect; the difference is sometimes called the enhanced greenhouse effect. The change in a greenhouse gas concentration because of anthropogenic emissions contributes to an instantaneous radiative forcing surface temperature and troposphere warm in response to this forcing, gradually restoring the radiative balance at the top of the atmosphere (IPCC 2013).

	Simplified definition: Heating of the Earth's surface as a result of certain gases in the atmosphere, which radiate heat back to the Earth (SPREP 2012).
Greenhouse gases	Greenhouse gases are those gaseous constituents of the atmosphere, both natural and anthropogenic, that absorb and emit radiation at specific wavelengths within the spectrum of terrestrial radiation emitted by the Earth's surface, the atmosphere itself, and by clouds. This property causes the greenhouse effect. Water vapour (H_2O), carbon dioxide (CO_2), nitrous oxide (N_2O), methane (CH_4) and ozone (O_3) are the primary greenhouse gases in the Earth's atmosphere. Moreover, there are a number of entirely human-made greenhouse gases in the atmosphere, such as the halocarbons and other chlorine- and bromine-containing substances, dealt with under the Montreal Protocol. Beside CO_2, N_2O and CH_4, the Kyoto Protocol deals with the greenhouse gases sulphur hexafluoride (SF_6), hydrofluorocarbons (HFCs) and perfluorocarbons (PFCs) (IPCC 2013).
Hazard	A dangerous phenomenon, substance, human activity or condition that may cause loss of life, injury or other health impacts, property damage, loss of livelihoods and services, social and economic disruption, or environmental damage (UNISDR 2009).
IPCC	Intergovernmental Panel on Climate Change
ITCZ	Intertropical Convergence Zone: The ITCZ is a band of high rainfall that stretches across the Pacific just north of the equator. It is an East-West band of low-level wind convergence near the equator where the southeast trade winds of the southern hemisphere meet the northeast trade winds of the northern hemisphere. ITCZ is strongest in the Northern Hemisphere summer and affects most countries on, or north of, the equator. (adapted from ABM & CSIRO 2011 Vol. 1: 247).
Kyoto Protocol	The Kyoto Protocol to the United Nations Framework Convention on Climate Change (UNFCCC) was adopted in 1997 in Kyoto, Japan, at the Third Session of the Conference of the Parties (COP) to the UNFCCC. It contains legally binding commitments, in addition to those included in the UNFCCC. Countries included in Annex B of the Protocol (most Organisation for Economic Cooperation and Development countries and countries with economies in transition) agreed to reduce their anthropogenic greenhouse gas emissions (carbon dioxide, methane, nitrous oxide, hydrofluorocarbons, perfluorocarbons, and sulphur hexafluoride) by at least 5% below 1990 levels in the commitment period 2008 to 2012. The Kyoto Protocol entered into force on 16 February 2005 (IPCC 2013).
Mitigation (of disaster risks)	The lessening or limitation of the adverse impacts of hazards and related disasters (UNISDR 2009).
Mitigation (of emissions)	A human intervention to reduce the sources or enhance the sinks of greenhouse gases (IPCC 2013). Efforts to reduce the levels of greenhouse gases in the atmosphere, either by limiting the sources or by enhancing the sinks. Examples include using fossil fuels more efficiently, switching to renewable energy sources such as solar energy and hydro-power, and expanding forests and other sinks to remove greater amounts of carbon dioxide from the atmosphere (SPREP 2012).
Molecule	A group of two or more atoms held together by chemical bonds. For example Carbon Dioxide is a chemical bond of one carbon and two oxygen atoms (CO_2).
Ocean acidification	A reduction in the pH of the ocean over an extended period, typically decades or longer, which is caused primarily by uptake of carbon dioxide from the atmosphere, but can also be caused by other chemical additions or subtractions from the ocean. Anthropogenic ocean acidification refers to the component of pH reduction that is caused by human activity (IPCC, 2011, p. 37).
	Simplified definition: An ongoing rise in acidity of ocean and sea waters. This is due to higher levels of dissolved carbon dioxide, which are a direct result of increased levels of carbon dioxide in the atmosphere. Acidification is likely to damage ocean ecosystems (SPREP 2012). The pH of Earth's oceans is decreasing, caused by the uptake of carbon dioxide from the atmosphere. Lower pH makes the oceans more acidic (adapted from ABM & CSIRO 2011 Vol 1: 248).
pH	A measure of the acidity or alkalinity of a solution, numerically equal to 7 for neutral solutions, increasing with increasing alkalinity and decreasing with increasing acidity. The pH scale ranges from 0 to 14 (ABM & CSIRO 2011 Vol. 1: 249).

Photosynthesis	The process by which plants take carbon dioxide from the air (or bicarbonate in water) to build carbohydrates, releasing oxygen in the process. There are several pathways of photosynthesis with different responses to atmospheric carbon dioxide concentrations (IPCC 2013).
Preparedness	The knowledge and capacities developed by governments, professional response and recovery organisations, communities and individuals to effectively anticipate, respond to, and recover from, the impacts of likely imminent or current hazard events or conditions (UNISDR 2009).
Prevention	The outright avoidance of adverse impacts of hazards and related disasters (UNISDR 2009).
Reforestation	Re-establishment of forest through planting and/or deliberate seeding on land classified as forest (FAO 2010).
Renewable energy	Energy that comes from sources that are not depleted or can be easily replenished, for example, hydro-power, solar energy and biofuels.
Resilience	Resilience is the capacity of a community, society or natural system to maintain its structure and functioning through stress or change (SPREP 2012).
Run-off	That part of precipitation that does not evaporate and is not transpired, but flows through the ground or over the ground surface and returns to bodies of water (IPCC 2013).
Salt water intrusion	Displacement of freshwater by saltwater in coastal areas or estuaries (SPREP 2012). Salt water enters the underground freshwater lens as an effect of sea-level rise, storm surges, periods of low rainfall and high temperatures and when large quantities of fresh water are removed for human use. Seawater seeps in from the bottom of the lens and eventually mixes with the freshwater to form brackish water, which is unfit for humans to drink and for plants to survive.
Sea-surface temperature	The temperature of the ocean surface. It is representing the temperature of the upper few metres of the ocean as opposed to the skin temperature, which is the temperature of the upper few centimetres (ABM & CSIRO 2011 Vol. 1: 249).
Sink	Any process, activity or mechanism which removes a greenhouse gas, an aerosol or a precursor of a greenhouse gas from the atmosphere. Forests and other vegetation are considered sinks because they remove carbon dioxide through photosynthesis (UNFCCC 2013).
SPCZ	South Pacific Convergence Zone: a band of high rainfall stretching approximately from Solomon Islands to the east of Cook Islands. It is a persistent and greatly elongated zone of low level convergence. It is strongest in the Southern Hemisphere summer and affects most countries in the South Pacific. A persistent and greatly elongated zone of low-level convergence extending from approximately 140^{0}E near the equator to approximately 120^{0}W at 30^{0}S. The zone is not quite linear, but is oriented more west to east near the equator and has a more diagonal orientation (northwest to southeast) at higher lattitudes (ABM & CSIRO 2011 Vol. 1: 250).
Sustainable development	Development that meets the needs of the present without compromising the ability of future generations to meet their own needs (UNFCCC).
Thermal expansion	The increase in volume (and decrease in density) that results from warming water (ABM & CSIRO 2011 Vol. 1: 250).
Trade winds	The wind system, occupying most of the tropics that blow from the subtropical high pressure areas toward the equator (ABM & CSIRO 2011 Vol. 1: 250).
Transpiration	The process where water contained in liquid form in plants is converted to vapour and released to the atmosphere.
UNFCCC	United Nations Framework Convention on Climate Change
Vulnerability	The degree to which a system is susceptible to, or unable to cope with, adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of the character, magnitude, and rate of climate variation to which a system is exposed, its sensitivity, and its adaptive capacity (UNFCCC 2013; note this definition is in the climate change context only).

	Simplified definition and combined with the disaster context: Vulnerability is the level of susceptibility of an individual, a community, an organisation or a system to adverse conditions, emergencies or disasters; a measure of its ability, or inability, to cope (SPREP 2012).
Warm Pool	(West Pacific Warm Pool) An extensive pool of the world's warmest water, with temperatures higher than 28-29^{O}C ranging from the central Pacific to the far eastern Indian Ocean (ABM & CSIRO 2011 Vol. 1: 250).
Weather	The effects of atmospheric conditions, at a specific time and place, in terms of variables such as temperature, rainfall and wind. Compared with climate, which is a long-term description, weather describes the current situation or predictions for the next few days. Apart from daily weather, also seasonal and annual weather patterns are described and sometimes referred to as the 'prevailing climate'.
West Pacific Monsoon	The West Pacific Monsoon (WPM) moves north to mainland Asia during the Northern Hemisphere summer and south to Australia in the Southern Hemisphere summer. The seasonal arrival of the monsoon usually brings a switch from very dry to very wet conditions. It affects countries in the far western Pacific.

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SPC Secretariat of the Pacific Community

Australian Government Department of the Environment

Australian Aid

giz Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

german cooperation DEUTSCHE ZUSAMMENARBEIT

USAID FROM THE AMERICAN PEOPLE

SPREP Secretariat of the Pacific Regional Environment Programme

USP THE UNIVERSITY OF THE SOUTH PACIFIC

SEREAD

UNESCO United Nations Educational, Scientific and Cultural Organization

PREL www.prel.org

International Federation of Red Cross and Red Crescent Societies