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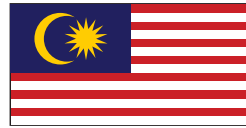
# Climate Change Education for Asia Pacific Small Islands Developing States



"Promoting South-South Cooperation through  
Climate Change Education for Asia Pacific Small Island  
Developing States"



United Nations  
Educational, Scientific and  
Cultural Organization



Malaysia  
Funds-in-Trust

“Promoting South-South Cooperation through Climate Change  
Education in Asia Pacific Small Island Developing States”

# **Climate Change Education for Asia Pacific Small Island Developing States**

**Climate Change Education for Asia Pacific Small Island Developing States  
“Promoting South-South Cooperation through Climate Change Education  
in Asia Pacific Small Island Developing States”**

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UNESCO would also like to express its gratitude to the participants of the Training of Trainers on Climate Change Education for Small Island Developing States (CCE-SIDS) in Asia and the Pacific held in Malaysia in March 2016.

UNESCO gratefully acknowledges the funding provided by the Government of Malaysia for its work on Promoting South-South Cooperation for Climate Change Education for Asia Pacific Small Island Developing States.

# FOREWORD

**Secretary General, Ministry of Education Malaysia, and  
Vice-President, Malaysian National Commission for UNESCO**



The Small Island Developing States (SIDS) within the Asia Pacific region are immeasurably exposed to the danger of climate change, notably to sea level rise and increasing number and severity of extreme weather events. Any catastrophic climatic changes can cause the loss of life and damage to property and infrastructure which potentially can impair the social-economics of SIDS. In the mitigation of such, it is acknowledged that addressing climate change remains a priority and it takes more than the knowledge of science alone. It also requires the compounding aspects of education, culture and communications to highlight the seriousness of climate change which could bring upon the human society.

In light of this, the Government of Malaysia and the UNESCO Office in Jakarta are working closely through the Malaysia Funds-in-Trust (MFIT) project entitled "Promoting South-South Cooperation through Climate Change Education in Asia Pacific Small Island Developing States" to mitigate climate change through education. This Project is being implemented in close working partnerships with UNESCO Office in Jakarta, Ministry of Education Malaysia, and Malaysian National Commission for UNESCO and Universiti Kebangsaan Malaysia.

This project aims at developing applicable training material on Climate Change Education (CCE) for the benefit of environmental education in SIDS in Asia Pacific. The project also has major goals to increase the capacity of teacher trainers and national teacher training institutes (TTIs) to deliver CCE at primary and secondary school levels, as well as to equip teachers with instructional and pedagogical skills and knowledge in teaching environmental, specifically climate change issues. Through the implementation of the project, the training material will help to expand the level of environmental science literacy among the teachers and strengthen their knowledge on fundamental interrelationships and interdependencies between the nature, human systems, climate change and its' causes, as well as adaptation and mitigation measures. It is hoped that through this project, the principal of environmental sustainability will be demonstrated across the institutional operations, decision making practices, attitude and responsibility towards the community to improve school educational environments as a whole. Through the enhancement of CCE for SIDS, teachers will be able to instill the knowledge, skills and value in relation to climate change among the students, so that the younger generations will have a sense of responsibility and cultivate good stewardship on environmental protection and sustainable livelihood at the national and regional levels.

All of us have equal roles and responsibilities in addressing global climate change. This is just one and it doesn't just stop here.

Thank you.



DATO' SRI ALIAS BIN HAJI AHMAD

# FOREWORD

## Director and Representative, UNESCO Jakarta Office



Climate change is a complex global challenge because it is often intertwined with many other issues, such as economic development and poverty reduction. While developing countries are the least responsible for climate change, yet these are most at risk from its impacts. Education is an essential element of the global response to climate change.

Climate Change Education helps learners to understand and address the impacts of environmental problems, encourages changes in their overall attitudes and behaviours, helps them to adapt to climate-change related trends, contributes towards improving their livelihoods, and help increase economic security and income opportunities.

Small Island Developing States (SIDS) face various distinctive challenges to sustainable living and sustainable development, including severe vulnerability to climate change and sea level rise, natural and environmental hazards, availability of freshwater resources and energy, as well as fragile economic and social structures. Climate Change Education (CCE) within the framework of Education for Sustainable Development (ESD) is an essential response to these challenges.

CCE has broad global endorsement. The Paris Climate Conference of Parties 21 held in December 2015 reaffirmed global commitment towards action for Climate Change. This commitment builds on the 2030 Agenda for Sustainable Development with seventeen Goals (SDG) adopted at the UN Sustainable Development Summit in New York in September 2015. The Incheon Declaration fosters further support towards the implementation of Global Action Programme on ESD launched at UNESCO World Conference in Aichi-Nagoya in 2014.

UNESCO Education Strategy 2014-2021 aims to strengthen ESD by reorienting education in order to give everyone the knowledge, skills and attitudes needed to contribute to sustainable development. UNESCO is using the Climate Change Education for Sustainable Development (CCESD) initiative as an entry point for promoting sustainable development through education.

With the kind support from the Government of Malaysia, UNESCO is working to raise awareness of climate change and to promote actions to reduce its impacts. This Teacher Training Material is an accomplishment of the Malaysia Funds-in-Trust project, "Promoting South-South Cooperation through Climate Change Education for Asia Pacific Small Island Developing States" and was developed by utilizing the expertise and services of Malaysian institutions. This package of teacher training materials is designed to fill the needs and gaps on CCE for Small Island Developing States in Asia Pacific (SIDS in AP) and will be used for the Training of Trainers of Ministry of Education officials from Fiji, Niue, Palau, Tonga and Tuvalu.

I would like to express my gratitude to Education Unit Team UNESCO Jakarta Office and Malaysian working partners for developing this useful Training Material on Climate Change Education for Asia Pacific Small Island Developing States. I do hope these Teacher Training Materials, with examples of educational activities and sample lesson plans, will help teachers in SIDS in AP to promote ESD in the region.

A handwritten signature in black ink that reads "Shahbaz Khan". The signature is fluid and cursive.

DR. SHAHBAZ KHAN

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# ABBREVIATION

AP	Asia Pacific
AR5	Fifth Assessment Report
AusAID	Australian Agency for International Development
CaCO <sub>3</sub>	Calcium carbonate
CC	Climate Change
CCA	Climate Change Adaptation
CCE	Climate Change Education
CD	Compact Disc
CDM	Clean Development Mechanism
CER	Certified Emission Reduction
CF	Carbon Footprint
CH <sub>4</sub>	Methane
CO <sub>2</sub>	Carbon dioxide
CO <sub>2</sub> eq	CO <sub>2</sub> Equivalent
COP	Conference of Parties
DRR	Disaster Risk Reduction
EPA	Environmental Protection Agency
ERUs	Emission Reduction Units
FAO	Food and Agriculture Organization
GCMs	General Circulation Models
GHGs	Greenhouse Gases
Gt	Gigatonne
HFCs	Hydrofluorocarbons
IAS	Invasive Alien Species
IET	International Emission Trading
INDC	Intended Nationally Determined Contributions
IPCC	Intergovernmental Panel on Climate Change
IUCN	International Union for Conservation of Nature
Ji	Joint Implementation
KP	Kyoto Protocol
KSV	Knowledge, Skills and Values
N <sub>2</sub> O	Nitrous oxide
NAMA	Nationally Appropriate Mitigation Actions
NOAA	National Oceanic and Atmospheric Administration
O <sub>3</sub>	Ozone
PFC <sub>5</sub>	Perfluorocarbons
PICs	Pacific Island Countries
PIFACC	Pacific Islands Framework for Action on Climate Change
PIGGAREP	Pacific Islands Greenhouse Gas Abatement through Renewable Energy Project

RE	Renewable Energy
RETs	Renewable Energy Technologies
SLR	Sea Level Rise
SPREP	Secretariat of the Pacific Regional Environment Programme
ToT	Training of Trainers
TK	Traditional Knowledge
UKM	The National University of Malaysia (Universiti Kebangsaan Malaysia)
UNDP	United Nations Development Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNFCCC	United Nations Framework Convention on Climate Change
VOC	Volatile Organic Compounds
WG	Working Group
WHO	World Health Organization

# INTRODUCTION

Climate change poses a significant risk to the small islands in the Asia Pacific (AP) region. While there are many ways to address this scenario, it is crucial that Climate Change Education (CCE) should be formulated for the Small Island Developing States (SIDS). CCE plays an important role in creating awareness among the teachers and students. In the long run, such awareness will be fortified by instilling a sense of responsibility and good stewardship among the students by protecting their environment and adopting a green lifestyle.

Within the framework of Malaysia Funds-in-Trust (MFIT) project, the UNESCO Office in Jakarta, and its relevant Malaysian institution partners envisage building the capacity of teacher training institutions in Small Island Developing States in the Asia Pacific to deliver Climate Change Education. One of the outputs of this project, entitled “Promoting South-South Cooperation through Climate Change Education in Asia Pacific Small Island Developing States”, included Training Material for Climate Change Education produced in coordination with Educational Planning and Research Division of the Malaysian Ministry of Education, the Malaysian National Commission for UNESCO, and Universiti Kebangsaan Malaysia. The Project’s major goals are to:

- Increase the capacity of teacher trainers and national teacher-training institutes (TTIs) to deliver Climate Change Education through elementary, junior and secondary education;
- Equip teachers with instructional and pedagogical skills and knowledge in teaching environmental, and specifically, Climate Change issues;
- Improve the levels of pre-service and in-service teacher training in Asia Pacific SIDS in relation to CCE and Education for Sustainable Development in general;
- Provide a basis for the continued improvement and commitment of Asia Pacific SIDS to CCE and to Sustainable Development;
- Expand the level of environmental literacy within national education systems in target locations of SIDS in Asia Pacific;
- Enhance understanding of the fundamental interrelationships and interdependencies between the nature and human systems.

This training material on CCE for SIDS in AP has been developed for use by teachers at all levels and it focuses on the following purposes:

- To raise awareness of climate change through the role of education in achieving sustainable livelihoods and development;
- To equip and enhance teachers with pedagogical skills and knowledge on climate change, its impacts on the communities and recommended mitigating measures through an improvised teaching module and implementing a participatory teaching approach that actively involves students;
- To share educational materials, ideas and activities in climate change education with SIDS in Asia and the Pacific.

## SELECTED RESOURCES

Other suggested materials published by UNESCO include:

- UNESCO. 2010. Education for Sustainable Development Lens: A Policy and Practice Review Tool. Retrieved from <http://unesdoc.unesco.org/images/0019/001908/190898e.pdf>
- UNESCO. 2012. Education for Sustainable Development Sourcebook. Retrieved from <http://unesdoc.unesco.org/images/0021/002163/216383e.pdf>
- Deeb, A. et al. 2011. Climate Change Starter's Guidebook: An Issues Guide for Education Planners and Practitioners. Retrieved from <http://unesdoc.unesco.org/images/0021/002111/211136E.pdf>
- Selby, D., & Kagawa, F. 2013. Climate Change in the Classroom. Retrieved from <http://www.unesco.org/new/en/ccesd>
- UNESCO. 2012. Education for Sustainable Development: Good Practices in Addressing Biodiversity. Retrieved from <http://unesdoc.unesco.org/images/0022/002203/220307e.pdf>
- UNESCO. 2012. Education for Sustainable Development: Good Practices in Addressing Climate Change. Retrieved from <http://unesdoc.unesco.org/images/0022/002203/220304e.pdf>

# HOW TO USE THE TRAINING MATERIAL

This training material consists of two parts, namely Part 1: Teaching and Learning and Part 2: Activities and Sample Lesson Plans. Part 1 introduces the important lessons on climate change and it comprises four modules. Each of the modules comprises learning outcomes that would guide teachers to achieve the main objectives in delivering key knowledge and messages to the students. A list of suggested reading materials is provided at the end of each module. These additional reading materials would assist teachers to elevate their climate science literacy and assist the teachers for a better understanding of the climate change related subjects.

Module 1 is the “Introduction to Climate Change”, which provides fundamental scientific knowledge related to weather, climate change and climate system. Module 2 covers the topics on “Causes and Effects of Climate Change”, where it explains the anthropogenic and natural causes that contribute to the adverse effects of climate change. Meanwhile, Module 3 focuses on the “Sectoral Impacts of and Vulnerability to Climate Change”. This module elaborates on the impacts of climate change in various sectors that are related to SIDS, such as food security and livelihood, gender inequality, health and safety, energy, as well as natural resources which are inclusive of the ecosystem, biodiversity and water resources. Last but not least, Module 4 constitutes the main topic on “Responses and Efforts to Climate Change”, where it highlights the importance of climate change adaptation, climate change mitigation and disaster risk reduction (DRR). It also emphasizes on the international, regional, local and individual efforts in addressing climate change.

Part 2 of this training material consists of eleven (11) educational activities and seven sample lesson plans. It accentuates on enhancing the teacher’s pedagogical skills and reinforces the knowledge among the students by carrying out individual/group activities related to all of the modules covered in Part 1. Each of the activity is outlined with an overview, objectives, methodology (activities) and a list of teaching materials. The teaching materials stated in the activity consist of the teacher’s note, which refers to all of the modules in Part 1, and activity sheets. Enrichment Activity is a bonus section for Part 2. It has two supplementary activities that help students to understand and appreciate significant climate change issues. Meanwhile, the sample lesson plans are prepared as a guide to assist teachers in delivering a successful and effective class session. The sample lesson plans are to be read along with the 11 handouts, which are available in hardcopies listed in Appendices.

Overall, this training material would help the teachers to instil knowledge, skills and values (KSV) upon the students in response to climate change:

- Knowledge: Students will have a better understanding on climate change and its causes, acquire better ability to explain climate change impacts regionally, nationally and globally;
- Skills: Students will be able to explain, appreciate and take initiative in regards to climate change adaptation and mitigation efforts in their daily life for their families, schools and communities (including public speaking, active listening and group work);
- Value: Students will be inculcated with a sense of responsibility and good stewardship in protecting their environment and living a green lifestyle by implementing sustainable livelihoods.



The background is a solid teal color. Overlaid on this background are several dark teal silhouettes of trees. A large, detailed tree silhouette is centered in the background, with its branches spreading across most of the frame. In the bottom right corner, there is a smaller, simpler tree silhouette. The text is centered horizontally and vertically on the page.

**PART 1**  
**Teaching and Learning**

**MODULE 1**  
**Introduction to Climate Change**

### Learning Outcomes

Participants will be able to:

1. Understand the concept of weather, climate, climate system and climate change.
2. Distinguish the differences between weather and climate; climate change and climate variability.
3. Describe the carbon cycle and the greenhouse gas effects.

## SECTION 1.1 CLIMATE SYSTEM

To learn about climate change, we need to learn about the climate system. The Earth's water, clouds, atmosphere, and temperature are the factors in the climate system which are also connected to climate change. The climate system is highly complex and can be affected by the sun's radiation. Thus, it also influences the earth's climate. The climate system consists of:

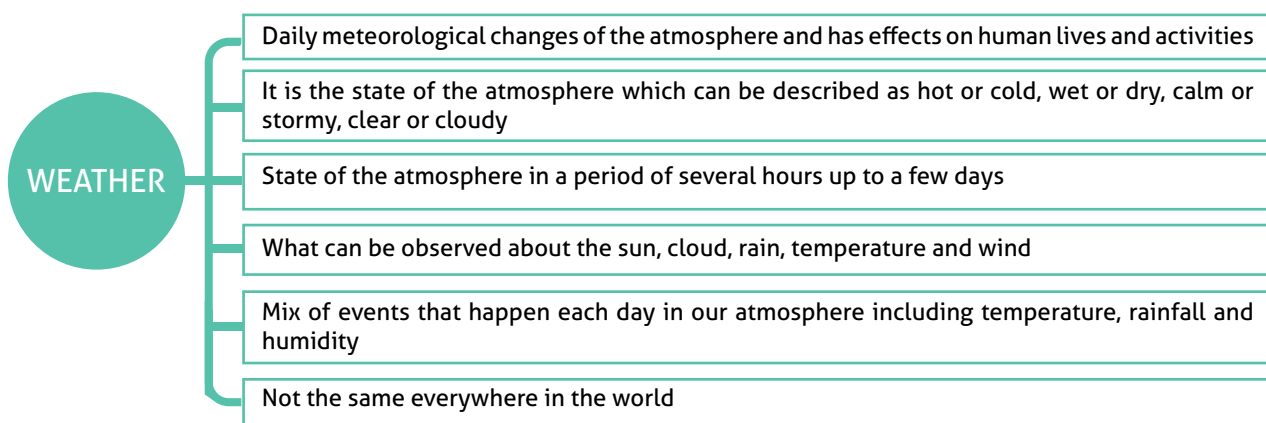
- Atmosphere: gaseous matter surrounding the Earth.
- Hydrosphere: liquid water (e.g., ocean, lakes, underground water, etc.).
- Cryosphere: solid water (e.g., snow and ice, etc.).
- Lithosphere: earth's land surface (e.g., rock, soil and sediment).
- Biosphere: earth's plants and animal life, including humans (all the living organisms).

The daily decisions of humans can be affected by the weather, whereas, weather is controlled or influenced by the climate system.

## SECTION 1.2 WEATHER

Weather refers to the meteorological state of the atmosphere at a specific time and place. It comprises elements such as precipitation, air pressure, temperature, wind, humidity and other phenomena such as hurricanes and thunderstorms.

### WHAT IS WEATHER?



## Elements of Weather

There are six main elements of weather, a change in one of the elements produces changes in the others.

Temperature	<ul style="list-style-type: none"><li>• The temperature of the air, measured with a thermometer Celsius (°C) or Fahrenheit (°F).</li><li>• Refers to how hot or cold the atmosphere is.</li></ul>
Atmospheric pressure	<ul style="list-style-type: none"><li>• The pressure exerted by the air and measured by a barometer.</li></ul>
Wind	<ul style="list-style-type: none"><li>• The speed and direction of the wind caused by air flowing from a high pressure area to a low pressure area.</li></ul>
Humidity	<ul style="list-style-type: none"><li>• Describing how wet or how dry the air is, and measured by a hygrometer.</li></ul>
Precipitation	<ul style="list-style-type: none"><li>• The main forms of precipitation; drizzle, rain, sleet, snow, or hail.</li></ul>
Cloudiness	<ul style="list-style-type: none"><li>• The state of being cloudy.</li></ul>

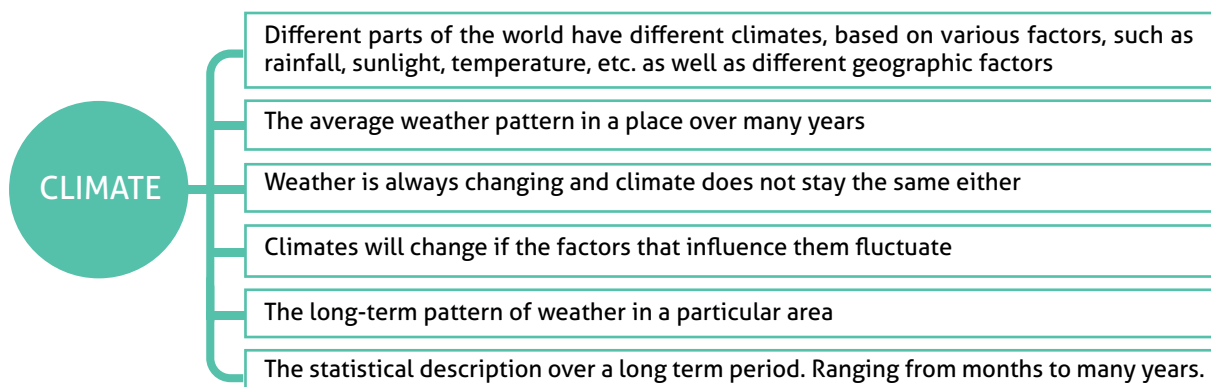
(Source: Adapted from FAO, 2008)

“Weather” and “Climate” are easily confused, but both have different concepts. Weather refers the local condition of the atmosphere at a particular time, including temperature, wind speed and rainfall and it varies from day to day and from season to season. Climate, however, is a statistical summary of all the weather conditions or patterns that have occurred at a certain location over a relatively long period of time (30 years is often used). Weather changes from hour to hour or day to day. Over many years, certain conditions become familiar weather in an area and it is called CLIMATE.

## SECTION 1.3 CLIMATE

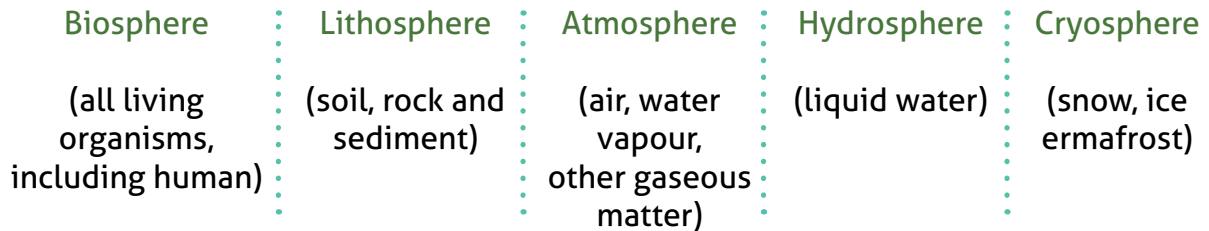
Climate refers to the average weather in terms of the mean and its variability over a certain time-span or a certain area. Climate varies in time; from season to season, year to year or decade to decade, or on much longer time-scales.

### WHAT IS CLIMATE?



## SUN'S RADIATION

**Interacting with**  
The climate system



**Produces**

<b>Atmospheric conditions</b> (surface air temperature, precipitation, humidity/atmospheric pressure, cloud cover/hours of sunshine, wind velocity and direction)			
Weather (daily atmospheric conditions in a specific location)		Climate (average atmospheric conditions – means and variability – over three decades in a specific location)	
different scales			
Global climate	Latitudinal climates	Regional climates	Local and microclimates

Figure 1.1: Formation of Climate

## SECTION 1.4 CLIMATE CHANGE

### What is Climate Change?

Climate change is influenced by the presence of greenhouse gases in the atmosphere, which can trigger changes in climate patterns across the globe. Climate change can also be defined as any changes in climate over time, whether due to natural variability or as a result of human activities. Changes can be found as follows:

- Temperatures are increasing or decreasing.
- Weather patterns are changing.
- Extreme weather events (such as floods and droughts), are becoming more common.
- Sea levels are rising (due to warmer oceans and melting ice caps).
- Oceans are becoming more acidic (due to their absorption of atmospheric CO<sub>2</sub>).
- Precipitation patterns are changing globally (some areas becoming wetter, while other areas are becoming drier).
- Seasonal patterns like monsoons are also changing.

Climate Variability	Climate Change
The way climate fluctuates yearly above or below a long-term average value and often used to denote deviations of climatic statistics over a given period of time (e.g. a month, season or year)	Long-term continuous change (increase or decrease) to average weather conditions or the range of weather.

## SECTION 1.5 CARBON CYCLE

Carbon is one of the most abundant elements on Earth. Most of the carbon is stored:

- as carbon dioxide (CO<sub>2</sub>) in the atmosphere,
- as biomass in land plants and soils,
- as fossil fuels in a variety of geologic reservoirs, and
- as a collection of ions in the ocean.

Carbon cycle is one of the biogeochemical processes that regulate the earth's climate (Figure 1.2). It circulates hundreds of billions of tons of carbon annually among countless terrestrial, oceanic and atmospheric sources. The excessive presence of carbon dioxide in the atmosphere is the main contributor to the greenhouse effect.

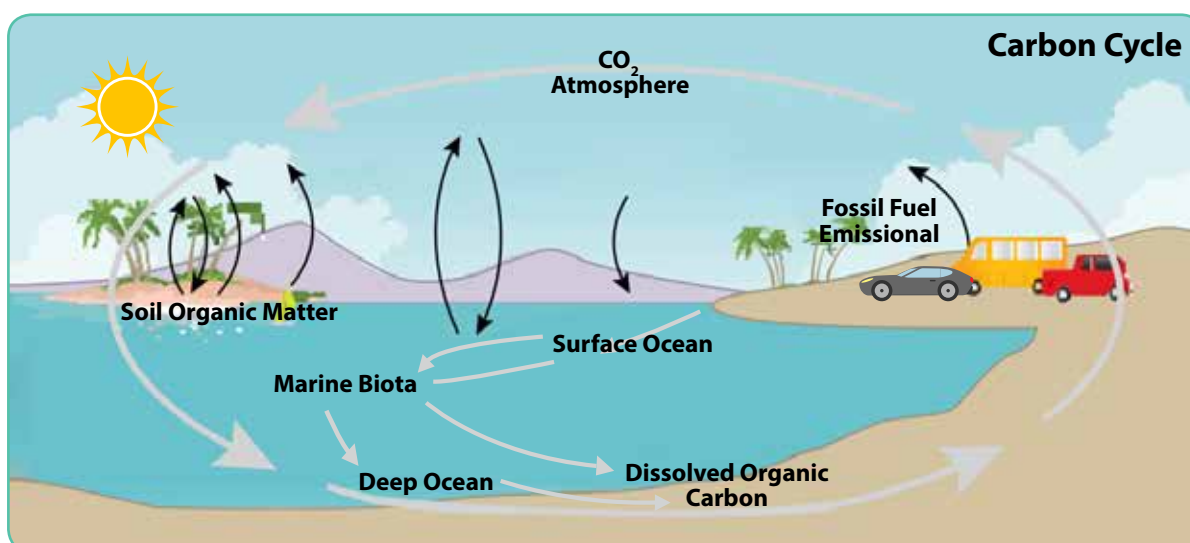


Figure 1.2: The Carbon Cycle

## SECTION 1.6 GREENHOUSE EFFECTS

Greenhouse gases are in the atmosphere, absorbing and holding heat, which causes the Earth's temperature to rise. The increase in greenhouse gases in the Earth's atmosphere is leading to the increase of the global temperature. The earth is getting warmer due to the greenhouse effect, whereby all the heat generated by solar energy hitting the earth's surface is reradiated back into space (Figure 1.3). Although the greenhouse effect is helpful in trapping some energy to keep the temperatures on our planet mild and suitable for living things, however, too much greenhouse gases can cause the atmospheric temperature to increase out of control.

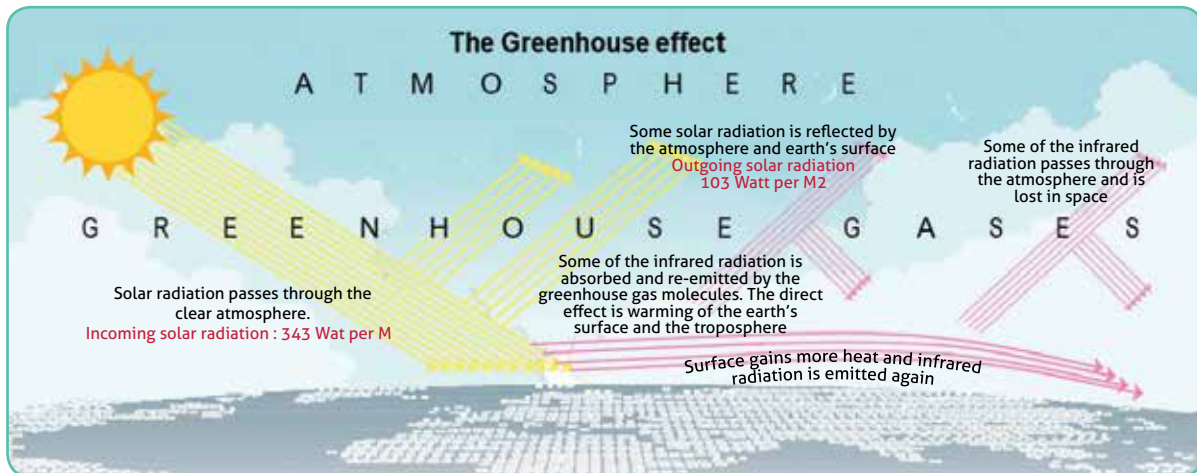


Figure 1.3: The Greenhouse Effect

## Causes of greenhouse effect

- Influenced directly by human activities
  - carbon dioxide (released through fossil fuel burning)
  - cement production,
  - deforestation;
  - methane (emitted by agriculture, livestock and organic waste)
  - biomass burning;
  - nitrous oxide (emissions increase due to use of agrochemicals)
- Influenced by non-human activities
  - even if humans stopped all activities that emit greenhouse gases, the impact of water vapour at current concentrations would continue to be experienced for generations. Non-human activities or by natural phenomena; e.g. volcanic eruptions, forest fires, etc.

Greenhouse Gases	Examples of Sectors Emitting Greenhouse Gases
Carbon dioxide ( CO <sub>2</sub> ) Methane (CH <sub>4</sub> ) Ozone (O <sub>3</sub> ) Water Vapour (H <sub>2</sub> O) Nitrous Oxide (N <sub>2</sub> O) Halocarbons	Tourism and Recreational Activities Mining Activities Transportation Production Industry Agriculture Open burning



**PART 1**  
**Teaching and Learning**

**MODULE 2**  
**Causes and Effects of  
Climate Change**

### Learning Outcomes

Participants will be able to:

1. Understand the causes and effects of climate change.
2. Describe the physical impacts of climate change such as sea level rise, ocean acidification, natural disaster and extreme weather.

## SECTION 2.1 IMPACTS OF HUMAN ACTIVITIES ON CLIMATE CHANGE

The main causes of climate change are due to human activities that include burning of fossil fuels, and conversion of forest land for urbanization and agriculture. Fossil fuel combustion mainly produces carbon dioxide, which is the main greenhouse gas that causes the climate change. Overall climate change effects driven primarily by carbon dioxide emissions are enhanced by emissions of other greenhouse gases such as nitrogen dioxide, ammonia gas, sulphur dioxide, methane, etc.

The land use change activities such as land-clearing, burning, deforestation and agriculture would alter the reflectivity and texture of the Earth's surface, thus changing the levels of absorbed radiation, evaporation and evapotranspiration. More importantly, the land use changes that involve removal of vegetation, such as deforestation, would reduce the land's capacity to absorb carbon dioxide, reduces the ability of soils to retain moisture, and may inhibit rainwater infiltration, commonly exacerbating erosion. The decay of plant biomass from land clearing activities contributes to CO<sub>2</sub> and methane emissions. Methane gas is produced by bacteria that live in landfill sites, piles of decaying plant biomass, peat bogs and in the guts of herbivorous animals like cows and sheep. Nevertheless, the methane gas does not last long in the atmosphere and is not released in large quantities compared to the man-made CO<sub>2</sub>, thus the latter has by far the greatest influence on global climate change. However, it should be noted that the methane's impact is 21 times Global Warming Potential compared to CO<sub>2</sub>, which means 1 kg CH<sub>4</sub> has the same effect of 21 kg CO<sub>2</sub>. There are evidences that show the global warming is primarily caused by human activities, which release significant amounts of carbon into the atmosphere (Figure 2.1).



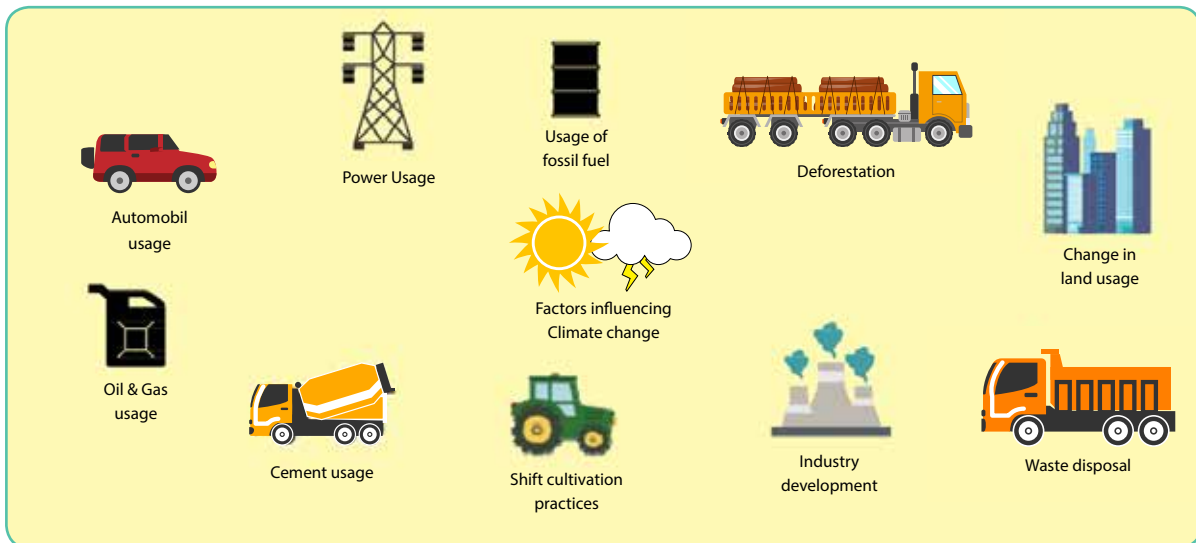


Figure 2.1: Impacts of Human Activities on Climate Change

## SECTION 2.2 OCEAN ACIDIFICATION

Carbon dioxide released from burning of fossil fuels into Earth's atmosphere, not only leads to a warmer Earth, but also changes the chemistry of Earth's oceans. The ocean acts as a carbon sink, which means it absorbs  $\text{CO}_2$ , and removes  $\text{CO}_2$  from the atmosphere. Currently, the ocean absorbs about one-third of the  $\text{CO}_2$  released into the atmosphere by the burning of fossil fuels. When  $\text{CO}_2$  dissolves in seawater,  $\text{CO}_2$  forms a weak acid, carbonic acid, that leads to decreased pH levels of the seawater (Figure 2.2). At high concentrations of atmospheric  $\text{CO}_2$ , high amount of  $\text{CO}_2$  absorption occurs, thus creating high acidity in the ocean, resulting in negative (adverse) impacts on marine life. This scenario is referred to as ocean acidification.

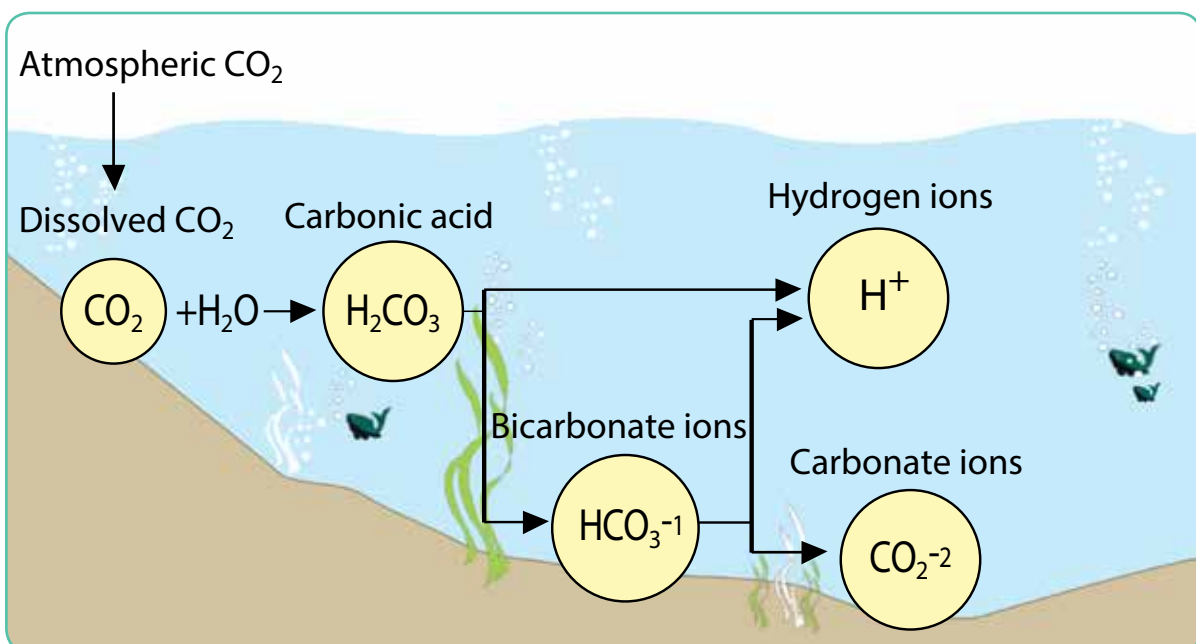


Figure 2.2: Schematic Diagram on Ocean Acidification Process

Ocean acidification gives significant adverse impacts to the marine organisms. As sea acidity increases, phytoplankton is reduced, resulting in less aquatic plants being able to uptake the greenhouse gases. More importantly, increased sea acidity threatens marine life such as corals and shellfish, impacts which are called coral bleaching or coral erosion; because the less alkaline seawater would decrease the amount of carbonate ions available for many marine organisms to form the calcium carbonate of their hard parts. How does increased acidity affect corals and shellfish?

- The calcium carbonate ( $\text{CaCO}_3$ ) in coral reefs and in the shells of other marine calcifiers comes in two different mineral forms, i.e. calcite and aragonite.
- When seawater acidity increases, this would decrease the aragonite saturation, and subsequently reduce the ability of coral polyps to create  $\text{CaCO}_3$  to build or rebuild their skeletons.
- Due to reduction in aragonite saturation levels, the coral polyps must divert energy from other important life functions to elevate ion concentrations within the immediate area of the coral tissue to allow it to continue creating its aragonite framework.
- If the coral polyps cannot produce  $\text{CaCO}_3$  quickly enough, the coral reef as a whole will stop growing and begin to erode.

According to the National Oceanic and Atmospheric Administration (NOAA), at least 19% of the world's coral reefs are already gone. An additional 15% could be gone within 20 years and, if global warming continues unchecked, all corals could be extinct within 100 years. The loss of coral reef habitat has detrimental implications for coastal fisheries in small islands where reef-based subsistence and tourism activities are often critical to the wellbeing and economies of islands (Bell et al., 2011). For example, acidification and loss of coral reefs have an impact on tourism sector which can contribute to loss of household income. The fish that we eat make their homes around the coral reefs, and if the reefs are dead, problems such as hunger, poverty and political instability could follow. In Kimbe Bay, Papua New Guinea, 65% of coastal fish are dependent on living reefs at some stage in their life cycle, and following degradation of the reefs have resulted in a decline of fish abundance (Jones et al., 2004).

Ocean acidification and loss of coral reefs has an impact on tourism sector, where women make up 40% of this sector. This can contribute to loss of income for a large number of women. Loss of coastal fisheries will impact men and women who use the landscape to earn money for their households in both the formal and informal market. Loss of economic opportunities can exacerbate existing inequalities between men and women and between income groups.

## SECTION 2.3 SEA LEVEL RISE

One of the most widely recognized climate change impacts to low-lying coastal areas is sea level rise (Church & White, 2011). The impact of sea level rise is particularly important in small islands where the majority of human communities and infrastructure is located in the coastal zones of the islands. Global sea level has risen at a rate of more than 1 mm per year (IPCC, 2014) and this will continue for centuries and perhaps millennia, regardless of what humanity does about greenhouse gases. Nevertheless, rates of sea level rise are not uniform across the globe and large regional differences have been detected, where in some parts, rates have been significantly higher than the global average.

Due to global warming, significant polar ice melting that occurred over the past few decades is said to be the main cause of sea level rise. When glaciers and land-based ice melt, the water runs into the sea and increases its level. If the ice keeps melting, the global sea level could rise enormously and this would put coastline areas under water, and perhaps small islands could disappear. Besides ice melting, thermal expansion of the oceans also contributes to the rise of sea level. When temperature increases, water expands as it warms; thereby the warmer water takes up more volume, which would result the increase in seawater level.

Moreover, a variety of other factors could also influence sea level, including gravity, ocean currents, atmospheric pressure, changes in ocean basin volume due to deformation on the sea floor and tectonic movements, salinity, etc., nevertheless these factors are much less important because they are smaller in numbers and take effect at much longer time scales than the previous described factors.

### Effects of Sea Level Rise

The increase of global sea level mainly affects coastal ecosystems and survival of the species that live in these habitats. Most coastal areas contain ecologically and economically important habitats such as tidal wetlands and sea grass beds, which may also be at risk from sea level rise. The impacts of sea level rise on the coasts will be felt most severely during storm surges and storm wave events and at times of high tides. Among physical effects of local sea level rise are listed as follows:

- Displacement of coastal lowlands and wetlands.
- Increased coastal erosion.
- Increased flooding (frequency and depth) - inundation by salt water.
- Salinization of surface and groundwater due to salt water intrusion.
- Groundwater rise.

On many small islands, coastal plains are among important land areas for agriculture. These areas face threats due to sea level rise, whereby coastal erosion occurs and the land areas might be inundated by the seawater. The erosion and inundation of the agricultural lands contribute to social and economic impacts, of which the

magnitude of the impacts varied among islands. For instance, on a high island such as Viti Levu in Fiji, and in a low island of Tarawa, Kiribati, the cost damages estimated by 2050 could be in the range of USD23-52 million per year (2-3% of GDP) and USD8-16 million (17-18% of GDP), respectively (World Bank, 2000). Briefly, the socioeconomic impacts of local sea level rise are summarized as follows:

- Loss of property and land.
- Loss of property value due to increased risk.
- Loss of agricultural capacities.
- Impacts on agriculture and aquaculture through decline in soil and water quality.
- Increased flood risk/loss of life.
- Damage or loss of coastal protection works and other infrastructure.
- Loss of renewable and subsistence resources.
- Loss of tourism, recreation, and coastal habitats.

## SECTION 2.4 SEA SURFACE TEMPERATURE RISE

Global climate change has also influenced sea surface temperature. The sea surface temperature had risen by about one degree Celsius over the past century and is expected to increase by up to another three degrees in the next 100 years if GHG emissions continue at current rates. Rising air temperatures affect the physical nature of the oceans. As air temperatures rise, seawater becomes less dense and separates from a nutrient-filled cold layer below. This is the basis for a chain effect that has an impact on all marine life that relies on these nutrients for survival. General physical effects of sea warming on the marine population that are crucial to consider, namely, changes in natural habitats and food supply, and changing sea chemistry or ocean acidification.

Rising sea temperatures influence various kinds of sea conditions, which result in adverse influence on the survival of microscopic phytoplankton, the base of food web in the marine ecosystem. Phytoplankton comprises one-celled plants that live at the ocean surface and use photosynthesis for nutrient fulfilment. Photosynthesis process produces food in plants which converts atmospheric carbon dioxide into organic carbon and oxygen in presence of sunlight. Sea warming would decline the abundance of algae that produce food for other marine life; this would limit the food sources, and thus would affect the survival of the marine species.

The increased sea temperature will also contribute to coral bleaching, of which this impact is also caused by ocean acidification. The rising water temperatures block photosynthetic reaction that results in a build-up of products that poison the marine algae consumed by the corals. The corals react to this by spitting out the algae, but in the process some of its own tissues are also spitted out, leaving the coral bleached white. If temperatures remain too high for too long and bleaching persists, the corals die. The bleached corals can recover, but only if cooler water temperatures return and the algae are able to grow again. If not, the corals slowly starve to death. Also, the coral polyp has tiny tentacles that function as appendages

to snatch passing plankton for food. With high sea surface temperature, the number of plankton would decline because of the unsuitable environment. This would affect coral reef population because of reduction in terms of food sources. Moreover, coral reefs are very fragile and sensitive ecosystems that can only tolerate a narrow temperature range.

## SECTION 2.5 NATURAL DISASTER AND EXTREME EVENT

Natural disasters are extreme, sudden events caused by environmental factors that cause emergency situations and pose significant danger to life and property. Climate change induced natural disasters include typhoons, hurricane and cyclones, heavy rain and flooding that disrupt daily lives, destroy vital infrastructure (including transportation networks), water and energy supply, human dwellings, business premise, crops, livestock and properties in the affected zones.

Climate change processes could intensify the hydrological cycle, leading to abnormal frequencies in the occurrence and intensity of climatologic events. This could be manifested by more severe tropical storms, more intense, temporally variable precipitation (i.e. heavy and prolonged downpours) leading to more severe and frequent floods. There are real concerns that rising sea levels associated with global warming and extreme events could inundate and threaten the very existence of some small islands and atoll nations.

Current and future climate-related drivers of risk for small islands pertaining to natural disasters include sea level rise, tropical and extra-tropical cyclones, increasing air and sea surface temperatures, and changing rainfall patterns that lead to severe floods and prolonged inundation. The key climate and ocean drivers of change that impact small islands include variations in air and ocean temperatures and chemistry, rainfall, wind strength and direction, sea levels, wave climate and ocean chemistry, the interactions and dynamics of which could all be manifested in extreme events such as tropical cyclones, drought and storm swell events. All these have variable impacts, dependent on the magnitude, frequency, temporal and spatial extent of the event, as well as on the bio-physical nature of the individual island itself, its political and socioeconomic setting.

Sudden extreme events like rainstorms and cyclones can create more havoc and wreak destruction in developed urban settlement areas compared to isolated uninhabited areas or the open sea. More significantly, the aftermath of such events can result in flooding, i.e. from excessive rain on land or over water, leading to sudden overtopping or overflowing of river banks or coastlines and inundating the surrounding floodplain and low-lying areas (UNESCO, 2011). The negative impacts of flooding include destruction of natural habitats, crops, livestock, homes, and properties; degradation in the water quality; loss of natural vegetation and animals, and potential spread of communicable diseases. Flooding puts life and property at risk as well as causing surface water pollution by overloading both the natural rivers and the artificial drainage. In addition, such natural disasters effects communities

including person with disability, women and children who are more vulnerable and susceptible to experiencing hazards from natural disasters more than others. Poor communities without a sound disaster-response infrastructure that caters to all community members are also at risk of being greatly affected by the impact of such sudden extreme events.

Climate change will affect disaster risks in two ways, i.e. firstly more extreme weather and climate related hazards will increase the frequency and intensity of natural disasters; and secondly, climate change and climate related hazards will increase the vulnerability of communities to natural hazards, particularly through sudden loss of lives and properties, ecosystem degradation, reduction in water and food availability and significant adverse changes to livelihoods (refer to relevant sections of Modules 2, 3 and 4 for further details on adaptation and mitigation measures in facing natural disasters).

### Suggested Reading Materials:

Webb, E. L., D.A. Friess, K.W. Krauss, D.R. Cahoon, G.R. Guntenspergen & J.Phelps. 2013. A Global Standard for Monitoring Coastal Wetland Vulnerability to Accelerated Sea Level Rise. *Nature Climate Change* 3, 458–465.

Rayner, S. and E.L. Malone. 2001. Climate Change, Poverty, and Intragenerational Equity: The National Level. *International Journal of Global Environment Issues*. 1: 2, 175–202.

UNICEF. 2007. *Climate Change and Children*. Retrieved from [https://www.unicef.org/publications/files/Climate\\_Change\\_and\\_Children.pdf](https://www.unicef.org/publications/files/Climate_Change_and_Children.pdf)



**PART 1**  
**Teaching and Learning**

**MODULE 3**  
**Sectoral Impacts of and**  
**Vulnerability to Climate Change**

## Learning Outcomes

Participants will be able to:

1. Describe the major sectoral impacts of and vulnerability to climate change.
2. Analyse the impacts and vulnerability in key sectors due to climate change.

## SECTION 3.1 INTRODUCTION TO IMPACTS AND VULNERABILITY

In recent decades, changes in climate such as sea level rise, heat waves, droughts, floods, hurricanes and cyclones have caused adverse significant impacts on the natural and human systems on all continents and across the oceans. The impacts include disruption of food production and water supply, damage to infrastructure and settlements, alteration of ecosystems, disrupted livelihoods for island populations and consequences for human health and wellbeing. Thus, climate change impacts pose serious threats and vulnerability to the community and nation, especially in AP SIDS because of limited size, proneness to natural hazards and low adaptive capacity.

The terms 'Impacts' and 'Vulnerability' defined for better understanding the sectoral impacts of and vulnerability to climate change. The definitions used in the IPCC's Working Group II (WGII) of Fifth Assessment Report (AR5) (IPCC, 2014) are as follows:

### Impacts

- Impacts primarily refer to the effects on natural and human systems of extreme weather and climate events, and climate change.
- Impacts generally refer to effects on lives, livelihoods, health, ecosystems, economies, societies, cultures, services, and infrastructure due to the interaction of climate changes or hazardous climate events occurring within a specific time period and the vulnerability of an exposed society or system.
- Impacts also referred to as consequences and outcomes. The impacts of climate change on geophysical systems, including floods, droughts, and sea level rise, are a subset of impacts called physical impacts.

### Vulnerability

- Vulnerability is the propensity or predisposition to be adversely affected.
- Vulnerability encompasses a variety of concepts and elements including sensitivity or susceptibility to harm and lack of capacity to cope and adapt.



## SECTION 3.2 FOOD SECURITY, LIVELIHOOD AND GENDER INEQUALITY

Small island countries are particularly vulnerable to climate change, since most of its population depends on agriculture and fisheries for its livelihood and food security. Its impacts will be both short term and long term, resulting from more frequent and more intense extreme weather events, caused by changing temperatures and precipitation patterns. The first likely to be affected are people whose livelihood depends on agriculture-based livelihood systems that are already vulnerable to food insecurity. Some of the risk are increased crop failure, new patterns of pests and diseases, lack of appropriate seeds and planting material, and loss of livestock.

### Food Security

Climate change will affect all four dimensions of food security; food availability, food accessibility, food utilization and food systems stability (FAO, 2008). (Figure 3.1)

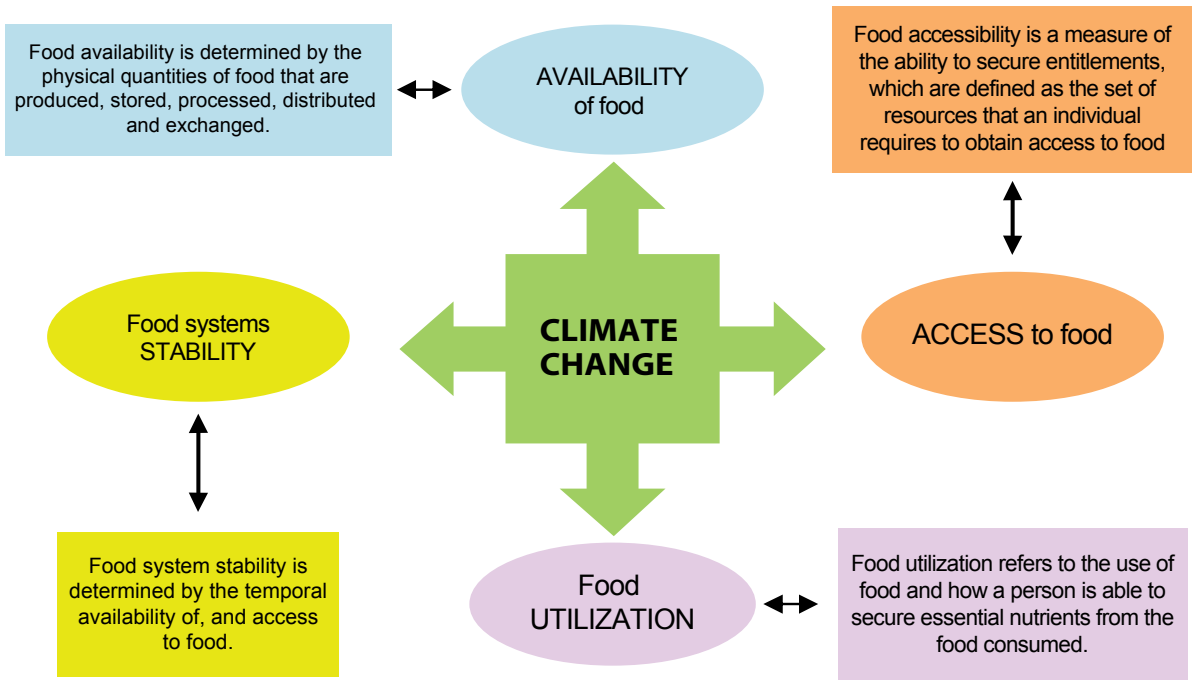


Figure 3.1: Interrelation of Climate Change, Food Security and Livelihood  
(Source : Adapted from FAO, 2008)

## How Climate Change Affects Food Security

- The accumulation of greenhouse gases in the atmosphere has resulted in the rising of the global temperatures. This is due to the burning of fossil fuels (coal, oil and gas) to meet the increasing energy demand, and the massive agriculture activities to meet the increasing food demand, which have also resulted in deforestation.
- Climate change affects food security, and food system (Figure 3.2) at the global, national and local level.
- It will impact food production and its distribution channels, as well as changing purchasing power and market flows.
- It will also affect human health, livelihood assets and gender inequality.
- Its impacts will be both short term and long term. Depending from the result of more frequent and more intense extreme weather events, or caused by changing temperatures and precipitation patterns which might exacerbate existing levels of poverty, gender and social inequalities, and scarcity of existing resources.

### FOOD SYSTEM ACTIVITIES

Producing food: natural resources, inputs, technology... Processing and packaging food: raw materials, standards, storage life... Distributing and retailing food: transport, marketing, advertising... Consuming food: acquisition, preparation, socializing...

### FOOD SYSTEM OUTCOMES CONTRIBUTING TO:

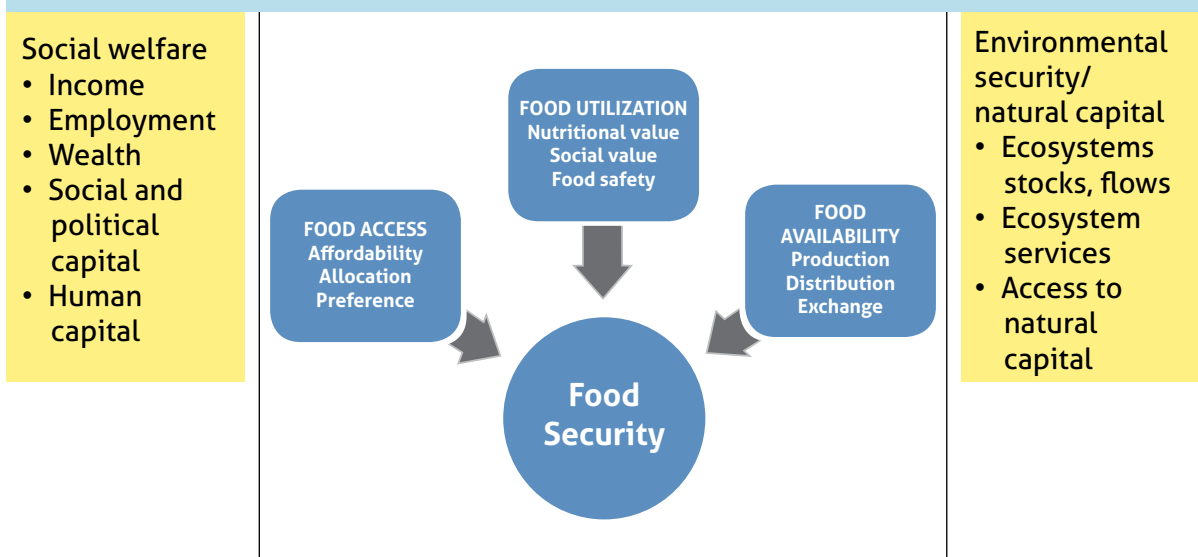


Figure 3.2: The Food System

## Livelihood

*"A livelihood comprises the capabilities, assets (including both material and social resources) and activities required for a means of living. A livelihood is sustainable when it can cope with and recover from stresses and shocks and maintain or enhance its capabilities and assets both now and in the future, while not undermining the natural resource base" (Carney, 1998).*

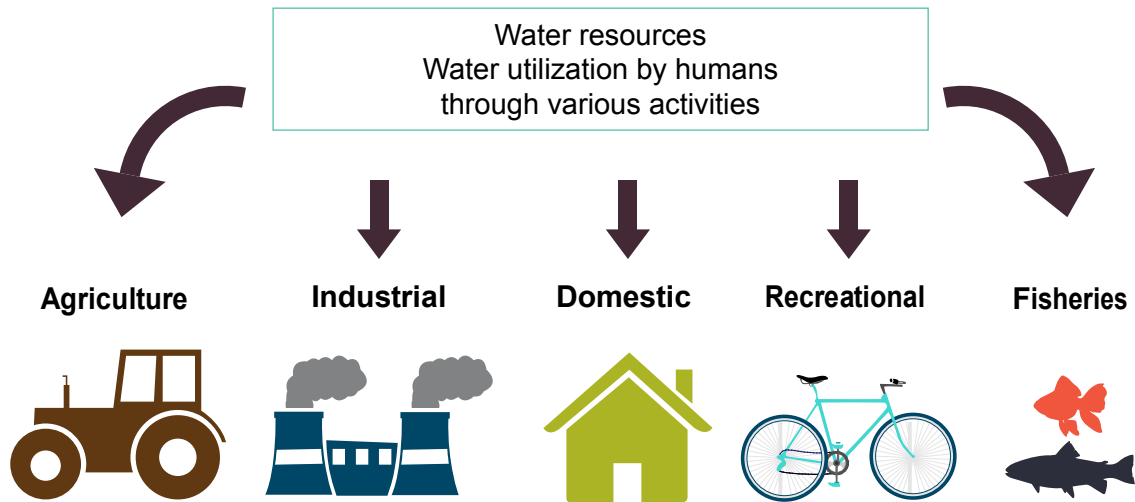
- Many elements heighten the vulnerability of the local people to climate change impacts and one important aspect is that their livelihoods are highly dependent on climate-sensitive sectors such as tourism, agriculture and fisheries.
- Climate change can and has altered many physical environments leading to the changes and loss of flora, fauna and other natural resources upon which the livelihoods of local people depend. Moreover, rising temperature and declining precipitation also disrupt or jeopardize the agriculture sector, thus aggravating food security issues in that particular region.
- If climate change remains uncontrolled there will be huge implications on our way of life, especially on livelihoods.

## Gender Inequality

- Women play a significant role in informal activities within the private sector in the Pacific Islands. Their focus is predominantly home-based subsistence agriculture, marketing of agricultural products and petty trading.
- Livelihood scarcity can exacerbate existing societal pressures and gender inequalities within the household and between women and men.
- Changes in access to livelihood opportunities and economic security for women may increase their vulnerability to domestic violence that would upset individual girls, women, families, communities, and the overall economy of Pacific Island States.
- It is important to recognize that woman should not be seen as simply victims to the impacts of climate change, but rather as opportunities for strengthening adaptation to climate change and building resilient communities to natural

disasters.

## SECTION 3.3 WATER RESOURCES



- Climate change is generating main concerns regarding water resources due to its impacts on the planet's hydrology. Hydrology comprises the circulation, movement, and quality of water in the Earth system (Figure 3.3).

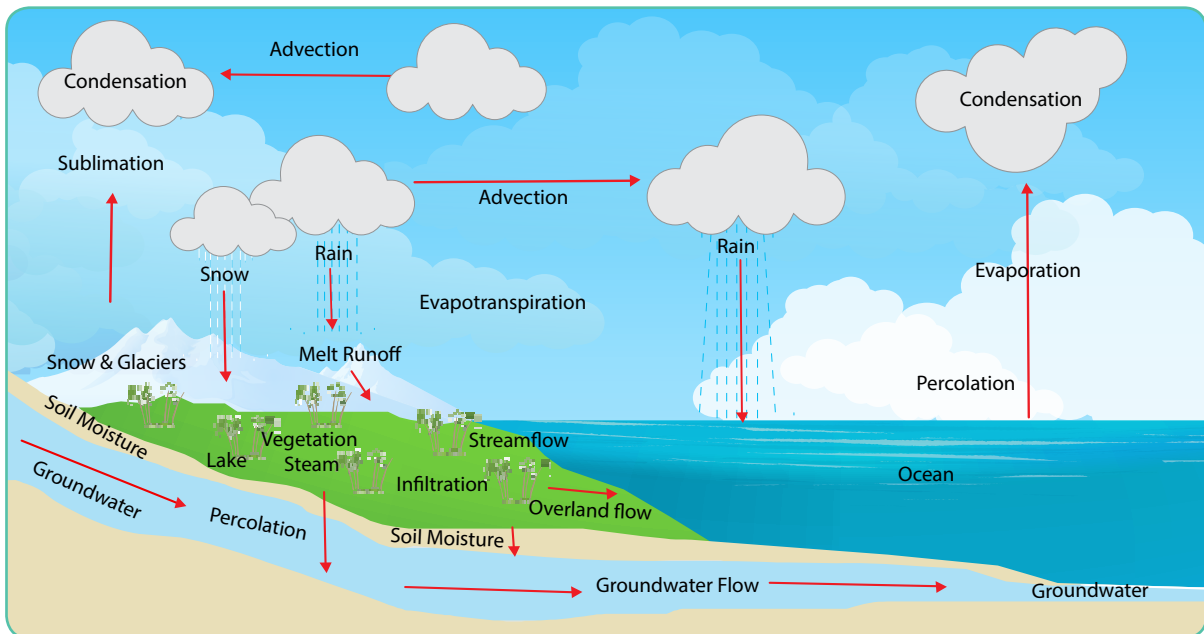
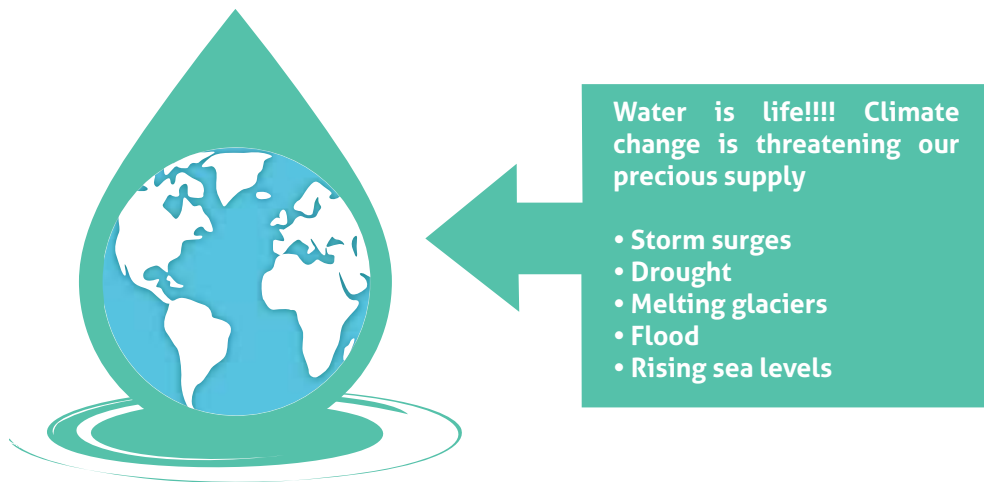


Figure 3.3: The Hydrologic Circle

- The sustainability of water supplies in future will be in jeopardy due to climate change and eventually its quality will likely decrease, impacting people's health and food supplies.



- Humans need to adjust the ways they use water because the adverse impacts of climate change on hydrologic cycle would result shortage in water supply.
- The social and economic development of the small islands often face limitation owing to the scarcity of fresh water.

## SECTION 3.4 ECOSYSTEM AND BIODIVERSITY

Among the most widely recognized climate change threats to small islands and low-lying coastal areas are sea level rise, inundation, and shoreline change and ocean acidification. Projected sea level rise of between 30-50 cm by 2050 would threaten low islands, while a 1 meter rise by 2100 would render some island countries unliveable and inhospitable (Tegart et al., 1990). Mangroves, coral reefs and sea grass habitats, which provide a wide range of ecosystem goods and services, are among the most vulnerable to climate change impacts in small islands, thus playing a significant role in affecting the livelihood and wellbeing of small island communities (Polidoro et al., 2010; Waycott et al., 2009, 2011).

### Coral Reefs

Among the most important resources in small tropical islands are coral reefs, which play a vital role in protecting these islands and atolls from extreme events and in supporting a rich biodiversity of marine life. Among the vital functions of coral reefs are dissipating wave energy and supplying sediment to island shores, thus protecting the shoreline and reducing the potential for coastal erosion. The rich habitats of coral reefs support a high diversity of marine species upon which many island communities are dependent for subsistence foods, besides anchoring beach and reef-based tourism and other socioeconomic activities and functions.

However, it is well documented that the coral reef ecosystems are very sensitive to climate change impacts such as temperature rise leading to thermal stress, and increasing CO<sub>2</sub> levels leading to increased coral bleaching and reduced reef calcification rates. For instance, unprecedented bleaching in Kiribati (Phoenix Islands)

reportedly caused almost 100 per cent coral mortality in the lagoon and 62 per cent mortality on the outer leeward slopes of the otherwise pristine reefs of Kanton Atoll during 2002/2003 (Alling et al., 2007). The global incidence and implications of temperature-related coral bleaching in small islands are well documented and combined with the effects of increasing ocean acidification these stressors could jeopardize the function and persistence of island coral reef ecosystems.

Studies have shown that although island reefs have variable responses and limited defences to climate change impacts, some are more resilient than others in facing the threats and recovering from thermal stress, ocean acidification and coral bleaching. Likewise, reduced water quality could increase their vulnerability to climate change and other environmental stresses. A study of over a 40-year period (1960s–2008) reported that the reefs of the Grand Recif of Tulear, Madagascar suffered severe deterioration due to direct anthropogenic disturbance, despite an average 1°C rise in temperature over this period (Harris et al., 2010). Coral recovery from the 2004 bleaching event in the central Pacific atolls of Tarawa and Abaiang (Kiribati) had improved in the absence of direct human impacts (Donner et al., 2010) and isolation of bleached reefs was shown by Gilmour et al. (2013) to be less inhibiting to reef recovery than direct human disruption. Coastal fisheries are badly affected by loss of coral reef habitat in small islands (Pratchett et al., 2009), where reef-based subsistence and tourism activities are often critical to the wellbeing and economies of these islands (Bell et al., 2011). Higher temperatures also affect larval recruitment and the spawning of adult reef species (Munday et al., 2009; Donelson et al., 2010). For example, Jones et al. (2004) reported from their studies in Kimbe Bay, Papua New Guinea that 65 per cent of coastal fish are dependent on living reefs at some stage in their life cycle and that fish abundance sharply declined following degradation of the reef system.

### Mangroves

Mangroves form a diverse group of unrelated trees, shrubs, palms, vines and ferns that share a common ability to live in waterlogged saline soils subjected to regular flooding. These highly specialized plants have developed unusual adaptations to the unique abiotic conditions in which they are found. Mangrove forests are important habitats that support a unique assemblage of organisms and provide many ecosystem functions such as coastal protection, and serve as nurseries for marine fishes (Rönnbäck, 1999).

Mangrove also acts as a source of organic carbon to the adjacent coastal ecosystem and a sink for atmospheric carbon dioxide (Yanai et al. 2006, Bouillon et al. 2008). The wide range of ecological services provided by mangrove include protection against extreme events (storm surges, floods and hurricanes), reduction of shoreline and riverbank erosion, as well as supporting a rich biodiversity of flora and fauna. These services are key features which sustain economic activities in the coastal

areas throughout the tropics. Besides the multiple ecological services provided by the mangrove ecosystem, a wide range of direct and indirect natural products from mangroves are vital to subsistence economies and provide a commercial base for the local and national economies.

Commercial and traditional products range from timber to charcoal and from tannins to medicines. A variety of food products are also harvested directly within the mangrove system through hunting, gathering, and fishing activities by the local communities. Mangroves in particular, provide natural coastal protection from erosion and storm events, while serving a host of commercial and subsistence uses to the local communities (Ellison, 2009; Krauss et al., 2010). The loss of mangrove species will have significant adverse economic and environmental impacts for coastal and island communities, especially in those areas with low mangrove diversity and high mangrove area or species loss.

The most significant climate change threat to the survival of mangroves is sea level rise and the inability of mangroves to tolerate increased water depth at the seaward margin (Waycott et al., 2011). In the Caribbean and tropical Pacific islands, sea level rise is somewhat attenuated by variable rates of sediment deposition in the mangroves forests (McKee et al., 2007; Krauss et al., 2003). Coastline accretion can occur where additional sediment inputs can be received from terrestrial runoff in the mangrove area.

## Seagrass

Seagrass is an ecologically important marine habitat that forms the basis of many complex ecosystems of the sea. The seagrass sheltering effects and abundant food supply makes it the preferred breeding site, nursery ground and temporary shelter for fishes and crustaceans. Turtles and dugongs are important herbivores that graze solely upon the seagrass beds. The thick seagrass vegetation generates a great quantity of organic material, and offers a good substrate for epiphytic small algae, microflora and sessile invertebrates. Many small animals and marine life take advantage of the unique microhabitats created by the mats of rhizomes of the seagrass plant itself. Thus, the seagrass beds serve as a very important sink for carbon sequestration.

The invertebrates are very important communities in seagrass beds as the ecosystem thrive based on the detrital food chain (Howard et al., 1989). Contrary to most ecosystems, in which higher trophic levels feed on living plant materials, seagrass systems are generally detrital in nature; i.e. energy transfer and foods are provided through dead plant material and associated microflora and fauna. Most invertebrates are secondary producers, which transfer energy to higher trophic levels; thus maintaining the delicate food chains from collapsing (Heck et al., 1995).

According to Ogston and Field (2010), sea level rise of 20 cm may double suspended sediment loads and turbidity in shallow waters, with negative impacts to photosynthetic species on the fringing reefs of Molokai, Hawaiian Islands.

Temperature stress is the main expected climate change impact on seagrass that can cause massive seagrass diebacks (e.g. Campbell et al., 2006; Waycott et al., 2011). A six-year study of seagrass beds in the Balearic Islands of Western Mediterranean (Marbá and Duarte, 2010) reported that shoot mortality and recruitment rates were adversely affected by higher temperatures. Seagrass also give complex and variable responses to climate change. Increased sedimentation and water depth, as well as reduced sunlight could retard the growth and proliferation of various seagrass species (Campbell et al., 2006; Ralph et al., 2007).

### SECTION 3.5 HEALTH AND SAFETY

Climate change is affecting our health and safety, in all sectors of society. Extreme events such as intense hurricanes, extreme heat waves, degraded air quality, rising sea levels and changes in precipitation resulting in flooding or droughts, will affect directly and indirectly the physical, social, and psychological wellbeing of humans. Increase in the greenhouse gases and other pollutants that change the global climate will also result in human health impacts. Climate change can be the trigger of the spread of diseases, as well as worsen human health particularly in vulnerable groups such as children, the elderly and sufferers of other respiratory ailments. A report by the Interagency Working Group on Climate Change and Health (Portie et al., 2010), listed a few highlights of allergies and disease likely to be affected by climate change as follows :

- **Vector borne and Zoonotic Diseases**

Disease risk may increase due to expansions in vector ranges, shortening of pathogen incubation periods, and disruption and relocation of large human populations.

- **Waterborne Diseases**

Precipitation frequency, increases in water temperature, evaporation-transpiration rates, and changes in coastal ecosystem health could increase the rate of water contamination with harmful pathogens and chemicals, resulting in increased human exposure.

- **Weather-Related Morbidity and Mortality**

Increases in the occurrence and intensity of extreme weather such as hurricanes, floods, droughts or cyclones, may affect people's health immediately during the disaster or later following the aftermath.

- **Asthma, Respiratory Allergies, and Airway Diseases**

Can be widespread because of increased human exposure to pollen (due to altered growing seasons), moulds (from extreme or more frequent precipitation), air pollution and aerosolized marine toxins (due to increased temperature, coastal runoff, and humidity) and dust (from droughts).

- **Cancer**

Due to increased duration and intensity of ultraviolet (UV) radiation.

- **Cardiovascular Disease and Stroke**

Due to increasing heat stress, increasing the body burden of airborne particulates, and changing the distribution of zoonotic vectors that cause infectious diseases linked with cardiovascular disease.



- **Foodborne Diseases and Nutrition**

Staple food shortages, malnutrition, and food contamination (of seafood from chemical contaminants, bio toxins, and pathogenic microbes, and of crops by pesticides), may be associated with climate change.

- **Heat-Related Morbidity and Mortality**

Heat-related illness and deaths are likely to increase in response to climate change due to rising temperatures in certain regions. Pregnant women are more susceptible to developing hypertension from high humidity.

## SECTION 3.6 ENERGY

Climate change presents increasing challenges for the energy demand, energy production, transmission and distribution. Climate change phenomena such as global warming, changing weather pattern, and increase in extreme weather events will have particular impacts on the energy sector. The impacts of climate change on energy sector are described in Table 3.1 and shown in Figure 3.4.

Table 3.1: Impacts of Climate Change on Energy Sector

Energy Demand	<ul style="list-style-type: none"> <li>• Higher average temperatures, together with increasing magnitude and frequency of extreme heat events escalate the demand for electricity/power, transport and industrial activities, which contributes to higher energy consumption.</li> </ul>	
Energy Production	Power Stations and other sources (e.g. thermal and hydroelectric stations)	<ul style="list-style-type: none"> <li>• The rise in global temperature may also affect electricity generation which affect thermal power plants. Although thermal power plants (currently providing about 80% of global electricity) are designed to operate under diverse climatic conditions, but it would also be affected by the decreasing efficiency of thermal conversion as a result of rising temperatures.</li> <li>• Changes in rainfall distribution and water evaporation due to increased temperatures significantly affect water resources and operation of reservoirs/water storage and hydroelectric power stations. However, a decline in rainfall levels and a rise in temperature, leading to increased water loss, could result in reduced power operations, reduced capacity or even temporary shutdowns</li> </ul>
	Renewable Energy (e.g. solar energy, wind energy, biogas etc.)	<ul style="list-style-type: none"> <li>• Changing weather patterns and extreme weather events present challenges to renewable energy such as solar, wind and biogas energy. An anticipated increase in cloudiness would affect solar energy outputs, while an increase in the number and severity of storms could damage equipment and infrastructure for solar and wind energy generation, thus reducing the potential generation capacity.</li> </ul>
Energy Transmission and Distribution	<ul style="list-style-type: none"> <li>• Climate change induced natural disasters including typhoons, heavy rain and flooding could affect power plants infrastructure including energy transport and other settlements in coastal areas. For example, storms and strong winds could damage electricity grids/power lines.</li> </ul>	

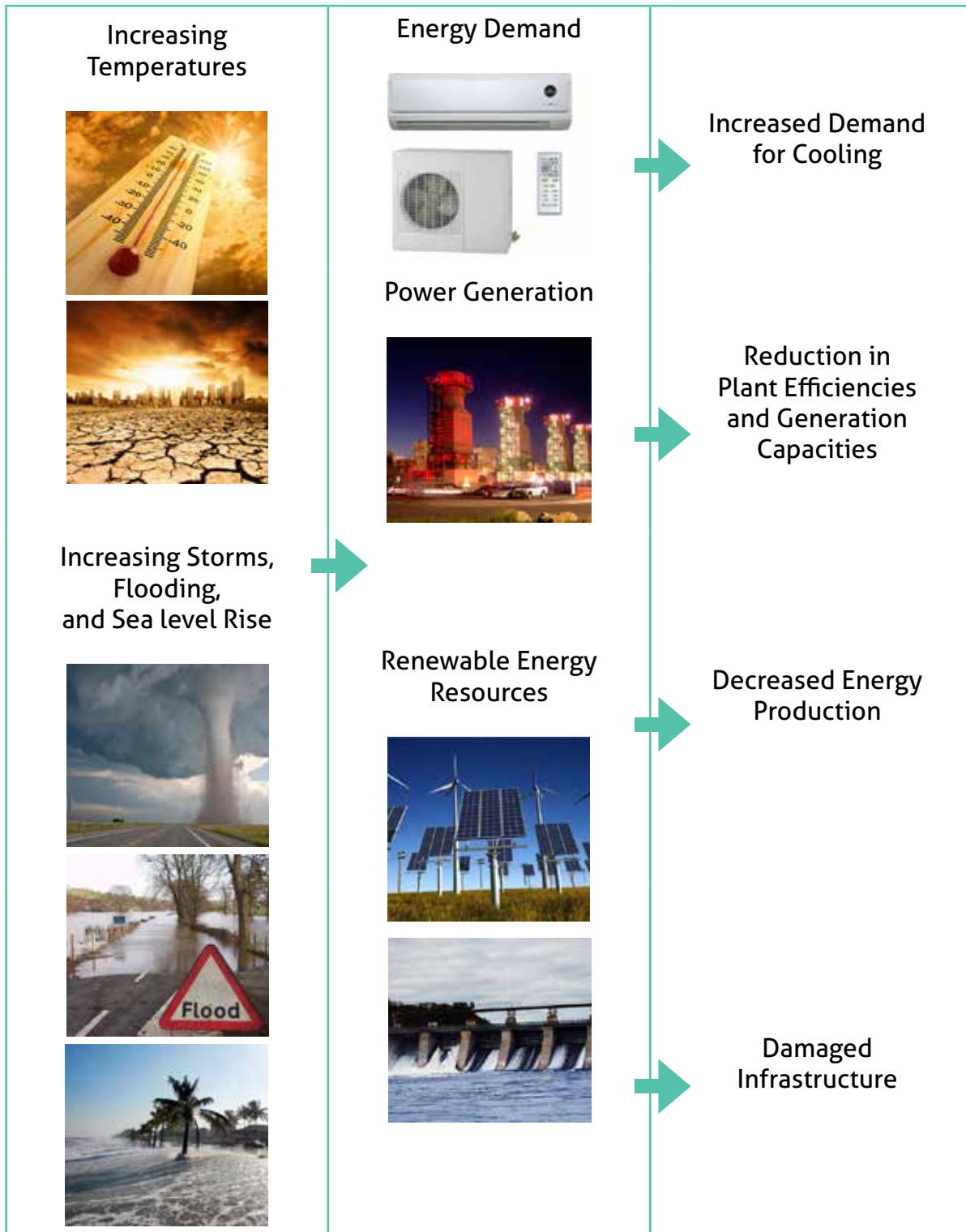


Figure 3.4: Impacts of Climate Change on Energy Sector

## Vulnerability in SIDS Energy Sector due to Climate Change

Energy sector in SIDS is heavily dependent on imported fossil fuels. Due to the global climate change, energy production, transmission and distribution or energy supply are going to be affected as follows:

- Extreme climate conditions (increasing temperature and decreasing water availability) contribute to increased electricity and energy demand that affect the efficiencies and capacities of energy generation and energy security. Increased energy demand also leads to increased carbon emissions;
- Increasing climate and disaster events such as flooding, sea level rise, storms and cyclones damage infrastructure and settlements which affect energy production, transmission and distribution as well as renewable energy resources.

Thus, energy sector in SIDS faces the challenges of high energy cost, fuel price and energy supply vulnerability, fiscal imbalances, and institutional capacities as elaborated in Figure 3.5.

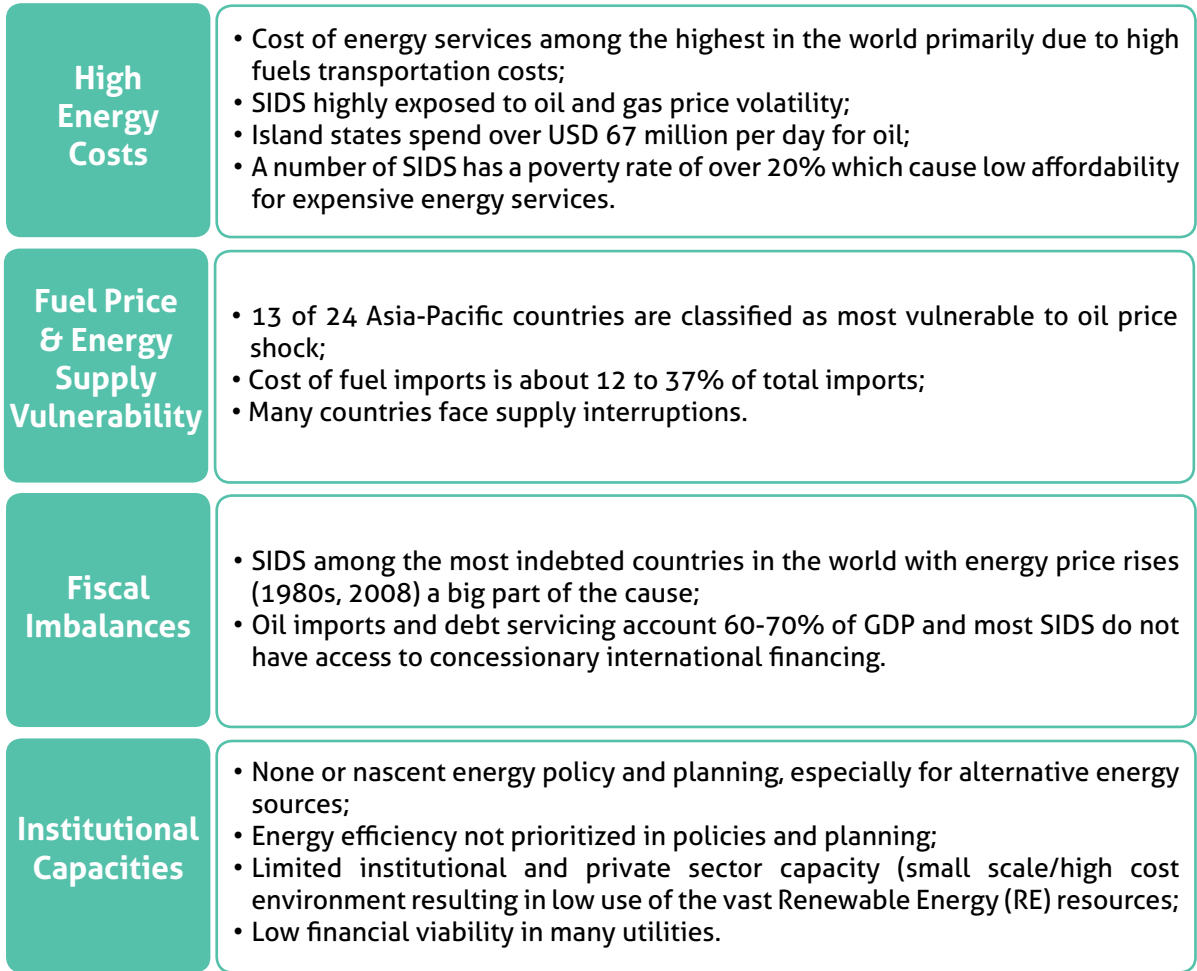


Figure 3.5: Challenges of Energy Sector in SIDS (Adapted from Feinstein, 2014)

## Carbon Footprint

Although Greenhouse Gas (GHG) emissions occur naturally, anthropogenic or human activities contribute a lot to increasing GHG emissions, which further contribute to climate change. Limiting climate change requires substantial and sustained reductions of GHG emissions.

- Carbon footprint (CF) is a measure of the total amount of GHG emissions produced directly and indirectly by an activity, organization, product, individual or a country. CF is usually calculated in equivalent tons of carbon dioxide (CO<sub>2</sub>) or carbon dioxide equivalent (CO<sub>2</sub>eq).
- Greenhouse gases (GHGs) can be emitted by driving car or motorbike, electricity and fuel consumption, cutting forest, and the production and consumption of food, manufactured goods, materials, wood, roads, buildings, and services. Globally, CO<sub>2</sub> emissions from fossil fuel combustion and industrial processes contributed about 78% of the total GHG emission (IPCC WGIII AR5, 2014).
- Calculation of CF is important to understand how (ways) to reduce the GHG emissions to combat the climate change or to make a positive impact on the environment. Examples of reducing CF include recycling, use less electricity and use public transportation etc.

## Suggested Reading Materials :

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IPCC. 2014. Part A: Global and Sectoral Aspects. In *Climate Change 2014: Impacts, Adaptation, and Vulnerability. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change* [Field, C.B., V.R. Barros, D.J. Dokken, K.J. Mach, M.D. Mastrandrea, T.E. Bilir, M. Chatterjee, K.L. Ebi, Y.O. Estrada, R.C. Genova, B. Girma, E.S. Kissel, A.N. Levy, S. MacCracken, P.R. Mastrandrea, and L.L. White (eds.)]. Cambridge, United Kingdom and New York, USA: Cambridge University Press.

IPCC. 2014. Summary for Policymakers. In *Climate Change 2014: Impacts, Adaptation, and Vulnerability. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*. [Field, C.B., V.R. Barros, D.J. Dokken, K.J. Mach, M.D. Mastrandrea, T.E. Bilir, M. Chatterjee, K.L. Ebi, Y.O. Estrada, R.C. Genova, B. Girma, E.S. Kissel, A.N. Levy, S. MacCracken, P.R. Mastrandrea, and L.L. White (eds.)]. Cambridge, United Kingdom and New York, USA: Cambridge University Press.

O'Brien, G., O'Keefe, P., Rose, J. and Wisner, B. 2006. Climate Change and Disaster Management. *Disasters*, 30, 64–80. doi: 10.1111/j.1467-9523.2006.00307.x

Wright, L. Kemp, S., and Williams, I. 2011. Carbon Footprinting: towards a Universally Accepted Definition. *Carbon Management*, 2 (1), 61–72. doi:10.4155/CMT.10.39



**PART 1**  
**Teaching and Learning**

**MODULE 4**  
**Responses and Efforts to Address  
Climate Change**

## Learning Outcomes

Participants will be able to:

1. Distinguish between climate change mitigation and adaptation measures.
2. Understand the concept and activities of disaster risk reduction.
3. Explain the international, regional and SIDS efforts to address climate change.
4. Understand the importance of local and traditional knowledge to address climate change
5. Illustrate individual efforts and actions responding to climate change.

Climate change is recognized as the major environmental problem facing the globe. Hence, it is necessary to take urgent actions to address climate change at all levels such as international (global), regional, national and local. Due to the significant threats of climate change faced by humans and nature, responses to climate change are crucial through mitigation and adaptation measures as shown in Figure 4.1.

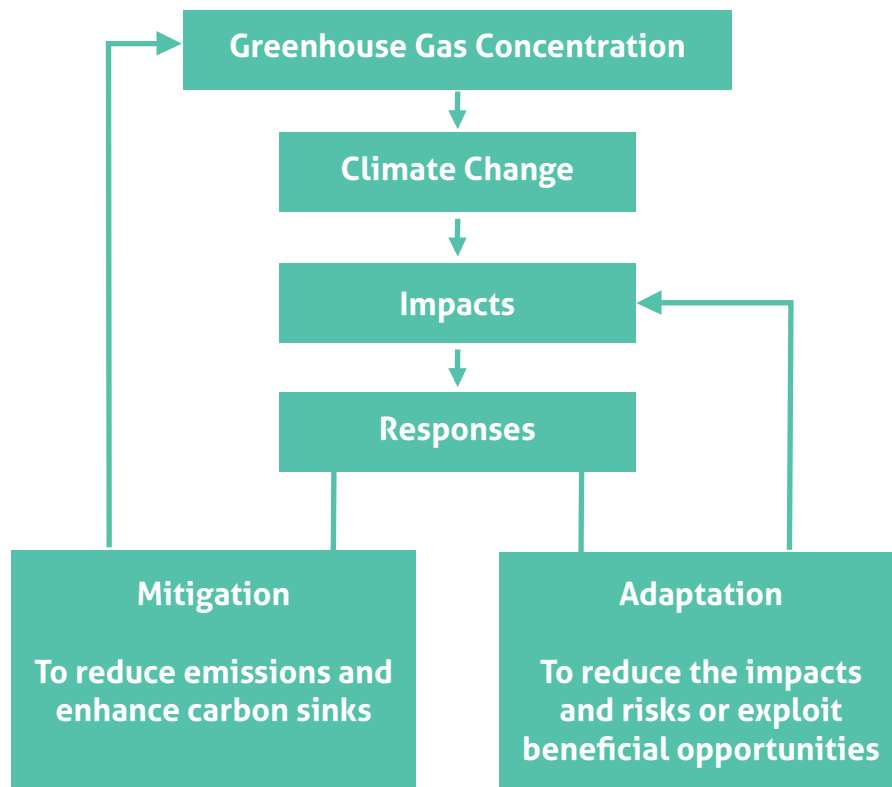


Figure 4.1: Climate Change Responses: Mitigation and Adaptation

## SECTION 4.1 CLIMATE CHANGE MITIGATION

IPCC's Working Group I (WGI) of Fifth Assessment Report (AR5) defines that climate change mitigation is a human intervention to reduce the sources or enhance the sinks of greenhouse gases (IPCC, 2013).

Climate change mitigation refers to any measures or actions that reduce or prevent emission of greenhouse gases (GHGs) and absorb or sink of taking GHGs out of the atmosphere. Examples of mitigation measures or strategies are presented in Figure 4.2.

There is a need for special role of international cooperation on mitigation policies by the national governments because most GHGs have long atmospheric lifetimes and mix throughout the global atmosphere.

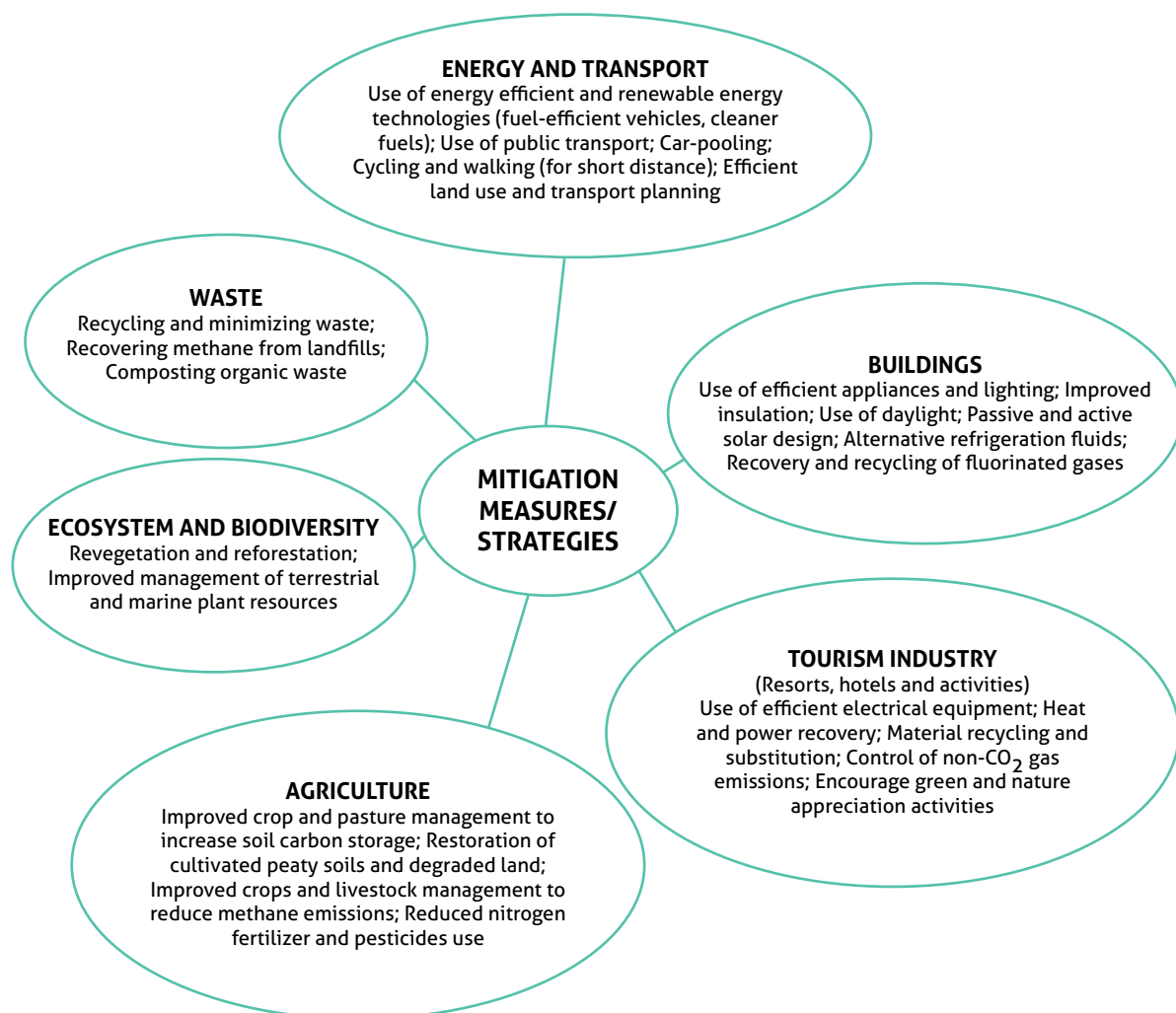


Figure 4.2: Examples of Mitigation Measures or Strategies in SIDS



## SECTION 4.2 CLIMATE CHANGE ADAPTATION

Climate change adaptation (CCA) refers to the process of adjustment to actual or expected climate and its effects. In human systems, adaptation seeks to moderate or avoid harm or exploit beneficial opportunities. In some natural systems, human intervention may facilitate adjustment to expected climate and its effects (IPCC AR5 WG II, 2014). Adaptation responses attempt to reduce vulnerability and increase resilience to climate change.

Community based adaptation is crucial to address both the impacts of climate change and natural disaster in SIDS (Figure 4.3). Community-based adaptation is a community-led process, based on community's priorities, needs, knowledge, and capacities, which should empower people to plan for and cope with the impacts of CC and disasters.

Community based adaptation is gaining acceptance and support as an approach to enabling communities to build resilience to the impacts of CC and disaster, and strengthen their institutions, processes and livelihood assets.

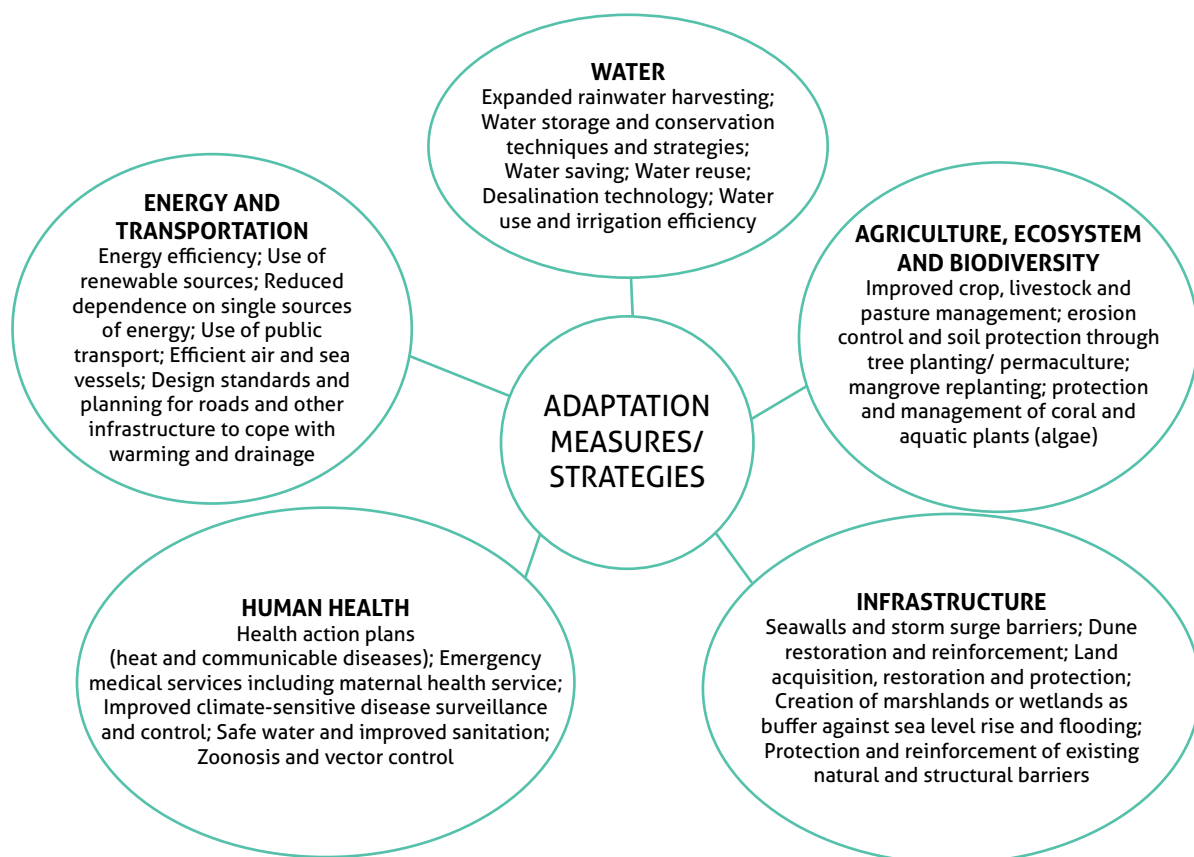


Figure 4.3: Adaptation Measures or Strategies in SIDS

## SECTION 4.3 DISASTER RISK REDUCTION

Disaster Risk Reduction (DRR) is a systematic approach to identifying, assessing and reducing the effects and risks of natural disasters such as floods, earthquakes, landslides, storms, cyclones, volcanic eruptions on people and communities.

DRR encompasses minimizing vulnerabilities and disaster risks throughout a society, avoiding (prevention) or limiting (mitigation and preparedness) the adverse impacts of natural disasters, within the broad context of sustainable development.

It can be noted that the word mitigation is used from the perspectives of both DRR and CC, but for each it means something different as presented in Figure 4.4.

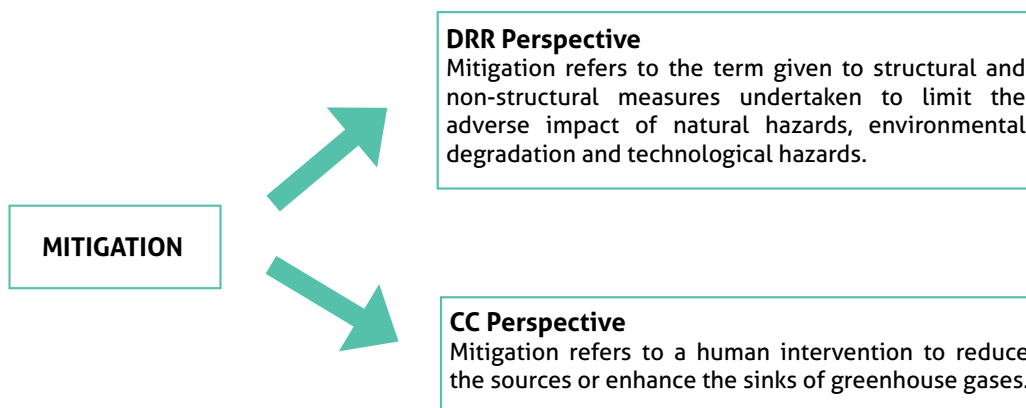


Figure 4.4: The Word 'Mitigation' Used for Different Meaning

However, climate change adaptation and disaster risk reduction are linked in that CCA is an integral component of DRR or vice versa. If climate change adaptation policies and measures are to be efficient and effective they must build on and expand existing DRR efforts. DRR can deal with current climate variability and be the first line defence against climate change, being therefore an essential part of adaptation. The convergence between CCA and DRR is shown in Figure 4.5 and Figure 4.6 presents examples of common practices of CCA and DRR.

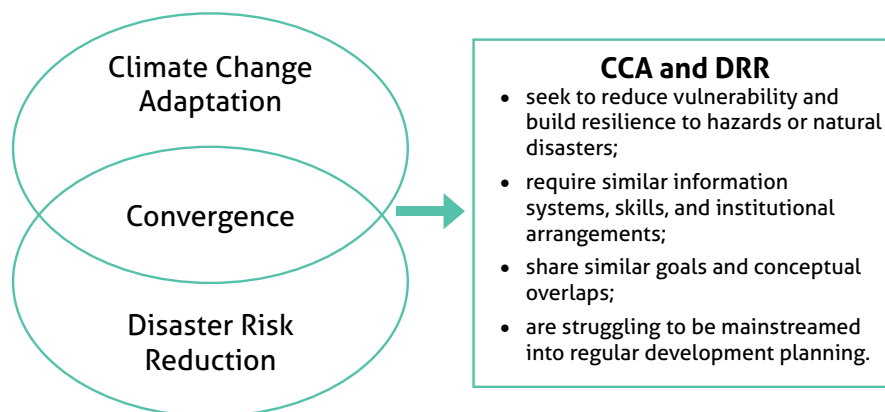


Figure 4.5: Convergence Between CCA and DRR

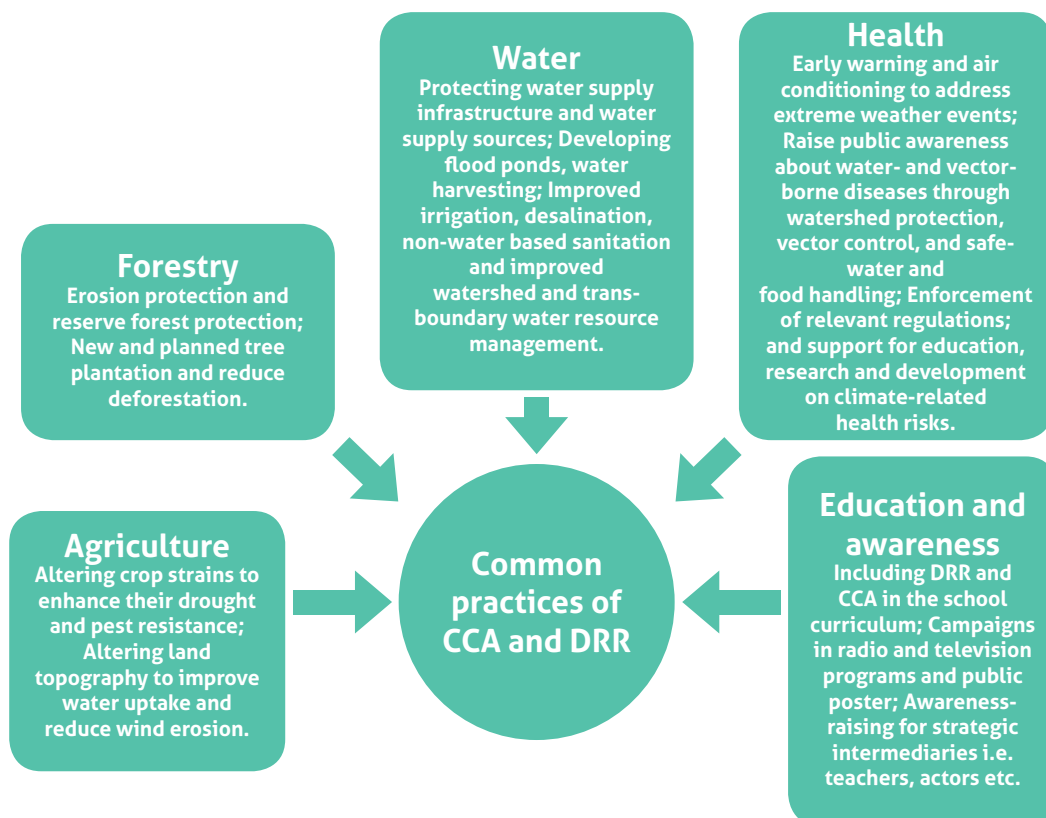


Figure 4.6: Examples of Common Practices of CCA and DRR  
(Modified from UNISDR, 2008 cited in Begum et al., 2014)

## SECTION 4.4 INTERNATIONAL EFFORTS TO ADDRESS CLIMATE CHANGE

The United Nations plays a vital role in global efforts to address climate change. The United Nations Framework Convention on Climate Change (UNFCCC) and Kyoto Protocol are key international or political agreements on climate change through which global negotiations are made.

### United Nations Framework Convention on Climate Change (UNFCCC)

- The IPCC's (Intergovernmental Panel on Climate Change) first assessment report in 1990 spurred governments to create the United Nations Framework Convention on Climate Change (UNFCCC).
- By standards for international agreements, negotiation of the UNFCCC was signed by 154 nations at the 1992 United Nations Conference on Environment and Development known as the "Earth Summit" in Rio de Janeiro.
- The UNFCCC has been entered into force since 21 March 1994. The UNFCCC has near universal membership with 196 nations.
- The ultimate objective of the UNFCCC is to stabilize greenhouse gas concentrations in the atmosphere at a level that will prevent dangerous human interference with the climate system.

## Kyoto Protocol (KP)

- The Kyoto Protocol (KP) is the first international treaty to set legally binding (legal implications when they are not followed) agreement under which industrialized countries will reduce their collective emissions of greenhouse gases by 5.2% compared to the year 1990.
- The KP was negotiated at the third session of the Conference of Parties (COP 3) in Kyoto, Japan on 11 December 1997. The KP entered into force on 16 February 2005.
- The KP's first commitment period started in 2008 and ended in 2012. The protocol was amended in 2012 to accommodate the second commitment period (2013-2020) but this amendment has (as of January 2015) not entered into legal force. As of UNFCCC, there are currently 192 Parties (191 states/nations and 1 regional economic integration organization) to the Kyoto Protocol.
- The KP implemented the objective of the UNFCCC to fight global warming and climate change by reducing greenhouse gas concentrations in the atmosphere.
- The Protocol is based on the principle of common but differentiated responsibilities: it puts the obligation to reduce current emissions on developed countries on the basis that they are historically responsible for the current levels of greenhouse gases in the atmosphere.

The Kyoto Protocol established three flexible mechanisms in order to reduce the emissions:

International Emissions Trading (IET) provides direct emission trading between industrialised countries (applies to nation states, although the participation of companies is not explicitly excluded).

Joint Implementation (JI) offers to implement emission reducing project or project that enhances emission removals by sinks between industrialised countries and count the resulting emission reduction units (ERUs) towards meeting its own Kyoto target.

Clean Development Mechanism (CDM) provides for industrialised parties to implement projects that reduce emissions in developing parties, or absorb carbon through afforestation or reforestation activities, in return for certified emission reductions and assist the host parties in achieving sustainable development and contributing to the ultimate objective of the UNFCCC.

## **SECTION 4.5 REGIONAL AND SIDS EFFORTS TO ADDRESS CLIMATE CHANGE**

Recognizing the current and potential future impacts of climate change and keeping with commitments under the UNFCCC, the Pacific Island Leaders adopted a number of efforts including Pacific Islands Framework for Action on Climate Change 2006–2015 (PIFACC); Secretariat of the Pacific Regional Environment Programme (SPREP); the Pacific Disaster Risk Reduction and Disaster Management Framework for Action 2005–2015: Building the Resilience of Nations and Communities to Disaster; and Pacific Islands Greenhouse Gas Abatement Through Renewable Energy Project (PIGGAREP).

### **Pacific Islands Framework for Action on Climate Change 2006–2015 (PIFACC)**

In 2005, the Pacific Island Leaders endorsed the Pacific Islands Framework for Action on Climate Change which was developed by the Secretariat of the Pacific Regional Environment Programme (SPREP). The Framework's goal is to ensure that Pacific Island peoples and communities build their capacity to be resilient to the risks and impacts of climate change.

This action plan is regional in nature, with national activities complemented by regional and international programming in support. It provides an indicative menu of options for action on climate change. This action plan is intended to contribute to the implementation of the Framework through actions taken in response to meeting the key outcomes under the following principles:

- Implementing adaptation measures;
- Governance and decision-making;
- Improving our understanding of climate change;
- Education, training and awareness;
- Contributing to global greenhouse gas reduction; and
- Partnerships and cooperation.

### **Pacific Islands Greenhouse Gas Abatement through Renewable Energy Project (PIGGAREP)**

Renewable Energy has become a priority issue in Pacific Island Countries (PICs). The Pacific Islands Greenhouse Gas Abatement through Renewable Energy Project (PIGGAREP) is aimed at reducing the growth rate of GHG emissions from fossil fuel use in the PICs through the widespread and cost effective use of their RE resources. The PIGGAREP commenced in 2007 and has been implementing appropriate mitigation measures through renewable energy activities.

It consists of various activities whose outputs will contribute to the removal of the major barriers to the widespread utilization of RE technologies (RETs). The project is expected to bring about in the PICs:

- (i) Increased number of successful commercial RE applications;
- (ii) Expanded market for RET applications;
- (iii) Enhanced institutional capacity to design, implement and monitor RE projects;
- (iv) Availability and accessibility of financing to existing and new RE projects;
- (v) Strengthened legal and regulatory structures in the energy and environmental sectors; and
- (vi) Increased awareness and knowledge on RE and RETs among key stakeholders.

The Secretariat of the Pacific Regional Environment Programme (SPREP) is now focusing on assisting the region with follow-on activities from PIGGAREP through a variety of sources, including SIDS Dock as well as other opportunities. SPREP is aiming to support the region in the development and implementation of Nationally Appropriate Mitigation Actions (NAMA) and Intended Nationally Determined Contributions (INDC).

## National Communications and Climate Change Policy

Addressing the climate change impact, many of the SIDS in AP submitted National Communications to the UNFCCC that have assessed their own vulnerability to climate change and in-country adaptation strategies. These communications provide an insight into national concerns about climate change, the country's vulnerability, and the priorities that different SIDS place on adaptation options.

To demonstrate solidarity with global efforts to manage the causes and impacts of climate change, some of the SIDS's Government in AP have formulated national climate change policies. Some of these policies are listed below:

- Republic of Fiji National Climate Change Policy (2012).
- Niue National Climate Change Policy (2009) - A Safer, More Resilient Niue to Impacts of Climate Change and Towards Achieving Sustainable Livelihoods.
- Palau Climate Change Policy (2015 Draft) - For Climate and Disaster Resilient Low Emissions Development.
- The Kingdom of Tonga Joint National Action Plan on Climate Change Adaptation and Disaster Risk Management 2010 – 2015 (2010).
- TE KANIVA: Tuvalu Climate Change Policy (2012) - Charting Tuvalu through the Challenges of Climate Change.

These policies provide guidance on government's responses to climate change issues; promote integration of climate change issues in national planning, budgeting and implementation processes; offer mitigation initiatives to mitigate the causes of climate change and implement effective mitigation measures to reduce GHG

emissions; offer adaptation initiatives to develop effective adaptation responses and enhance adaptive capacity in order to protect livelihoods, natural resources and assets, and vulnerable areas due to the impacts of climate change; and, provide a platform for coordination among sectors and direction on national positions and priorities regarding mitigation and adaptation.

**Tonga is the first country in the region to develop a Joint National Action Plan on Climate Change Adaptation and Disaster Risk Management. The country is very keen to be the first to fully implement this joint initiative (Ministry of Environment and Climate Change, Tonga, 2010)**

#### **Six priority goals of the Plan**

- Improved good governance for climate change adaptation and disaster risk management (mainstreaming, decision making, organizational and institutional policy frameworks)
- Enhanced technical knowledge base, information, education and understanding of climate change adaptation and effective disaster risk management
- Analysis and assessments of vulnerability to climate change impacts and disaster risks
- Enhanced community preparedness and resilience to impacts of all disasters
- Technically reliable, economically affordable and environmentally sound energy to support the sustainable development of the Kingdom and with Civil Societies, Non-Government Organisations and the Private Sectors.

#### **Major CCA strategies and disaster risk (DR) management in the plan**

- Coastal Areas – Foreshore protection along the most vulnerable coastal areas (< 3m above mean sea level)
- Assess ocean current flow
- Reassess design of current protection systems
- Early warning system and monitoring
- Improved Government Information management services in Meteorology,
- Geology, Climate Change and NEMO
- 24 hours / 7 days service/ monitoring
- Capacity (human resources, facilities, financial) needed to enforce building code
- Improve capacity to monitor water quality and better utilization of water resources
- Good Farm Planning and techniques (including livestock) and tree management (mixed farming, organic farming crops tolerant)
- Improve infrastructure
- Strengthen food and water hygiene
- Public Awareness/training on communicable/vector borne/ waterborne/ foodborne and nutritional related diseases prevention
- Proper regulatory framework for renewable energy in place
- Promote renewable energy and energy efficiency initiatives

## SECTION 4.6 LOCAL AND TRADITIONAL KNOWLEDGE TO ADDRESS CC IN SIDS

Local and indigenous people that live close to natural resources often observe the activities around them. They are the first to identify, learn, and adapt to any changes within their environment. Therefore, knowledge and practices used by indigenous and local people through traditional knowledge are useful to predict disasters and reduce the effects of climate change for designing mitigation and adaptation strategies. Women have specific useful skills, knowledge and local wisdom in growing certain crops and food preservation, which can help combat reduced crop yields. They are also affected more when traditional crops fail. Even though women are responsible for most of the agriculture production, they often have limited land ownership and less access to productive resources to improve yields.

The importance of local and traditional knowledge and practices, island heritage and cultures is essential for addressing climate change in SIDS. Among Asia Pacific and other Pacific peoples, the relationship of people, land, sea, island heritage and cultures as well as the spiritual realm constitutes the very basis for understanding environmental and climate change and its impact on society.

However, Pacific local community experiences of past climate change events might serve to address present day challenges of climate change. Some Pacific cultures disappeared, while others continue to thrive. For example in the past, most of the Tuvalu people had a practice of using bicycles but now most of the people use motorbikes for their local transport. However, the current practice of motorbike usage contributes to increase in the Island's GHG emissions, whereas using bicycles would have enhanced the mitigation measures.

For the wider global community to benefit from indigenous and local perspectives and approaches to adaptation, a conscious effort to understand the contextualization of climate change in different communities and cultures is required (UNESCO, 2012). In addition, efforts to understand contextualization of climate change differ amongst different community members such as women, men, children and people with disabilities. Traditional knowledge from women, men, children and all members of the community can generate important adaptation strategies for climate resilient community development. However, the issues of climate change should be explained and understood in the local context. Table 4.1 demonstrates examples of traditional knowledge being practiced in SIDS for addressing climate change issues (adapted from Nakashima et al., 2012).



Table 4.1: Examples of Traditional Knowledge and Practices in SIDS

SIDS	Traditional Knowledge and Practices
<p><b>Torres Islands, Cape Verde of Eastern Atlantic, Tuvalu</b></p>	<p>Traditional Calendars (Lunar Based and Seasonal Calendar)</p> <ul style="list-style-type: none"> <li>• Used by indigenous and local small island communities to interpret and respond to shifts in weather and climate patterns.</li> <li>• Use of lunar observations in the organization of local artisanal fisheries practices and weather forecasting for instance 'If there is a green circle around moon, weather will be fresh and rainy; if it is white one, it will be windy'.</li> </ul>
<p><b>Tonga, Tuvalu, Torres Island of Vanuatu</b></p>	<p>Traditional Forecasting Technique</p> <ul style="list-style-type: none"> <li>• Anticipating extreme weather events rely upon observations of the sea and lagoon (the sizes, strengths and sounds of waves, the colour and smell of the water, and the amount of seaweed deposited on the beach); the sky (type and colour of clouds, the appearance of the moon in a particular way); and the winds (primarily direction and speed) (IFAD, 2016).</li> <li>• Using phenology, for example the abundance of particular fruit like mangoes and breadfruit is a sign of strong wind or heavy rain, and a rise in the groundwater table of taro gardens is an indicator of rising seas; bird and animal behaviour e.g. low-flying albatross is a sign of poor weather, and animals seeking higher ground is a warning sign of approaching tsunami (IFAD 2016); and, insects and arachnids e.g. their appearance indicates the approach of unfavourable weather.</li> </ul>
<p><b>Rongelap Atoll of Marshall Islands</b></p>	<p>Traditional Agricultural Practice</p> <ul style="list-style-type: none"> <li>• Managing taro pits as 'humidity pockets' to simultaneously increase food production and reduce consumption of freshwater.</li> <li>• Taro pits are dug in the ground-water lens, and are lined with successive layers of plants, organic mulch and coral rubble.</li> </ul>
<p><b>Tuvalu, Pacific Islands</b></p>	<p>Traditional Preparation and Storage of Emergency Foods</p> <ul style="list-style-type: none"> <li>• Traditional method of stocking foods in family's food storage (kaufata) during extreme weather events.</li> <li>• Fermentation of local root crops.</li> <li>• Use of local foods that suit local environments and maximise their suitability for long-term storage such as scraped and dried Pandanus (<i>Tectorius</i> spp.), dried giant swamp taro (<i>Cyrtosperma</i> spp.), boiled/ baked, pounded and dried taro (fam. Araceae), dried coconut and dried fish</li> </ul>
<p><b>Tuvalu</b></p>	<p>Traditional techniques adapted to protect food security</p> <ul style="list-style-type: none"> <li>• Nanumea women community on Funafuti has adapted by burying a plastic drum and filling it with germinating nuts and/or taros.</li> <li>• During 'King tide' events in Tuvalu, the germinating nuts and taros are safe as they are protected from the rising saltwater by the plastic drums in which they are kept. (Nakashima et al. 2012).</li> </ul>

In addition, although traditional knowledge is a non-formal knowledge pass down from the older generation to the next generation, this knowledge is useful to the local people, especially in facing climate change. The following traditional knowledge are also being practised in some of the SIDS in AP:

- In Niue, the appearance of yam indicates upcoming storm while strong wind indicates increase of coconut crab population.
- The people in Tonga still believe in traditional knowledge for example on the first day of the new year and the last day of the year, if there is young shoot on top of the banana stem, it indicates that there would be cyclone for the upcoming year. Also, if one observe that bee hives are hidden behind a tree, then there would be a hurricane coming.
- In Palau, if people observe the moon and blooming of certain tree species to tell of the changes in the weather. Also, if spiders are seen in and around the house, it is sign that typhoon is coming.
- The people in Tuvalu island still observe the weather by looking at the cloud. Just by looking at the cloud or sky, the fishermen would just go to certain part of the water at particular time to fish. It is believed in old generation, fishing during windy night will reap more fish.
- In Fiji, traditional knowledges include cloud cover observation, wind directions, position of the sun, shape of the moon, movement of terrestrial or marine live and seasonal fruits and crops are being used to predict weather pattern. For example, bee hives formed on the ground warns of an up-coming cyclone; animals moving inland foretells a tsunami; continuous sighting of red skies before nightfall for more than a week warn of disaster approaching such as cyclones, hurricanes; if see birds are seen around that means there will be a hurricane soon.

However, traditional knowledge of predicting weather is very much useful when modern weather information is not available. Indeed, traditional knowledge must be integrated with scientific knowledge so that it can be proven right and helps to reduce climate change risks and impacts.

## SECTION 4.7 INDIVIDUAL EFFORTS TO ADDRESS CLIMATE CHANGE

Although Governments and International, National and Local Organizations have been taking leadership in mitigating and adapting to climate change, however, addressing climate change requires contributions from all of us. Some of the individual efforts and actions in responding to climate change are illustrated below and by that, we can make a difference:

### Education Awareness and Communication

- Stay informed about the latest technology including early warning systems and government's policies and laws for addressing climate change. This will help to develop an appropriate and targeted idea of how individual activities can be part of the solution to the urgent problems of climate change.

- Share individual's (your) ideas and knowledge with community members including family, friends and teachers to promote environmentally friendly actions and behaviours. It is noteworthy to include and respect the ideas and knowledge of all members of community, including women, girls, boys and men.

## Behavioural and lifestyle changes

Each of us can take actions on climate change. Greenhouse gas emissions are the direct result of our activities including energy use, transportation choices and shopping habits. However, every individual has the power to act and reduce the global emissions. Within different levels, such as household, workplace, leisure, recreational and street places, each of us can take actions and use our knowledge and awareness of climate change to reduce emissions, and encourage others to reduce their emissions too. Examples of individual efforts for climate change actions are illustrated below:

### Household level (some of them are also relevant to the school/work/market place)

- Lights: use natural light whenever you can during the day. At night, use energy-saving light bulbs.
- Electronic devices: unplug your TV, computers and mobile phone charger. Unplugging these devices helps both to save electricity and lengthen their lifespan.
- Water heater: turn the water heater to medium rather than high and be aware that water heaters consume a lot of electricity. Where possible, install solar water heaters.
- Air conditioning: avoid using air conditioning on cooler days – use fans and natural ventilation wherever possible.
- Keep your house "green": refrain from using chemicals harmful to our health and the environment. Replace these with plant-based/organic products and environmentally friendly alternatives.
- Change your diet: include more locally produced vegetables and fruits in your meal. This is both better for your health, and helps to reduce carbon footprint and greenhouse gas emissions, because avoiding transport services would reduce emissions from fuel avoidance.
- Reduce, reuse and recycle (3Rs): when it breaks down, organic waste releases methane. Use recyclable packaging, and buy eco-friendly and durable products. Compost organic waste and use it as organic fertilizer. Non-organic waste should be disposed properly to save the environment.

## Travel

- Walking or cycling save fuel and helps to reduce greenhouse gas emissions.
- Share rides with friends and colleagues (to work or when socializing) where possible.
- Travel by public rather than private transport.

## School/ Workplace

- Cut down on paper use and printing. Paper is made from wood, which stock carbon and keep our air fresh. When more paper is wasted, more forests will be cut. Currently, paper accounts for 70% of office waste. Only print if necessary. Encourage to print or photocopy double-sided.
- Practice green cultures. For example, avoid using polystyrene and plastics; use signage reminding people to save water and electricity in washrooms, classrooms and workplaces. Saving water will also reduce GHG emission as it takes energy to pump, treat, or heat water. Let people know how much energy and water they can save through these simple changes.

## Shopping

- Avoid using plastic bags because the manufacturing of the plastic bags require energy that may emit GHG. Always remember to bring own shopping bags.
- Choose energy-saving devices. Many electrical appliances such as refrigerators, air-conditioners and computers now carry energy-saving labels.

## Community level

- Plant trees and food crops to help to protect forests and oceans, and enhance food security. Trees help to reduce climate change because they absorb carbon dioxide.
- Encourage everyone including children and women to swim because it will help them protect themselves from extreme floods during rainy seasons;
- Learn to apply climate change adaptation activities in local area. Support vulnerable groups and regions.
- Check weather information and prepare well before any outdoor activity/event to adapt to the changes of the climate.
- Volunteer individual or community knowledge, skills and labour to environmental activities. This involvement has the potential to profoundly impact sustainable development efforts in local community.
- Connect and mobilize collective actions for positive change to address climate change. Address gender inequalities in community and ensure all members in your community have the opportunity to participate.

## Suggested Reading Materials :

IPCC. 2014. Summary for Policymakers. In *Climate Change 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change* (pp. 1-32).[Edenhofer, O., R. Pichs-Madruga, Y. Sokona, E. Farahani, S. Kadner, K. Seyboth, A. Adler, I. Baum, S. Brunner, P. Eickemeier, B. Kriemann, J. Savolainen, S. Schlömer, C. von Stechow, T. Zwickel and J.C. Minx (eds.)]. Cambridge, United Kingdom and New York, USA: Cambridge University Press.

Blanco G., R. Gerlagh, S. Suh, J. Barrett, H.C. de Coninck, C.F. Diaz Morejon, R. Mathur, N. Nakicenovic, A. OfosuAhenkora, J. Pan, H. Pathak, J. Rice, R. Richels, S.J. Smith, D.I. Stern, F.L. Toth, and P. Zhou. 2014. Drivers, Trends and Mitigation. In *Climate Change 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change* [Edenhofer, O., R. Pichs- Madruga, Y. Sokona, E. Farahani, S. Kadner, K. Seyboth, A. Adler, I. Baum, S. Brunner, P. Eickemeier, B. Kriemann, J. Savolainen, S. Schlömer, C. von Stechow, T. Zwickel and J.C. Minx (eds.)]. Cambridge, United Kingdom and New York, USA: Cambridge University Press.

Nurse, L.A., R.F. McLean, J. Agard, L.P. Briguglio, V. Duvat-Magnan, N. Pelesikoti, E.Tompkins, and A.Webb. 2014. Small Islands. In *Climate Change 2014: Impacts, Adaptation and Vulnerability. Part B: Regional Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change* (pp. 1613-1654) [Barros, V.R., C.B. Field, D.J. Dokken, M.D. Mastrandrea, K.J. Mach, T.E. Bilir, M. Chatterjee, K.L. Ebi, Y.O. Estrada, R.C. Genova, B. Girma, E.S. Kissel, A.N. Levy, S. MacCracken, P.R. Mastrandrea, and L.L. White (eds.)]. Cambridge, United Kingdom and New York, USA: Cambridge University Press.

IPCC. 2012. *Managing the Risks of Extreme Events and Disasters to Advance ClimateChange Adaptation. A Special Report of Working Groups I and II of the Intergovernmental Panel on Climate Change* [Field, C.B., V. Barros, T.F. Stocker, D. Qin, D.J. Dokken, K.L.Ebi, M.D.Mastrandrea, K.J. Mach, G.-K. Plattner, S.K. Allen, M. Tignor, and P.M. Midgley (Eds.)]. Cambridge, United Kingdom and New York, USA:Cambridge University Press.



**PART 2**  
**Activities and Sample Lesson Plans**

## **ACTIVITY 1 : WEATHER VERSUS CLIMATE**

### **Module 1**

#### **OVERVIEW**

This activity will help participants to identify and differentiate the concept of weather and climate.

#### **OBJECTIVES**

At the end of this activity, participants will be able to:

1. Distinguish 'weather' from 'climate'.
2. Understand the concept of weather and climate.

#### **ACTIVITIES**

1. Look at the list of words given.
2. Identify and categorize the given words under 'climate' or 'weather'.
3. Share with your friends the answers and discuss climate/weather in your context.
4. Teacher explains and concludes the differences between weather and climate.

#### **MATERIALS**

Teacher's Notes  
Activity sheet 1

## ACTIVITY SHEET 1

Differentiate the concept of weather and climate.

Participants to identify and categorize words related to climate and weather.

### List of words

The activity sheet features a central list of words in green-bordered boxes. To the left is a yellow vertical bar labeled 'WEATHER', and to the right is a light blue vertical bar labeled 'CLIMATE'. The words are arranged as follows:

WEATHER	List of words	CLIMATE
	AUTUMN	SUNNY
	HUMID	WINTER
	TROPICAL	RAINY
	WINDY	SPRING
	TUNDRA	CLOUDY
	MONSOON	SUMMER
	TEMPERATE	



## **ANSWER SHEET ACTIVITY 1**

Differentiate the concept of weather and climate.

Participants to identify and categorize words related to climate and weather.

### **WEATHER**

**HUMID**

**WINDY**

**SUNNY**

**RAINY**

**CLOUDY**

### **CLIMATE**

**AUTUMN**

**SPRING**

**SUMMER**

**WINTER**

**TROPICAL**

**TEMPERATE**

**TUNDRA**

**MONSOON**

## ACTIVITY 2 : CLIMATE CHANGE AND CLIMATE VARIABILITY

### Module 1

#### **OVERVIEW**

This activity will help participants to understand the concept of climate change and climate variability.

#### **OBJECTIVES**

At the end of this activity, participants will be able to:

1. Understand the concept of 'climate change' and 'climate variability'.
2. Distinguish 'climate change' from 'climate variability'.

#### **ACTIVITIES**

1. Create graphs on climate change and climate variability.
2. Present and share findings on climate change and climate variability with a partner or in groups.
3. Teacher explains and concludes the key aspects of climate change and climate variability.

#### **MATERIALS**

Teacher's Notes

Activity sheet 2

Handout 1 and Handout 2 (Sample data are available in Appendix 2 and Appendix 3)

## ACTIVITY SHEET 2

Using your own data, create graphs :

- on climate change involving your own country.
- to show climate variability.

Please note that:

- Data on climate change must be within the duration of at least 30 years.
- Data on climate variability must be seasonal / annually.
- Data characteristics are inclusive of duration (year or seasonal), temperature, humidity, wind.



## ACTIVITY 3 : CLIMATE CHANGE SITUATIONS

### Module 1

#### **OVERVIEW**

This activity will help participants to understand the key words of climate change through role play or drama.

#### **OBJECTIVE**

At the end of this activity, participants will be able to understand the concept of 'climate change' through playing roles and in situations.

#### **ACTIVITIES**

1. Get into groups of 4 – 5.
2. Create a drama or role play on the climate change situations.
3. Drama presentations.
4. Teacher emphasizes on important issues relating to climate change.

#### **MATERIALS**

Teacher's Notes  
Activity sheet 3

### ACTIVITY SHEET 3

1. Form groups of 4-5.
2. Create a drama based on the following climate change situations.

Haze

Drought

Coastal Floods

Tropical Cyclone

Heavy Rainfall

Air Pollution

Coastal Erosion

Sea Water  
Intrusion

## ACTIVITY 4 : CARBON CYCLE AND GREENHOUSE EFFECTS

### Module 1

#### OVERVIEW

This activity will help participants to understand the carbon cycle and greenhouse effects.

#### OBJECTIVE

At the end of this activity, participants will be able to understand and describe carbon cycle and greenhouse effects.

#### ACTIVITIES

1. Get into groups of 4 – 5.
2. Construct a carbon cycle or greenhouse effects in a graphic form based on your understanding of the given notes.
3. Present and share your graphic diagram with the class.
4. Teacher comments on issues relating to carbon cycle and greenhouse effects.

#### MATERIAL

Teacher's Notes

## ACTIVITY 5 : CAUSES OF CLIMATE CHANGE

### Module 2

#### OVERVIEW

This activity will help participants to argue and to defend their beliefs on the main causes of climate change through a discussion and presentation.

#### OBJECTIVES

At the end of this activity, participants will be able to:

1. Understand the causes and effects of climate change.
2. Voice out their opinion of the main causes of climate change.
3. Assert their views on climate change.

#### ACTIVITIES

1. Get the class into two big groups; the proponent (for) and the opponent (against).
2. Based on the given title, choose a side and debate on it.
3. Teacher explains the rules and how to select winners based on the notes given in the activity sheet.

#### MATERIALS

Teacher's Notes  
Activity sheet 5

## ACTIVITY SHEET 5

### Group Debate

Discuss the title below and perform a debate in support or against the title proposed.

### **“Human activities are the main causes of climate change”**

The teacher needs to control time for team discussion/preparation, debate intervals and who speaks when.

The debate “winners” will be determined by group consensus.

Be sure to keep notes during the debate on the points you want to make as well as those made by your fellow debaters, affirmative and non-affirmative.



## **ACTIVITY 6 : OCEAN ACIDIFICATION**

### **Module 2**

#### **OVERVIEW**

This activity will help participants to understand the causes and effects of ocean acidification.

#### **OBJECTIVES**

At the end of this activity, participants will be able to:

1. Explore the concept of ocean acidification through an experiment.
2. Understand the concept of ocean acidification.
3. Discuss how this affects marine life.

#### **ACTIVITIES**

1. Get the class into groups of four. Try out the experiment below.
2. Teacher explains and concludes the findings on ocean acidification experiment by relating to how this affects marine life around us.

#### **MATERIALS**

Teacher's Notes

Activity sheet 6

Water, salt, beaker, Bromophenol blue, compressed CO<sub>2</sub> blocks (dry ice)

## ACTIVITY SHEET 6

Experiment on Ocean Acidification:

*Increasing the Acidity of the Ocean: What happens to the pH of the ocean when you add carbon dioxide (CO<sub>2</sub>)?*

### PROCEDURE:

1. Fill a beaker with water and add a pinch of salt to make an 'ocean'.
2. Add Bromophenol blue as the pH indicators. You may also use other pH indicators such as methyl red, litmus paper and etc.
3. Put in a chunk of cooled and compressed CO<sub>2</sub> blocks (dry ice) to the "ocean" and observe the water as it changes its colour. If the water turns yellow, it indicates that the water is acidic (using Bromophenol blue).
4. Use protective gloves when handling the compressed CO<sub>2</sub> (should only be handled by teachers).
5. Describe why the 'ocean' becomes acidic when the dry ice dissolves and CO<sub>2</sub> bubbles enter the water.
6. Repeat Step 1 – 5 in another beaker using a straw to blow CO<sub>2</sub> directly into the water.
7. Examine if the water changes its colour (blue to yellow).
8. Teacher explains "*What happens to the pH of the ocean when you add carbon dioxide (CO<sub>2</sub>)?*"

*NOTES: Teacher to explain that the CO<sub>2</sub> from respiration "may not" change the colour of the water because the CO<sub>2</sub> is insufficient to trigger acidification of the water.*

## ACTIVITY 7 : SEA LEVEL RISE, TEMPERATURE RISE AND NATURAL DISASTER

### Module 2

#### OVERVIEW

This activity will help participants to understand and describe the physical impacts of climate change such as sea level rise, temperature rise and natural disaster.

#### OBJECTIVES

At the end of this activity, participants will be able to:

1. Explore the concept of sea level rise, temperature rise and natural disaster.
2. Understand the concept of sea level rise, temperature rise and natural disaster.
3. Describe the impact of climate change on sea level rise, temperature rise and natural disaster through songs.

#### ACTIVITIES

1. Form three groups.
2. Each group will discuss the illustration given to them.
3. Compose a song to portray the impact of climate change on sea level rise, temperature rise and natural disaster.
4. Each group will perform its song to the class.
5. Teacher comments on the performance and its relevance on the key concepts of sea level rise, temperature rise and natural disaster.

#### MATERIALS

Teacher's Notes  
Activity sheet 7

## ACTIVITY SHEET 7

### Activity: Natural Disaster

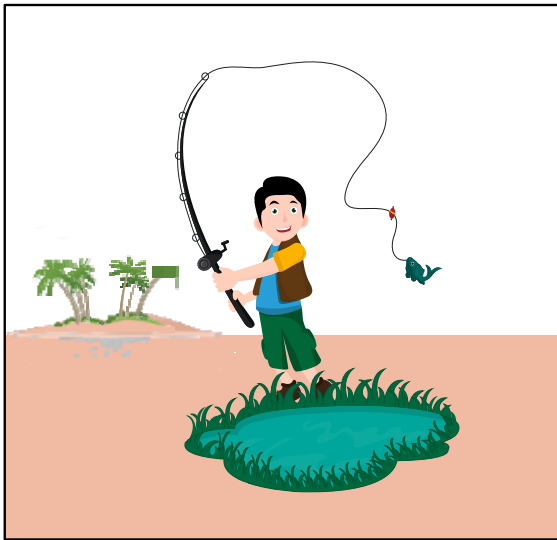
1. Look at the picture on natural disaster below.
2. Discuss and understand the concept of natural disaster that exists in your country.
3. Ask the groups to write lyrics for their song about natural disaster from their understanding about the picture.
4. Choose a melody for their song (based on the local folk songs).
5. When participants are ready, sing the song to the whole class.



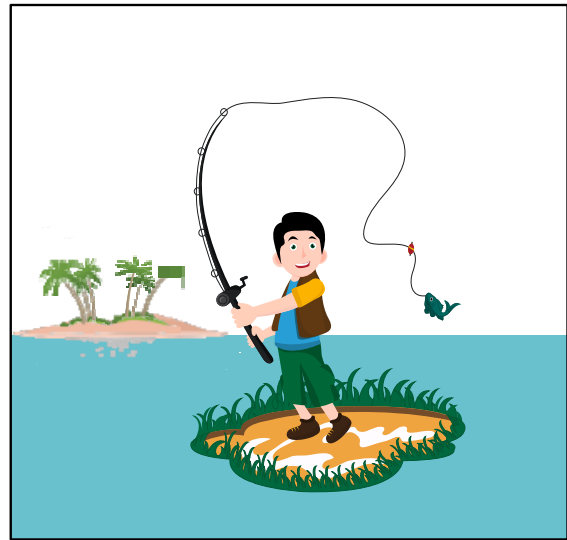
## Activity: Sea Level Rise

1. Look at the picture on the impacts of sea level rise below.
2. Discuss and understand the concept of the impacts of sea level rise that occurred in your country.
3. Ask the groups to write lyrics for their song about the impacts of sea level rise from their understanding of the disaster.
4. Choose a melody for their song (based on the local folk songs).
5. When participants are ready, sing the song to the whole class.

### Then



### Now



## Activity: Temperature Rise

1. Look at the picture on temperature rise below.
2. Discuss and understand the concept of temperature rise that occurred in your country.
3. Ask the groups to write lyrics for their song about temperature rise from their understanding about the picture.
4. Choose a melody for their song (based on the local folk songs).
5. When participants are ready, sing the song to the whole class.



## ACTIVITY 8 : IMPACTS OF AND VULNERABILITY TO CLIMATE CHANGE

### Module 3

#### OVERVIEW

This activity will help participants to understand climate change impacts and vulnerability.

#### OBJECTIVES

At the end of this activity, participants will be able to understand the key words of climate change impacts and vulnerability.

#### ACTIVITIES

1. Answer the word puzzle given by reading the clues given.
2. Discuss the answers with the whole class.
3. Teacher explains and concludes the key aspects of climate change impacts and vulnerability.

#### MATERIALS

Teacher's Notes  
Activity sheet 8

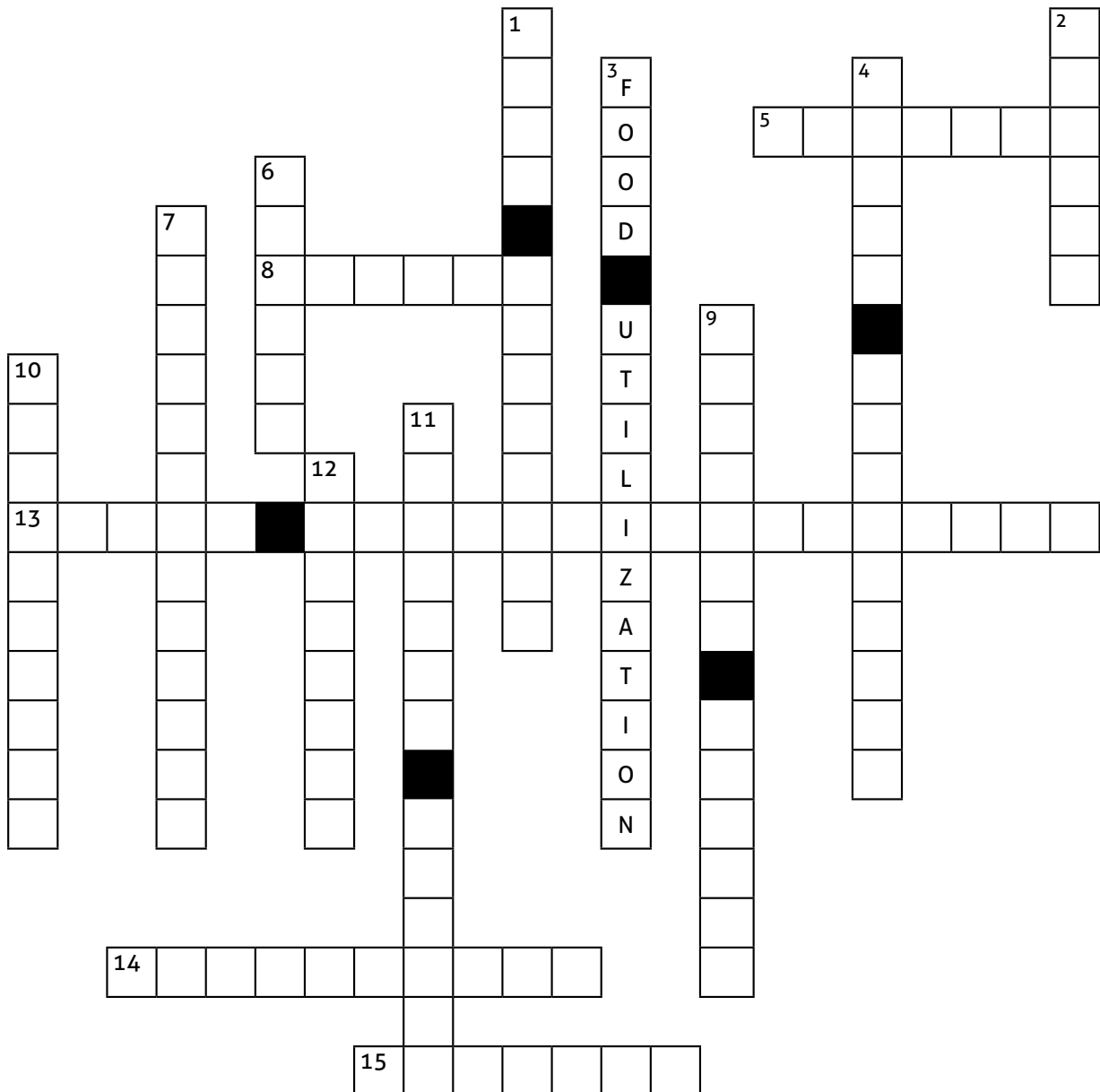
## ACTIVITY SHEET 8

1. Read the clues given and answer the word puzzle.
2. Discuss the answers in pairs.
3. Participants reflect on the words in the puzzle pertaining to their daily life.  
(Note: Dark spaces indicate two words)

Name : \_\_\_\_\_

### Word Puzzle

Complete the crossword below





## ACTIVITY SHEET 8

### ACROSS

5. \_\_\_\_\_ refers to the state of the atmosphere in a particular place and time.
8. Climate change will also affect one of the components of food security. \_\_\_\_\_ ibility
13. Increased amount of carbon dioxide absorbed by the oceans is changing ocean chemistry by decreasing pH and increasing acidity.
14. \_\_\_\_\_ refers to the process of adjustment to actual or expected climate and its effects.
15. \_\_\_\_\_ refer to the effects on natural and human systems of extreme weather and climate events, and climate change.

### DOWN

1. Food is always available, affordable, accessible and safe for humans.
2. \_\_\_\_\_ is a naturally-abundant element which forms the basis of all living organisms.
3. Four dimensions of food security that will affect by climate change are food availability, food accessibility, \_\_\_\_\_ and food systems stability.
4. Climate change will be effecting this resources.
6. Changing climate impacts our \_\_\_\_\_ and wellbeing.
7. \_\_\_\_\_ refers to the propensity or predisposition to be adversely affected.
  
9. \_\_\_\_\_ refers to the general increase in the earth's average temperature.
10. The climate system consists of \_\_\_\_\_, hydrosphere, cryosphere, lithosphere, and biosphere.
11. Different factors including the Earth's water, clouds, atmosphere, and temperature that \_\_\_\_\_ work together to produce weather.
12. Changes in \_\_\_\_\_ distribution and water evaporation due to increased temperatures significantly affect water resources.

## ANSWER SHEET ACTIVITY 8

### ACROSS

5. Refers to the state of the atmosphere in a particular place and time.  
**(Answer: Weather)**
8. Climate change will also affect one of the components of food security.  
\_\_\_\_\_ ibility **(Answer: Access)**
13. Increased amount of carbon dioxide absorbed by the oceans is changing ocean chemistry by decreasing pH and increasing acidity.  
**(Answer: Ocean Acidification)**
14. \_\_\_\_\_ refers to the process of adjustment to actual or expected climate and its effects. **(Answer: Adaptation)**
15. \_\_\_\_\_ refers to the effects on natural and human systems of extreme weather and climate events, and climate change.  
**(Answer: Impacts)**

### DOWN

1. Food is always available, affordable, accessible and safe for humans.  
**(Answer: Food security)**
2. is a naturally abundant element which forms the basis of all living organisms.  
**(Answer: Carbon)**
3. Four dimensions of food security that will be affected by climate change are food availability, food accessibility, \_\_\_\_\_ and food systems stability.  
**(Answer: Food Utilization)**
4. Climate change will be effecting this resources.  
**(Answer: Water Resources)**
6. Changing climate impacts our \_\_\_\_\_ and wellbeing.  
**(Answer: Health)**
7. refers to the propensity or predisposition to be adversely affected.  
**(Answer: Vulnerability)**
9. \_\_\_\_\_ refers to the general increase in the earth's average temperature.  
**(Answer: Climate Change)**
10. The climate system consists of \_\_\_\_\_, hydrosphere, cryosphere, lithosphere, and biosphere. **(Answer: Atmosphere)**
11. Different factors including the Earth's water, clouds, atmosphere, and temperature that work together to produce weather.  
**(Answer: Climate System)**
12. Changes in distribution and water evaporation due to increased temperatures significantly affect water resources.  
**(Answer: rainfall)**

## ACTIVITY 9 : CARBON FOOTPRINTS

### Module 3

#### OVERVIEW

This activity will help participants to understand how to calculate their carbon dioxide emissions from their daily activities.

#### OBJECTIVES

At the end of this activity, participants will be able to:

1. Understand and calculate the carbon dioxide emissions from their daily activities.
2. Describe how carbon dioxide emissions influence climate change.

#### ACTIVITIES

1. Discuss how an excess of carbon dioxide contributes to climate change in your country.
2. Identify human behaviours that contribute to carbon dioxide emission (i.e. driving, farming)
3. Use the manual calculation of carbon footprint as attached in Appendix 1 or online carbon footprint calculator using the links below to calculate your own carbon footprint.
4. Discuss your carbon footprint calculation with the whole class.

#### MATERIALS

Teacher's Notes  
Appendix 1

## ACTIVITY 10 : CLIMATE CHANGE MITIGATION AND ADAPTATION

### Module 4

#### OVERVIEW

This activity will help participants to argue and to defend their beliefs on climate change mitigation and adaptation through a debate.

#### OBJECTIVES

At the end of this activity, participants will be able to:

1. Understand the concept of climate change mitigation and adaptation.
2. Present opinion on climate change mitigation and adaptation.
3. Assert views on climate change mitigation and adaptation.

#### ACTIVITIES

1. Get the class into two big groups; the proponent (for) and the opponent (against).
2. Based on the given title, choose a side and debate on it.
3. Teacher explains the rules and how to select winners based on the notes given in the activity sheet.

#### MATERIALS

Teacher's Notes  
Activity sheet 10

## ACTIVITY SHEET 10

### GROUP DEBATE

Discuss the title below and perform a debate in support or against the title proposed.

### **"Climate Change Mitigation is More Important than Climate Change Adaptation."**

The teacher needs to control time for team discussion/preparation, debate intervals and who speaks when.

The debate "winners" will be determined by group consensus.

Be sure and keep notes during the debate of the points you want to make and the points you and your fellow debaters made, both good and bad.

## ACTIVITY 11 : CLIMATE CHANGE IMPACTS AND I

### Module 4

#### OVERVIEW

This activity will help participants to understand their own individual efforts and actions in responding to climate change issues.

#### OBJECTIVES

At the end of this activity, participants will be able to:

1. Understand and distinguish climate change impacts in relation to their own self/own contexts.
2. Analyse the impacts and vulnerability in key sectors due to climate change pertaining to yourself.

#### ACTIVITIES

1. Participants to get into pairs or groups.
2. Fill in Activity Sheet 11 with facts related to yourself as a teacher.
3. Discuss the answers with your partner or in groups.
4. Participants share the answers with the whole class.

#### MATERIAL

Teacher's Notes  
Activity sheet 11

**ACTIVITY SHEET 11**

Climate change impact	Effect on my daily life	What can I do to cope?	Where to get support?	Notes
Food security and livelihood				
Coral bleaching which affect marine ecosystem				
Sea water intrusion /salinization				
Changes in temperature/ sea level rise				
Flood, drought, hurricane and cyclones				
Health and safety				

## ENRICHMENT ACTIVITIES

### 1. Photo Quest

Instructions:

- Using a digital camera/mobile phone camera/video camera and/or through your own free-drawing, take photos or draw 10–15 things in and around your school, neighbourhood or home that are potentially adding to climate change issues.
- Prepare a PowerPoint presentation of your findings and present it to another group or the class.

### 2. Regional Efforts in addressing Climate Change

(<http://www.nature.org/ourinitiatives/regions/asiaandthepacific/micronesia/explore/palau-bleaching.xml>)

Please read the text carefully and answer the following questions.

The texts in the box were retrieved from the above link on 25th November 2015.

**Dr. Yimnang Golbuu was recently awarded the prestigious Pew Fellowship in marine conservation!** The three-year, \$150,000 fellowship will allow Yim and Palau International Coral Reef Center (PICRC) to assess Palau's network of protected areas and determine how best to expand the network.

"I am honored and humbled to receive this prestigious award," Yim says. "This is really not my award. This is the result of the work of PICRC, my fellow researchers, and PICRC's partners who collaborate to protect Palau's marine environment. **I am very happy that PICRC's work has been recognized internationally as evidenced by the awarding of this fellowship.**"

In Palau's Nikko Bay, it's visible from the boat. Steven Victor points out what looks like a little forest of alabaster bonsai trees. It's a white patch of coral, and its ethereal beauty belies the fact that it's actually unhealthy. Steven's pointing out bleached coral, and its presence indicates that the reefs **of Palau are under pressure.**

Coral bleaching has the potential to destroy the resources that have been providing Palauans with food and resources for over 3000 years. The Nature Conservancy, the Palau International Coral Reef Center (PICRC) and a network of conservation professionals have been monitoring Palau's reefs since 1998.



That's when a devastating coral bleaching event associated with El Niño severely damaged many of Palau's reefs, along with countless others around the globe. Reefs are still recovering from the damage they sustained, and the Conservancy is at the global forefront of trying to understand why some resilient reefs are more capable of bouncing back than others.

Last year, another bleaching event hit Palau. In response to this event, a team of PICRC and Conservancy scientists dramatically expanded their regular monitoring efforts to learn more about the reefs and their resilience and to gather crucial data that will inform the work undertaken by marine conservationists, here in the region as part of the Micronesia Challenge and all over the world.

"There's still a lot of work to do," says Steven, who's a native Palauan and regional conservation planner with the Conservancy's Micronesia program. "But we have built a network of partner agencies and communities that have begun to implement conservation and monitoring efforts based on key reef health indicators that will allow us to measure the effectiveness of our conservation efforts."

## SIAES

Work for the monitoring team begins early on a sunny Monday morning. There's no set order for visiting sites, so the team takes advantage of the nice weather to check a particularly far-flung location called Siaes off their list.

The 45-minute ride from Koror, Palau's capital, takes the team southwest through schools of dolphins and swirling clouds of black noddies. The boats use GPS to drop anchor at a predetermined spot, where the team's half-dozen divers collect their air tanks and slip over the side of the boat.

First into the water is Yimnang Golbuu, PICRC's head scientist, who has been diving at this site for years now. As a native Palauan, he understands the unique place the reefs — and the resources they provide — occupy in local life. "Without them, Palau would not be Palau," he says.

Yim and his team descend to the reef, roughly 10 meters below, with a 50-meter-long, tape measure-like device called a transect line. After it's pulled taut by scientists along the same stretch of reef that was last monitored, the scientists swim along the line, taking a high-resolution photograph every meter for later analysis.

After about an hour, the scientists ascend. They hadn't seen much bleaching: positive news, but expected, since this year's event has been milder than 1998's.

## NGETNGOD

During that event, few sites were hit as hard as Ngetngod (pronounced "Nyet node"), the team's Tuesday destination. Today, Steven stays on the boat while the rest of the team dives. From a bulky protective case, he pulls out a sonde. French for "probe," a sonde looks a bit like a microphone. Steven lowers it by a cord into the water, measuring the temperature and salinity at each meter. The sonde indicates the ocean temperature is 87° F. Waters here are normally 84° F.

A complex set of natural and human-influenced factors — including temperature, salinity, water turbidity, weather conditions and species composition and many more — affect a reef's vulnerability to bleaching. By cross-comparing temperatures and other data, scientists are gaining a better understanding of how some of these factors interact.

When Steven joined the Conservancy, he began to work with partners to translate and convey the scientific data being collected through these monitoring efforts to the Palauans who manage local reefs.

"Our work is dependent on partnership," he says, gesturing to the cerulean sea, where the divers are still swimming among napoleon wrasses, black-tipped sharks and bumphead parrotfish. "Knowledge is shared, skills are developed and a wide range of organizations and community members work in concert to improve our ability to manage healthy and productive reefs."

## NIKKO BAY

Another monitoring trip on Thursday keeps the scientists closer to their home base. Nikko Bay lies just minutes away from PICRC's headquarters in Koror. Sheltered by Palau's famed rock islands, these reefs are situated in waters that experience little circulation, which leads to abnormally high temperatures. White corals dot the seabed beneath the boat.

While the reefs of Nikko Bay took a hit, they're recovering, and the data they provided researchers will be crucial to better understanding reef resilience, which will help in protecting Palau's reefs through better-designed Marine Protected Areas.

"Thanks to the network of partner agencies and communal landowners that have participated wholeheartedly in conservation and monitoring efforts," Steven says, "we're getting a more accurate picture of the health of our reefs and an improved understanding of bleaching."

Answer the following questions.

1. Who is Dr. Steven Yimnang Golbuu?

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2. What does Dr. Golbuu mean by "what looks like a little forest of alabaster bonsai trees"?

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3. Why do you think "the reefs of Palau are under pressure"?

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4. What are the effects of coral bleaching?

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5. How does PCIRC team respond to coral bleaching?

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6. "Without them, Palau would not be Palau". Explain this.

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7. What is "NgetNgod"?

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8. What are the factors that affect the reef's vulnerability to bleaching? How do the scientists respond to these concerns?

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## SAMPLE LESSON PLAN 1

### MODULE 1: INTRODUCTION TO CLIMATE CHANGE

Module 1	<p>Introduction to Climate Change            Section 1.1 Climate System            Section 1.2 Weather            Section 1.3 Climate            Section 1.4 Climate Change            Section 1.5 Carbon Cycle            Section 1.6 Greenhouse Gas Effects</p>
Learning Objectives	<p>By the end of this module, the participants will be able to:</p> <ol style="list-style-type: none"> <li>i. Define and contrast the meaning of weather and climate;</li> <li>ii. Explain the concept of 'Climate Change'; and</li> <li>iii. Understand and explain some key impacts of climate change in SIDS in Asia and the Pacific.</li> </ol>
Time	60 minutes
Supporting Materials	<p>Weather and climate data (see preparation below)            Graph paper, pencils, rulers (or graphing software like Excel), pictures of natural disasters and extreme weather events (e.g. heat waves, storms, melting ice)            Handout 1 : Weather Data for Niue            Handout 2 : Weather Data for Melekeok, Palau            Handout 3 : Climate Change</p>
Preparation	<p>Find high and low temperature data over the past 5 days or month at The Weather Channel, Weather Underground, or your local news source. You can also google for the local weather forecast (as the given example).</p> <p>Find your local climate data.            There are many ways to find climate averages for your region. You can get in touch with your state climatologist or local news forecasters. You can search for climate data at the NOAA Climate Data Center or Weather Underground. One of the simplest ways to find your local climate data (as of July 2013) is via The Weather Channel. Follow the directions below to access climate data. (The steps are outlined in the graphic.)</p> <ul style="list-style-type: none"> <li>• Search your zip code or city and state.</li> <li>• Click "Monthly" on left.</li> <li>• Click "Averages" below the month calendar to see a summary of your regional climate.</li> <li>• To get a table of data instead of monthly averages, choose the table tab above the graph.</li> <li>• To see daily averages for a particular month, choose "daily averages" from the drop down menu (top left).</li> </ul>

<p>Warm Up Activity 5 minutes</p>	<ul style="list-style-type: none"> <li>• Ask participants about the day's weather.</li> <li>• Prompt them to describe aspects such as temperature, precipitation, cloud cover, and wind.</li> <li>• Ask the following questions: <ul style="list-style-type: none"> <li>- Is today's weather normal? Is it what you would expect?</li> </ul> </li> <li>• Tell the participants that in this activity they will explore how weather and climate are similar and different by exploring weather and climate temperature data over the past week or 5 days. They will compare daily temperature with averaged climate data.</li> <li>• Participants list what they know about weather and climate.</li> <li>• Trainer uses Handout 1 and Handout 2 to explain that weather is the current atmospheric conditions, including temperature, rainfall, wind, and humidity. Climate is the usual weather conditions based on 30 years of averaged weather data for a location. Climate is what you expect. Weather is what actually happens.</li> </ul>
<p>Activity 1 10 minutes</p>	<ul style="list-style-type: none"> <li>• In groups of 3, participants create graphs of <ul style="list-style-type: none"> <li>- high and low temperature climate averages over a month and</li> <li>- high and low temperature weather data over the past month or 5 days.</li> </ul> </li> <li>• Prompt participants to put temperature on the Y-axis and time on the X-axis.</li> <li>• Assist participants to consider what range of temperature would work well on the axis before they start graphing data.</li> </ul>
<p>Activity 2 15 minutes</p>	<ul style="list-style-type: none"> <li>• Based on their graphed data, participants discuss the following questions in their own groups: <ul style="list-style-type: none"> <li>- Which is more variable: this week's high and low temperatures or the climate averaged high and low temperatures? Why?</li> <li>- Is the weather temperature data warmer, cooler, or about the same as the average?</li> <li>- If you were asked to predict the temperature for tomorrow, which data would you find the most useful: the previous day's temperature or the average temperature for that day?</li> </ul> </li> <li>• Each group presents their findings.</li> </ul>
<p>Activity 3 10 minutes</p>	<ul style="list-style-type: none"> <li>• Give each group the following scenario.</li> <li>• Based on the scenario, they have to predict and discuss the answer to the question.</li> </ul> <p>Scenario: Nazil and Klyia are on their way to school on an April morning. Once they get on the city bus, Nazil takes off his jacket.</p> <p>"I'm hot," he says. "I thought it was supposed to be cool today like it was yesterday," says Klyia as she unwinds her scarf. "It was cool the day before, but now the temperature is climbing. It's going to be warm." "It's hot today because of global warming," says an elderly woman sitting in the row in front of them. She turns to look at Nazil and Klyia and shakes her head back and forth with gloom. "No it's not," says a man across the aisle angrily. "It's just the weather, not the climate." "Climate and weather are the same," says a woman in a business suit who is on her way to work. "No it's not," calls the bus driver over his shoulder.</p>

	<p>Nazil and Klyia look at each other with confusion. They didn't mean to start an argument. If you were on the bus with these people, how would you respond?</p> <p>Questions:</p> <ol style="list-style-type: none"> <li>1. If yesterday was cool and today is warm, could that be due to global warming?</li> <li>2. Are weather and climate the same or different? How would you respond to the people on the bus?</li> <li>3. How would you figure out what weather is normal for that time of year and that location?</li> <li>4. Can you think of a way that we can use weather data to figure out how climate is changing?</li> </ol>
<p>Activity 4 15 minutes</p>	<ul style="list-style-type: none"> <li>• Trainer asks participants on their understanding of climate change.</li> <li>• Trainer jots down participants ideas on the board, summarizing the key points leading to an explanation of concepts related to climate change.</li> <li>• Trainer explains the concept of climate change and some key phenomena of climate change based on Handout 3.</li> <li>• In groups of 3, ask participants if they have heard about the changes in their locality or country for e.g., change rainfall pattern, the type of crops that used to be harvested, agricultural calendar (cropping time etc.).</li> <li>• Ask each group to collect information from the media or the Net and prepare for a presentation.</li> <li>• Note: If they have known about some changes and include that in their presentations, conclude that climate change is happening. Their presentation will highlight the changes observed in local places then give some examples at regional or global level so that they can know that climate change is happening at global level as well. It will show how big the problem is.</li> </ul>
<p>Closure 5 minutes</p>	<ul style="list-style-type: none"> <li>• Participants are encouraged to collect pictures of weather they experience in their locality.</li> </ul>



## SAMPLE LESSON PLAN 2

### MODULE 1: INTRODUCTION TO CLIMATE CHANGE

### MODULE 2: CAUSES AND EFFECTS OF CLIMATE CHANGE

Module 1	Introduction to Climate Change Section 1.6 Greenhouse Gas Effects
Module 2	Causes and Effects of Climate Change Section 2.1 Impacts of Human Activities on Climate Change
Learning Objective	By the end of this module, the participants will be able to explain the greenhouse effects and describe the causes of climate change
Time	60 minutes
Warm up activity  10 minutes	<ul style="list-style-type: none"> <li>• Ask two participants to volunteer in the activity.</li> <li>• Bring them at the front and let one participant sit on a chair.</li> <li>• Give a blanket/cloths to the standing participant and ask him/her to cover his/her friend who is sitting on the chair.</li> <li>• Add on the blanket to the sitting participant one by one up to 4-5 blankets.</li> <li>• Then ask him/ her how he/she is feeling.</li> <li>• Note: As the blankets are added and added the participant will feel warmer and warmer.</li> <li>• Similarly, the earth gets warmer and warmer by the addition of greenhouse gases, which could cause the greenhouse effect, and hence global warming occurs. Here, the blanket acted as the Greenhouse Layer and the participant as the earth. Whatever difficulty the participant is feeling, more difficulty is being faced by the earth.</li> </ul>
Activity 1 - The Greenhouse Effect  20 minutes	<ul style="list-style-type: none"> <li>• Divide the participants in a group of 5-6.</li> <li>• Give each group these questions: <ul style="list-style-type: none"> <li>- Is global warming happening due to greenhouse effect?</li> <li>- What are the major sources of the greenhouse gases?</li> <li>- Is greenhouse effect good or bad? Why?</li> </ul> </li> <li>• Based on these questions, let each group do the paper cutting of the following: Earth, name of Greenhouse Gases, Greenhouse Layer, Sun, and arrow (drawing in papers); which are required to show the Greenhouse Effect.</li> <li>• Ask them to arrange the pictures in correct order to represent Greenhouse Effect.</li> <li>• Pictures can be attached at the board or wall.</li> <li>• Then ask them to explain briefly about their picture arrangement and greenhouse effect.</li> </ul>
Activity 2 – The Greenhouse Effect (GHG) Game  20 minutes	<ul style="list-style-type: none"> <li>• Divide the participants in a group of 5-6.</li> <li>• Prepare the greenhouse gases (GHGs) cards (Handout 4).</li> <li>• Assign a key player from each group.</li> <li>• Trainer shows one of the GHG card to the key player and the group members pose questions to the key player in order to guess the GHG.</li> <li>• The key player can only answer either 'Yes' or 'No' to the questions or statements given by the group members.</li> <li>• The group that manages to guess the correct GHG collects points.</li> </ul>
Closure  10 minutes	<ul style="list-style-type: none"> <li>• Trainer summarizes the causes of climate change and GHG.</li> <li>• Participants are asked to collect pictures of human activities that might harm climate change.</li> </ul>

## SAMPLE LESSON PLAN 3

### MODULE 2 : CAUSES AND EFFECTS OF CLIMATE CHANGE

Module 2	Causes and Effects of Climate Change Section 2.1 Impacts of Human Activities on Climate Change Section 2.2 Ocean Acidification Section 2.3 Sea level Rise Section 2.4 Temperature Rise Section 2.5 Natural Disaster and Extreme Event
Learning Objectives	By the end of this module, the participants will be able to: <ul style="list-style-type: none"> <li>i. Describe the main greenhouse gases and greenhouse gas emission from human activities; and</li> <li>ii. Identify ways to reduce negative impacts on the environment and mitigate climate change.</li> </ul>
Time	60 minutes
Supporting materials	Pictures of human activities, Handout 5 and Handout 6
Warm Up Activity 10 minutes	<ul style="list-style-type: none"> <li>• Participants share the pictures they have collected from the previous session on human activities that induce climate change.</li> <li>• Each group briefly explains one of the pictures and why the group has chosen the picture.</li> </ul>
Activity 1 – Who’s the culprit? 20 minutes	<ul style="list-style-type: none"> <li>• Divide participants in groups of 4 – 5.</li> <li>• Distribute a copy of Handout 5 to each group.</li> <li>• Based on the images in Handout 5, each group discusses the ‘culprit’ that has contributed to the emission of GHGs and how each activity has impacted on the environment and climate.</li> <li>• Each group presents the team findings.</li> </ul>
Activity 2 20 minutes	<ul style="list-style-type: none"> <li>• In groups of 4, each group is given a copy of Handout 6.</li> <li>• Each group has to discuss the human activities that have led to the impacts found in the handout.</li> <li>• They also suggest ways of reducing the impacts.</li> <li>• Each group presents its findings.</li> </ul>
Closure 10 minutes	<ul style="list-style-type: none"> <li>• Trainer summarizes the human activities that have impacted on climate change and ways of reducing the impacts.</li> </ul>

## SAMPLE LESSON PLAN 4

### MODULE 3 : SECTORAL IMPACTS OF AND VULNERABILITY TO CLIMATE CHANGE

Module 3	Sectoral Impacts of and Vulnerability to Climate Change Section 3.6 Energy
Learning Objectives	By the end of this module, the participants will be able to: <ul style="list-style-type: none"> <li>i. Understand and calculate the carbon dioxide emissions from their daily activities; and</li> <li>ii. Describe how carbon dioxide emissions influence climate change.</li> </ul>
Time	60 minutes
Supporting materials	Softcopy of Carbon Footprint Calculator, Picture 1, Picture 2, Picture 3, Picture 4
Warm Up Activity 10 minutes	<ul style="list-style-type: none"> <li>• Show Picture 1 – 4 to the participants.</li> <li>• Elicit responses on what is released in the human activities shown in the pictures.</li> <li>• Discuss the responses given based on impacts of climate change.</li> </ul>
Activity 1 20 minutes	<ul style="list-style-type: none"> <li>• Elicit responses on participants understanding of Carbon Footprint.</li> <li>• Distribute Handout 1 to the participants.</li> <li>• Explain what Carbon Footprint is.</li> <li>• Divide the participants in groups of 4.</li> <li>• In their groups, participants list the following: <ul style="list-style-type: none"> <li>- The number of people in the household</li> <li>- The amount of energy used at home</li> <li>- The kind of transportation used</li> </ul> </li> <li>• Calculate each group’s carbon footprint using the basic carbon calculator provided.</li> </ul>
Activity 2 25 minutes	<ul style="list-style-type: none"> <li>• Based on the results from the calculation, each group discusses how the team can help reduce the amount of carbon dioxide emitted.</li> <li>• Each group showcases its findings on the spreadsheet provided.</li> <li>• The spreadsheets are pasted around the room and a member of each group is stationed with the group’s spreadsheet to explain the findings.</li> <li>• The other members do the gallery walk to gain input on other groups’ findings.</li> </ul>
Closure 5 minutes	<ul style="list-style-type: none"> <li>• Trainer summarizes the impacts of carbon dioxide emission to the environment.</li> <li>• Trainer emphasizes on the important measures that need to be taken to overcome the phenomena.</li> </ul>

## SAMPLE LESSON PLAN 5

**MODULE 1: INTRODUCTION TO CLIMATE CHANGE**

**MODULE 2: CAUSES AND EFFECTS OF CLIMATE CHANGE**

**MODULE 3: SECTORAL IMPACTS OF AND VULNERABILITY TO CLIMATE CHANGE**

Module 1 Module 2 Module 3	Introduction to Climate Change Causes and Effects of Climate Change Sectoral Impacts of and Vulnerability to Climate Change
Learning Objectives	By the end of this module, the participants will be able to: <ul style="list-style-type: none"> <li>i. Describe climate change impacts on human and natural systems; and</li> <li>ii. Understand of climate change impacts on SIDS in the Asia Pacific in general.</li> </ul>
Time	60 minutes
Supporting materials	Spreadsheet, coloured markers/pens, various climate change situations
Warm Up Activity  10 minutes	<ul style="list-style-type: none"> <li>• Conduct a quiz based on the following questions: <ul style="list-style-type: none"> <li>- What is the difference between weather and climate?</li> <li>- How do you define climate change?</li> <li>- What causes climate change?</li> <li>- What are climate change impacts?</li> <li>- What do you understand by greenhouse effects?</li> <li>- How many key GHGs are found in the atmosphere?</li> <li>- What human activities generate GHGs?</li> </ul> </li> </ul>
Activity 1  20 minutes	<ul style="list-style-type: none"> <li>• Participants work in groups of 4.</li> <li>• Participants respond to this question – What impacts may climate change have on our lives?</li> <li>• Each group discusses this question based on one of these areas: health, agriculture and fisheries, water and marine resources, ecosystems, energy, construction and transport.</li> <li>• Each group presents the team findings/results of their discussion.</li> </ul>
Activity 2 – The Impact Game  20 minutes	<ul style="list-style-type: none"> <li>• Divide the participants in groups of 4.</li> <li>• Write various climate change impacts separately in separate paper and give that to all the groups. For e.g., hurricane, drought, floods, sea level rise etc.</li> <li>• Brief the participants that they will imagine and fit themselves in the climate change event as given in the paper. Each group will then act and speak a few words thinking what they will do if they face such a situation. For example, if a group receives the paper on floods, then from the group one will act as human, one as plants and wildlife, and one as soil or infrastructure or any other thing that is prevailing there.</li> <li>• The group will compile the impacts on each aspect and present as a group.</li> <li>• Note: This activity will help them to think of other vulnerable- to-people situations and know the extent of how climate change is affecting many people globally as well as the whole natural system.</li> </ul>
Closure  10 minutes	<ul style="list-style-type: none"> <li>• Discuss the following questions with the participants. <ul style="list-style-type: none"> <li>- What are the climate change impacts in SIDS in the Asia Pacific?</li> <li>- How are they similar to the impacts at global level?</li> </ul> </li> </ul>

## SAMPLE LESSON PLAN 6

### MODULE 2: CAUSES AND EFFECTS OF CLIMATE CHANGE

### MODULE 3: SECTORAL IMPACTS OF AND VULNERABILITY TO CLIMATE CHANGE

Module 2	Causes and Effects of Climate Change Section 2.2 Ocean Acidification Section 2.3 Sea level Rise Section 2.4 Temperature Rise Section 2.5 Natural Disaster & Extreme Weather
Module 3	Sectorial Impacts of and Vulnerability to Climate Change Section 3.2 Food Security and Livelihood Section 3.3 Water Resources Section 3.4 Ecosystem and Biodiversity Section 3.5 Health and Safety
Learning Objectives	By the end of this module, the participants will be able to: i. Describe the impacts of climate change on SIDS; and ii. Understand and identify ways to overcome the impacts.
Time	60 minutes
Supporting materials	Picture 5, Handout 8, Handout 9
Warm Up Activity 10 minutes	<ul style="list-style-type: none"> <li>Show Picture 5 to the participants.</li> <li>Elicit responses to the picture as to what has resulted from CC in SIDS?</li> <li>Discuss the responses given based on impacts of climate change.</li> </ul>
Activity 1 15 minutes	<ul style="list-style-type: none"> <li>Divide participants in groups of four.</li> <li>Distribute Handout 8 and Handout 9 to each group.</li> <li>Based on the handouts given, each group discusses the impacts of climate change on SIDS according to the assigned areas:               <ul style="list-style-type: none"> <li>Ocean Acidification</li> <li>Sea level Rise</li> <li>Temperature Rise</li> <li>Natural Disaster and Extreme Event</li> <li>Food Security and Livelihood</li> <li>Water Resources</li> <li>Ecosystem and Biodiversity</li> <li>Health and Safety</li> </ul> </li> <li>Present the results of the discussion in a graphic manner.</li> </ul>
Activity 2 25 minutes	<ul style="list-style-type: none"> <li>Based on the assigned areas in Activity 1, each group discusses on possible ways to overcome the impacts.</li> <li>Presents the result of the discussion in the form a sketch/play.</li> </ul>
Closure 10 minutes	<ul style="list-style-type: none"> <li>Trainer summarizes the impacts that have been highlighted in the activities on SIDS.</li> <li>Trainer emphasizes on the important measures that need to be taken to overcome the phenomena.</li> </ul>

## SAMPLE LESSON PLAN 7

### MODULE 3: SECTORAL IMPACTS OF AND VULNERABILITY TO CLIMATE CHANGE

### MODULE 4: RESPONSES AND EFFORTS TO ADDRESS CLIMATE CHANGE

Module 3	Sectorial Impacts of and Vulnerability to Climate Change Section 3.4 Ecosystem and Biodiversity Responses and Efforts to Address Climate Change
Module 4	Section 4.3 Disaster Risk Reduction Section 4.4 International Efforts to Address Climate Change Section 4.5 Regional and SIDS Efforts to Address Climate Change Section 4.6 Local and Traditional Practices for Addressing Climate Change in SIDS
Learning Objectives	By the end of this module, the participants will be able to: i. Read and understand issues on weather-linked disasters; ii. Explain issues on weather-linked disasters; iii. Prepare PowerPoint presentation slides on Pacific Island Mangroves; and iv. Write a letter to your local council.
Time	80 minutes
Supporting materials	Handout 10 (Newspaper article), Handout 11 (Pacific Island Mangroves in a Changing Climate and Rising Sea).
Warm Up Activity 10 minutes	<ul style="list-style-type: none"> <li>In groups of three, read Handout 10 and list issues related to weather-linked disasters.</li> <li>Discuss how these issues can be addressed pertaining to local context.</li> </ul>
Activity 1 20 minutes	<ul style="list-style-type: none"> <li>Based on the issues discussed in Warm Up activity, form three groups.</li> <li>Distribute Handout 11 according to arrangement below:  Group 1 : 'Pacific Island Mangroves' Group 2 : 'Mangrove Ecosystem Values' Group 3 : 'Threats to Pacific Island Mangroves'</li> <li>Read Handout 11 in groups and identify the main issues addressed by the given pages.</li> </ul>
Activity 2 30 minutes	<ul style="list-style-type: none"> <li>Prepare PowerPoint presentation slides on the given pages of Handout 11.</li> <li>Present your slides to the class.</li> </ul>
Closure 20 minutes	<ul style="list-style-type: none"> <li>Write a letter to your local council suggesting mangrove replanting as a way to reduce climate change effects to your own country. Give suggestions based on the notes presented by your friends on Pacific Island Mangroves.</li> </ul> <p>Note : Teacher may treat this activity as homework to be taken back and completed at home by students if the time does not permit for in class activity.</p>



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# Glossary

## GLOSSARY

- 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 (IPCC, 2001).
- Adjustment in natural or human systems to a new or changing environment. Adaptation refers to adjustments in natural or human systems, intended to reduce vulnerability to current or anticipated climate change and variability or exploit beneficial opportunities (AusAID, 2012).
- Afforestation** Planting of new forests on lands that historically have not contained forests (IPCC, 2001).
- Afforestation is usually defined as the establishment of forest on land that has been without forest for a period of time (e.g., 20–50 years or more) and was previously under a different land use (IPCC, 2000).
- Anthropogenic** Resulting from, influenced or produced by human beings (IPCC, 2001).
- Atmosphere** One of the four components of the Earth’s ecosystem (the other three are biosphere, hydrosphere, and lithosphere), it is a brand of gases enveloping the Earth’s surface. Ninety-nine percent of its mass is concentrated within 20 miles of the earth’s surface, and its two largest constituents (in the lowest part) are nitrogen (about 78%) and oxygen (about 21%). The remaining one percent includes mostly argon and minute amounts of carbon dioxide, water vapour, and xenon. In meteorology, atmosphere is divided into seven layers called regions (from the lowest to the highest): troposphere, stratosphere, mesosphere, chemosphere, thermosphere, ionosphere, and exosphere. (businessdictionary.com, 2015)
- 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, 2001).

Biodiversity/ Biological diversity	“Biological diversity” means the variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems. (www.cbd.int, 2015)
Biomes	A biome is a major and distinct regional element of the biosphere, typically consisting of several ecosystems (e.g. forests, rivers, ponds, swamps within a region). Biomes are characterised by typical communities of plants and animals (IPCC, 2001).
Biomass	The total mass of living organisms in a given area or volume; dead plant material can be included as dead biomass (IPCC, 2001).
Biosphere (terrestrial and marine)	The part of the Earth system comprising all ecosystems and living organisms, in the atmosphere, on land (terrestrial biosphere) or in the oceans (marine biosphere), including derived dead organic matter, such as litter, soil organic matter and oceanic detritus (IPCC, 2001).
Capacity	Capacity refers to the ability to hold or contain people or things; the largest amount or number that can be held or contained; and the ability to do something, e.g. a mental, emotional, or physical ability. (merriam-webster, 2015)
Carbon cycle	The natural processes that influence the exchange of carbon (in the forms of carbon dioxide (CO <sub>2</sub> ), carbonate and organic compounds, etc.) between the atmosphere, ocean and terrestrial systems. Major components include photosynthesis, respiration and decay between atmospheric and terrestrial systems (approximately 100 billion tons/year), thermodynamic exchange between the ocean and atmosphere, carbon exchange in the deep ocean (approximately 90 billion tons/year). Deforestation and the burning of fossil fuels releases approximately 7Gt carbon into the atmosphere annually. The total carbon in reserve is approximately 2000 Gt in land biota, soil and detritus, 730 Gt in the atmosphere and 38,000 Gt in the oceans (IPCC, 2001).



Carbon cycle	On long-time scales, atmospheric CO <sub>2</sub> concentration is influenced by the balance of geochemical processes including organic carbon burial in sediments, silicate rock weathering, and volcanism (AusAID, 2012). 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, 2001).
Carbon dioxide emission	Carbon dioxide emissions are those stemming from the burning of fossil fuels and the manufacture of cement. They include carbon dioxide produced during consumption of solid, liquid, and gas fuels and gas flaring (World Bank, 2015)
Carbon footprint	The total amount of greenhouse gases that are emitted into the atmosphere each year by a person, family, building, organization, or company. A person's carbon footprint includes greenhouse gas emissions from fuel that an individual burns directly, such as by heating a home or riding in a car. It also includes greenhouse gases that come from producing the goods or services that the individual uses, including emissions from power plants that make electricity, factories that make products, and landfills where trash gets sent. (epa.gov, 2015)
Clean Development Mechanism (CDM)	The CDM allows emission-reduction projects in developing countries to earn certified emission reduction (CER) credits, each equivalent to one tonne of CO <sub>2</sub> . These CERs can be traded and sold, and used by industrialized countries to meet a part of their emission reduction targets under the Kyoto Protocol. The mechanism stimulates sustainable development and emission reductions, while giving industrialized countries some flexibility in how they meet their emission reduction limitation targets. (UNFCCC, 2015)

**Climate** Climate is often defined as the weather averaged over time (typically, 30 years as defined by the World Meteorological Organization) (AusAID, 2012)

Climate in a narrow sense is usually defined as the average weather, or more rigorously, as the statistical description in terms of the mean and variability of relevant quantities over a period of time ranging from months to thousands or millions of years. The classical period for averaging these variables is 30 years, as defined by the World Meteorological Organization. The relevant quantities are most often surface variables such as temperature, precipitation and wind. Climate in a wider sense is the state, including a statistical description, of the climate system (IPCC, 2001).

**Climate change** Refers to any distinct change in measures of climate lasting for a long period of time. In other words, “climate change” means major changes in temperature, rainfall, snow, or wind patterns lasting for decades or longer (US EPA, 2009).

Climate change refers to a change in the state of the climate that can be identified 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 forcing, or to persistent anthropogenic changes in the composition of the atmosphere or in land use (AusAID, 2012).

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Climate system	The climate system is the highly complex system consisting of five major components: the atmosphere, the hydrosphere, the cryosphere, the land surface and the biosphere, and the interactions between them. The climate system evolves in time under the influence of its own internal dynamics and because of external forcings such as volcanic eruptions, solar variations and anthropogenic forcings such as the changing composition of the atmosphere and land use change (IPCC, 2001).
Climate variability	Climate variability refers to variations in the mean state and other statistics (such as the occurrence of extremes, etc.) of the climate on all temporal and spatial 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, 2001).
Climatology	The study of climate, differs from meteorology in that climate is the long-term pattern of temperature, precipitation, wind patterns, etc. at a particular location, over periods of a year or more, whereas weather is the current (or very near-term) state of affairs at the location or region of interest (USAID LEAF PowerPoint).
CO <sub>2</sub> e	CO <sub>2</sub> e refers to Equivalent CO <sub>2</sub> , which is the concentration of carbon dioxide (CO <sub>2</sub> ) that would cause the same level of radiative forcing as a given type and concentration of greenhouse gases. It is expressed in units of ppmv (parts per million by volume) for example, 1CO <sub>2</sub> e = 412 ppmv.
CO <sub>2</sub> Equivalent	CO <sub>2</sub> Equivalent refers to 100-year emissions from different greenhouse gases, which are converted to global warming potential (GWP) and expressed as a common unit. IPCC uses CO <sub>2</sub> Equivalent as CO <sub>2</sub> eq.
Conservation	Supporting the protection of intact (and not currently threatened) natural resources in developing countries.
Coastal system	Systems containing terrestrial areas dominated by ocean influences of tides and marine aerosols, plus nearshore marine areas.

Coral bleaching	Coral bleaching occurs when the relationship between the coral host and zooxanthellae (a tiny marine algae), which give coral much of their colour, breaks down. Without the zooxanthellae, the tissue of the coral animal appears transparent and the coral's bright white skeleton is revealed. Corals begin to starve once they bleach. While some corals are able to feed themselves, most corals struggle to survive without their zooxanthellae.
Cryosphere	The component of the climate system consisting of all snow, ice and frozen ground (including permafrost) on and beneath the surface of the Earth and ocean (IPCC, 2001).
Deforestation	Deforestation is the direct human-induced conversion of forested land to non-forested land. (FAO, 2015)
Disaster	A serious disruption of the functioning of a community or a society causing widespread human, material, economic or environmental losses which exceed the ability of the affected community or society to cope using its own resources (AusAID, 2012).
Disaster Risk Reduction	An action taken to reduce the risk of disasters and the adverse impacts of natural hazards, through systematic efforts to analyse and manage the causes of disasters, including through avoidance of hazards, reduced social and economic vulnerability to hazards, and improved preparedness for adverse events. (UNISDR, 2015)
Drought	Drought is a 'prolonged absence or marked deficiency of precipitation', a 'deficiency that results in water shortage for some activity or for some group', or a 'period of abnormally dry weather sufficiently prolonged for the lack of precipitation to cause a serious hydrological imbalance' (Heim, 2002).
Ecosystem services	The benefits people obtain from ecosystems. These include provisioning services such as food and water; regulating services such as flood and disease control; cultural services such as spiritual, recreational, and cultural benefits; and supporting services such as nutrient cycling that maintain the conditions for life on Earth. The concept "ecosystem goods and services" is synonymous with ecosystem services. (WRI, 2015)

Ecosystem	A system of living organisms interacting with each other and 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).
Energy	It comes from many sources and in many forms. The forms of energy are classified in two general categories: potential and kinetic. Potential energy is energy stored in an object. Chemical, mechanical, nuclear, gravitational, and electrical are all stored energy. Kinetic energy does the work. Light, heat, motion, and sound are examples of kinetic energy. (energy4me.org, 2015)
Energy efficiency	Energy efficiency, means using less energy to provide the same level of energy. It is therefore one method to reduce human greenhouse gas emissions. (bgs.ac.uk, 2015)
Evapotranspiration	The combined process of evaporation from the Earth's surface and transpiration from vegetation.
External forcing	External forcing refers to a forcing agent outside the climate system causing a change in the climate system. Volcanic eruptions, solar variations and anthropogenic changes in the composition of the atmosphere and land use change are external forcings (IPCC, 2001).
Extreme (weather) Event	An extreme weather event is an event that is rare at a particular place and time of year. Definitions of rare vary, but an extreme weather event would normally be as rare as or rarer than the 10th or 90th percentile of the observed probability density function. By definition, the characteristics of what is called extreme weather may vary from place to place in an absolute sense. Single extreme events cannot be simply and directly attributed to anthropogenic climate change, as there is always a finite chance the event in question might have occurred naturally. When a pattern of extreme weather persists for some time, such as a season, it may be classed as an extreme climate event, especially if it yields an average or total that is itself extreme (e.g., drought or heavy rainfall over a season) (IPCC, 2001).

- Food Security** The World Food Summit of 1996 defined food security as existing “when all people at all times have access to sufficient, safe, nutritious food to maintain a healthy and active life”. Commonly, the concept of food security is defined as including both physical and economic access to food that meets people’s dietary needs as well as their food preferences. In many countries, health problems related to dietary excess are an ever increasing threat. In fact, malnutrition and foodborne diarrhoea are become double burden.  
(WHO, 2015)
- Forest Degradation** Changes within the forest which negatively affect the structure or function of the stand or site, and thereby lower the capacity to supply products and/or services. (FAO, 2016)
- Gender Inequality** Gender inequality refers to unequal treatment or perceptions of individuals based on their gender. It arises from differences in socially constructed gender roles as well as biologically through chromosomes, brain structure, and hormonal differences (Wood, 2005).
- Glacier** A mass of land ice that flows downhill under gravity (through internal deformation and/or sliding at the base) and is constrained by internal stress and friction at the base and sides. A glacier is maintained by accumulation of snow at high altitudes, balanced by melting at low altitudes or discharge into the sea (IPCC, 2001)
- Global warming** An average increase in temperatures near the Earth’s surface and in the lowest layer of the atmosphere. Increases in temperatures in our Earth’s atmosphere can contribute to changes in global climate patterns. Global warming can be considered part of climate change along with changes in precipitation, sea level, etc. (US EPA, 2009)

**Greenhouse gases (GHGs)** Greenhouse gases (GHGs) are those gaseous of the atmosphere, both natural and anthropogenic, that absorb and emit thermal infrared radiation entering the Earth's atmosphere and being emitted from the Earth's surface. Water vapour, carbon dioxide, nitrous oxide, methane, ozone in the troposphere and halocarbons are the primary greenhouse gases in the atmosphere (AusAID, 2012).

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 thermal infrared radiation emitted by the Earth's surface, the atmosphere itself, and by clouds. This property causes the greenhouse effect. Water vapour (H<sub>2</sub>O), carbon dioxide (CO<sub>2</sub>), nitrous oxide (N<sub>2</sub>O), methane (CH<sub>4</sub>) and ozone (O<sub>3</sub>) 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<sub>2</sub>, N<sub>2</sub>O and CH<sub>4</sub>, the Kyoto Protocol deals with the greenhouse gases sulphur hexafluoride (SF<sub>6</sub>), hydrofluorocarbons (HFCs) and perfluorocarbons (PFCs) (IPCC, 2001)

**Greenhouse effect** Greenhouse gases effectively absorb thermal infrared radiation, emitted by the Earth's surface, by the atmosphere itself due to the same gases, and by clouds. Atmospheric radiation is emitted to all sides, including downward to the Earth's surface. Thus, greenhouse gases trap heat within the surface-troposphere system. This is called the greenhouse effect. Thermal infrared radiation in the troposphere is strongly coupled to the temperature of the atmosphere at the altitude at which it is emitted. In the troposphere, the temperature generally decreases with height. Effectively, infrared radiation emitted to space originates from an altitude with a temperature of, on average, -19°C, in balance with the net incoming solar radiation, whereas the Earth's surface is kept at a much higher temperature of, on average, +14°C. An increase in the concentration of greenhouse gases leads to an increased infrared opacity of the atmosphere, and therefore to an effective radiation into space from a higher altitude at a lower temperature. This causes a radiative forcing that leads to an enhancement of the greenhouse effect, the so-called enhanced greenhouse effect (IPCC, 2001)

Halocarbon	A collective term for the group of partially halogenated organic species, including the chlorofluorocarbons (CFCs), hydrofluorocarbons (HFCs), halons, methyl chloride, methyl bromide, etc. Many of the halocarbons have large Global Warming Potentials. The chlorine and bromine-containing halocarbons are also involved in the depletion of the ozone layer (IPCC, 2001).
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 (AusAID, 2012).
Human systems	Human (made) systems are those in which human being intervened through component, attributes, or relationships. (answers.com, 2015)
Hydrosphere	The hydrosphere is the liquid water component of the Earth. It includes the oceans, seas, lakes, ponds, rivers and streams. The hydrosphere covers about 70% of the surface of the Earth and is the home for many plants and animals. (earth.rice.edu, 2015)
Ice cap	<p>The component of the climate system comprising liquid surface and subterranean water, such as oceans, seas, rivers, fresh water lakes, underground water, etc. (IPCC, 2001)</p> <p>An ice cap is a glacier, a thick layer of ice and snow, that covers fewer than 50,000 km<sup>2</sup>. Ice caps tend to be slightly dome-shaped and spread out from their centre. (National Geographic, 2015)</p> <p>A dome shaped ice mass, usually covering a highland area, which is considerably smaller in extent than an ice sheet (IPCC, 2001).</p>



Ice sheet	A mass of land ice that is sufficiently deep to cover most of the underlying bedrock topography, so that its shape is mainly determined by its dynamics (the flow of the ice as it deforms internally and/or slides at its base). An ice sheet flows outward from a high central ice plateau with a small average surface slope. The margins usually slope more steeply, and most ice is discharged through fast-flowing ice streams or outlet glaciers, in some cases into the sea or into ice shelves floating on the sea. There are only three large ice sheets in the modern world, one on Greenland and two on Antarctica, the East and West Antarctic Ice Sheets, divided by the Transantarctic Mountains. During glacial periods there were others (IPCC, 2001).
Ice shelf	A floating slab of ice of considerable thickness extending from the coast (usually of great horizontal extent with a level or gently sloping surface), often filling embayments in the coastline of the ice sheets. Nearly all ice shelves are in Antarctica, where most of the ice discharged seaward flows into ice shelves (IPCC, 2001).
Ice stream	A stream of ice flowing faster than the surrounding ice sheet. It can be thought of as a glacier flowing between walls of slower-moving ice instead of rock (IPCC, 2001).
Invasive Species	Invasive alien species (IAS) are species whose introduction and/or spread outside their natural past or present distribution threatens biological diversity. (cbd.int, 2015)
Joint Implementation (JI)	The mechanism known as “joint implementation,” defined in Article 6 of the Kyoto Protocol, allows a country with an emission reduction or limitation commitment under the Kyoto Protocol (Annex B Party) to earn emission reduction units (ERUs) from an emission-reduction or emission removal project in another Annex B Party, each equivalent to one tonne of CO <sub>2</sub> , which can be counted towards meeting its Kyoto target. Joint implementation offers Parties a flexible and cost-efficient means of fulfilling a part of their Kyoto commitments, while the host Party benefits from foreign investment and technology transfer. (UNFCCC, 2015)

- 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 (CAP) 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, 2001).
- Lithosphere** The lithosphere is the solid, outer part of the Earth. The lithosphere includes the brittle upper portion of the mantle and the crust, the outermost layers of Earth's structure. (National Geographic, 2015)
- The upper layer of the solid Earth, both continental and oceanic, which comprises all crustal rocks and the cold, mainly elastic part of the uppermost mantle. Volcanic activity, although part of the lithosphere, is not considered as part of the climate system, but acts as an external forcing factor (IPCC, 2001)
- Livelihood** A livelihood comprises the capabilities, assets (including both material and social resources) and activities required for a means of living. A livelihood is sustainable when it can cope with and recover from stresses and shocks and maintain its capabilities and assets both now and in the future, while not undermining the natural resource base. (FAO, 2015)
- Land use and land use change** Land use refers to the total of arrangements, activities and inputs undertaken in a certain land cover type (a set of human actions). The term land use is also used in the sense of the social and economic purposes for which land is managed (e.g., grazing, timber extraction and conservation). Land use change refers to a change in the use or management of land by humans, which may lead to a change in land cover (IPCC, 2001)

Microclimate	Microclimate is the set of meteorological parameters that characterize a localized area. The scale of geography associated with a microclimate is on the order of one square meter or as large as the order of 100 km <sup>2</sup> . (EO Earth, 2015)
Mitigation	Actions resulting in reduction of the degree or intensity of greenhouse gas emissions. (AusAID, 2012). An anthropogenic intervention to reduce the sources or enhance the sinks of greenhouse gases (IPCC, 2001).
Monsoon	A monsoon is a tropical and subtropical seasonal reversal in both the surface winds and associated precipitation, caused by differential heating between a continental-scale land mass and the adjacent ocean. Monsoon rains occur mainly over land in summer (IPCC, 2001).
Montreal Protocol	The Montreal Protocol on Substances that Deplete the Ozone Layer was adopted in Montreal in 1987, and subsequently adjusted and amended in London (1990), Copenhagen (1992), Vienna (1995), Montreal (1997) and Beijing (1999). It controls the consumption and production of chlorine- and bromine-containing chemicals that destroy stratospheric ozone, such as chlorofluorocarbons, methyl chloroform, carbon tetrachloride and many others (IPCC, 2001).
Natural systems	Natural systems are those that came into being by natural processes. For example, the food chain and the water cycle. (answers.com, 2015).
Ocean acidification	A decrease in the pH of sea water due to the uptake of anthropogenic carbon dioxide (IPCC, 2001).
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, 2001).
Plankton	Microorganisms living in the upper layers of aquatic systems. A distinction is made between phytoplankton, which depend on photosynthesis for their energy supply, and zooplankton, which feed on phytoplankton.

Permaculture	<p>Consciously designed landscapes which mimic the patterns and relationships found in nature, while yielding an abundance of food, fibre and energy for provision of local needs. People, their buildings and the ways in which they organise themselves are central to permaculture. Thus the permaculture vision of permanent or sustainable agriculture has evolved to one of permanent or sustainable culture. (Holmgren, 2015)</p> <p>Permaculture is the conscious design of human systems that work with, rather than against, the power of the natural world, to increase abundance for all living things. It is based on a specific set of principles and tools, and draws from both modern science and the successful practices and wisdom of indigenous peoples. It uses local resources wherever possible, to solve local problems. (Grow Permaculture, 2015)</p>
Precipitation	<p>Precipitation is water released from clouds in the form of rain, freezing rain, sleet, snow, or hail. It is the primary connection in the water cycle that provides for the delivery of atmospheric water to the Earth. Most precipitation falls as rain. (USGS, 2015)</p>
Reforestation	<p>Planting of forests on lands that have previously contained forest but have since been converted to some other use (IPCC, 2001).</p>
Renewable energy	<p>Any naturally occurring, theoretically inexhaustible source of energy, as biomass, solar, wind, tidal, wave, and hydroelectric power, that is not derived from fossil or nuclear fuel. (Dictionary Reference, 2015)</p>
Resilience	<p>Resilience comes from having the capacity to mitigate (diminish impacts) or adapt (respond to change.) It signifies the capacity of a system to absorb disturbances and surprises. It can mean the ability to reorganise so as to retain the same essential function, structure and identity. Resilience is an inherent quality of all healthy living systems. It is a state of dynamic equilibrium which enables systems to grow and evolve while keeping their coherence. (GAIA Foundation, 2015)</p>
Respiration	<p>The process whereby living organisms convert organic matter to carbon dioxide, releasing energy and consuming molecular oxygen (IPCC, 2001).</p>

Risk	The combination of the probability of an event and the scale of its negative consequences. Disaster risk are the potential disaster losses, in lives, health status, livelihoods, assets and services, which could occur in a particular community or a society over some specified future time period (AusAID 2012).
Salinization	Salinization refers to a build-up of salts in soil, eventually to toxic levels for plants. (People Oregonstate, 2015)
Sink	(Carbon) sink refers to any process, activity or mechanism that removes a greenhouse gas, an aerosol or a precursor of a greenhouse gas or aerosol from the atmosphere (IPCC, 2001).
Sea level change	Sea level can change, both globally and locally, due to (i) changes in the shape of the ocean basins, (ii) changes in the total mass of water and (iii) changes in water density (IPCC, 2001).
Semiarid	Semiarid region is characterized by very little annual rainfall, usually from 10 to 20 inches (25 to 50 cm). (Dictionary Reference, 2015)
Sensitivity	Degree to which a system will respond to a change in climatic conditions. E.g. extent of change in ecosystem composition, structure and functioning. (GRIDA, 2015)
Solar radiation	Electromagnetic radiation emitted by the Sun. It is also referred to as shortwave radiation. Solar radiation has a distinctive range of wavelengths (spectrum) determined by the temperature of the Sun, peaking in visible wavelengths (IPCC, 2001).
Subarctic (or boreal)	This climate is intermediary between moderate climate and very cold climate. The summers are colder and the winters more rigorous than in the moderate climate. It is possible to find this type of climate only in the northern hemisphere: the extreme North-East of the United States, Canada, major part of Russia and the North-East of China. (Meteorology Climate, 2015)
Susceptibility	The state or fact of being likely or liable to be influenced or harmed by a particular thing. (Oxford Dictionaries, 2015)

Sustainable Development	“Development that meets the needs of the present without compromising the ability of future generations to meet their own needs” (Bruntland, Report 1987).
Sustainable livelihood	A livelihood is sustainable when it can cope with and recover from the stresses and shocks and maintain or enhance its capabilities and assets both now and in the future without undermining the natural resource base. (Frankenberger, 2000).
Thermal infrared radiation	Radiation emitted by the Earth’s surface, the atmosphere and the clouds. It is also known as terrestrial or longwave radiation, and is to be distinguished from the near-infrared radiation that is part of the solar spectrum. Infrared radiation, in general, has a distinctive range of wavelengths (spectrum) longer than the wavelength of the red colour in the visible part of the spectrum. The spectrum of thermal infrared radiation is practically distinct from that of shortwave or solar radiation because of the difference in temperature between the Sun and the Earth-atmosphere system (IPCC, 2001).
Traditional Knowledge	<p>“Traditional knowledge” refers to collective and unique knowledge of traditions used by indigenous local people to sustain and adapt themselves to their environment over time. This information is passed on from one generation to the next within the indigenous local people. Traditional knowledge is usually shared among elders, healers or hunters and gatherers, and is passed on to the next generation through ceremonies, stories or teachings. (AFN, 2015)</p> <p>“Traditional knowledge,” as a broad description of subject matter, generally includes the intellectual and intangible cultural heritage, practices and knowledge systems of traditional communities, including indigenous and local communities (traditional knowledge in a general sense or lato sensu). In other words, traditional knowledge in a general sense embraces the content of knowledge itself as well as traditional cultural expressions, including distinctive signs and symbols associated with traditional knowledge. (WIPO, 2015)</p>

Tundra	<p>Tundra is among Earth's coldest, harshest biomes. Tundra ecosystems are treeless regions found in the Arctic and on the tops of mountains, where the climate is cold and windy and rainfall is scant.</p> <p>(National Geographic, 2015)</p>
United Nations Framework Convention on Climate Change (UNFCCC)	<p>It is often referred to as the Convention on Climate Change, signed by more than 150 countries at the Earth Summit in Rio de Janeiro in 1992. Its ultimate objective is to achieve "stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system". The Convention did not state the legal obligations on emission levels while only required countries in the Annex I to reduce emissions to levels of 1990 in 2000. The Convention took effect in March 1994 with ratification of more than 50 countries. Currently 195 countries have ratified the Convention. In March 1995, the Conference of the Parties (CAP), the governing body of the convention, held the first meeting in Berlin. The Convention Secretariat is based in Bonn, Germany (AusAID 2012).</p>
Vulnerability	<p>The characteristics and circumstances of a community, system or asset that make it susceptible to the damaging effects of a hazard. Vulnerability to impacts of climate change is the degree to which a system (e.g. a natural, social or economic system) is susceptible to and unable to cope with, adverse effects of climate change (AusAID, 2012).</p>
VOC	<p>Volatile Organic Compounds (VOCs) are a large group of carbon-based chemicals that easily evaporate at room temperature.</p> <p>(Health State, 2015)</p>
Weather	<p>The actual state of the atmosphere in a period of several hours up to a few days (in a given place) (Gramelsberger &amp; Feichter, 2011). Describes atmospheric conditions at a particular place in terms of air temperature, pressure, humidity, wind speed and precipitation etc. (AusAID, 2012)</p>
Zoonosis	<p>A zoonosis is any disease or infection that is naturally transmissible from vertebrate animals to humans. Animals thus play an essential role in maintaining zoonotic infections in nature. Zoonosis may be bacterial, viral, or parasitic, or may involve unconventional agents. As well as being a public health problem, many of the major zoonotic diseases prevent the efficient production of food of animal origin and create obstacles to international trade in animal products.</p> <p>(WHO, 2015)</p>



# Appendices



Fill in any relevant values in Column 2.  
if you are using a printed version you will then need  
a calculator to multiply these numbers by the factors  
in Column 3 to give Kg of CO<sub>2</sub> released  
Finally add the total of all the numbers in Column 4  
to calculate your total carbon footprint



### NUMBER OF PEOPLE :


	1 Energy source	2 Annual Total	3 Factor	4 Kg of CO <sub>2</sub> released	5 % of your total CO <sub>2</sub> emissions
HOME Energy Usage	Electricity (from ESB)	kWhr	0.63		
	Electricity (from An Bord Gais)	kWhr	0.20		
	Electricity (from Airtricity)	kWhr	0.07		
	Gas (Heating)	kWhr	0.20		
	Oil (Kerosene)	litres	2.52		
	Oil (Gasoil)	litres	2.67		
	Oil (HFO)	litres	3.22		
	Gas (Prop/but)	litres	1.50		
	Coal	kilogrammes	2.46		
	Peat	kilogrammes	1.36		
Wood	kilogrammes	1.04			
TRAVEL Energy Usage	Car	kilometres	0.15		
	Car (Second Person)	kilometres	0.15		
	Bus	kilometres	0.08		
	Train	kilometres	0.04		
	Air	kilometres	0.05		
	Air (No. of oneway flights per year)	number	5.60		





**TOTAL CO<sub>2</sub> released per year : 0.0 Tonnes (per person)**

## APPENDIX 2

### Handout 1: Weather Data for Niue

**Niue**  
 Mon  
 Partly Cloudy


79<sup>°F</sup> |<sup>0</sup>
Precipitation: 0%  
 Humidity: 70% Wind: 4 mph

			Temperature	Precipitation	Wind			
			n	78	n			
74	73	73						75
n	78	n						
12AM	3AM	6AM	9AM	12 PM	3PM	6PM	9PM	
Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	
								
79° 71	78° 71	79° 72	79° 72°	79° 73°	79° 79°	80° 74	81° 75°	

Accessed from [www.weather.com](http://www.weather.com) on 25<sup>th</sup> November 2015

## APPENDIX 2

### Handout 2: Weather Data for Melekeok,

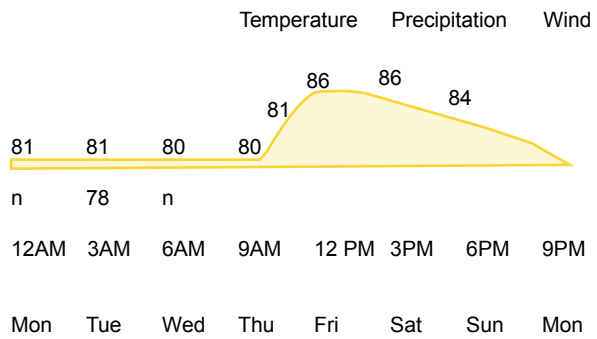
#### Melekeok, Palau

Tue  
Isolated Thunderstorms



86°F | °

Precipitation: 60%  
Humidity: 87%  
Wind: 6 mph



86° 78° 11 p 8r 78 8r 1r 86° 78° 86° 78° ar 78° ar 78°

Accessed from [www.weather.com](http://www.weather.com) on 25<sup>th</sup> November 2015

## APPENDIX 3

### Handout 3: Climate Change



NOAA National Weather Service

OCTOBER 2007

#### What is Climate Change?

Climate change is a long-term shift in the statistics of the weather (including its averages). For example, it could show up as a change in climate normals (expected average values for temperature and precipitation) for a given place and time of year, from one decade to the next.

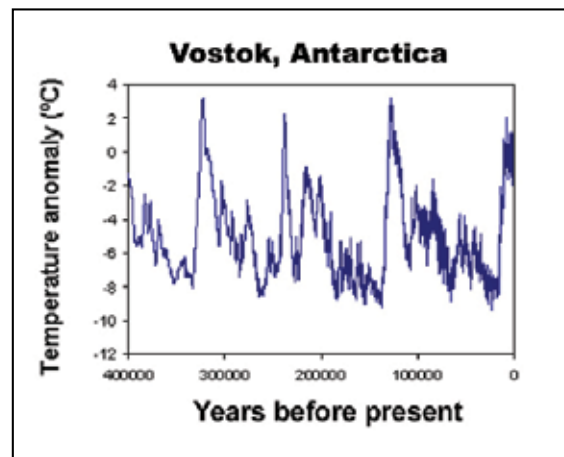
We know that the global climate is currently changing. The last decade of the 20th Century and the beginning of the 21st have been the warmest period in the entire global instrumental temperature record, starting in the mid-19th century.

#### Why is the Climate Changing?

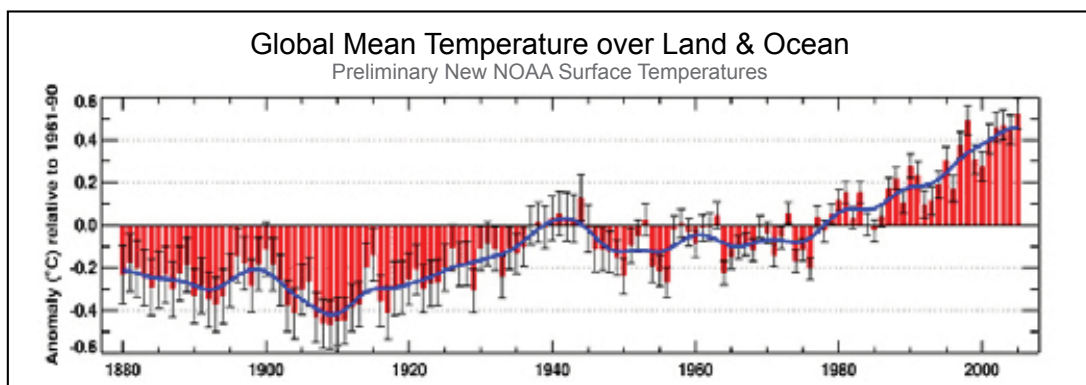
##### Natural variability

Climate change is a normal part of the Earth's natural variability, which is related to interactions among the atmosphere, ocean, and land, as well as changes in the amount of solar radiation reaching the earth. The geologic record includes significant evidence for large-scale climate changes in Earth's past. An

example of this variability is shown in the plot below of temperature data for the last 420,000 years, derived from an Antarctic ice core.



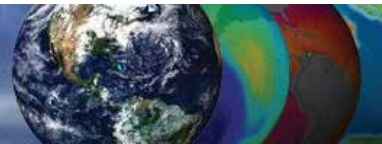
Temperature changes in Antarctica determined from the deuterium proxy measured in the Vostok ice core record. (Reference: Petit, J.R., et al. 1999. Climate and atmospheric history of the past 420,000 years from the Vostok ice core, Antarctica. *Nature* 399: 429-436.) Available at <http://www.ncdc.noaa.gov/paleo/abrupt/story2.html>



Line plot of global mean land-ocean temperature index, 1880 to present. Individual years are plotted and the blue line is the five-year mean. (Data and plot available from NCDC at <http://www.ncdc.noaa.gov/oa/climate/research/anomalies/anomalies.html>).



# CLIMATE CHANGE



## Human-induced change

### Greenhouse Gases

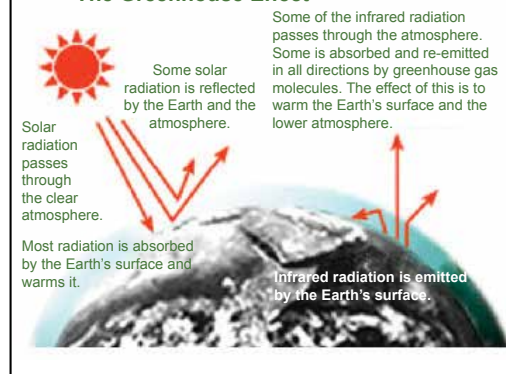
Certain naturally occurring gases, such as carbon dioxide (CO<sub>2</sub>) and water vapor (H<sub>2</sub>O), trap heat in the atmosphere causing a greenhouse effect. Burning of fossil fuels, like oil, coal, and natural gas is adding CO<sub>2</sub> to the atmosphere. The current level is the highest in the past 650,000 years. The Fourth Assessment Report of the Intergovernmental Panel on Climate Change concludes, "that most of the observed increase in the globally averaged temperature since the mid-20th century is very likely due to the observed increase in anthropogenic greenhouse gas concentrations."

## What is being done to Study the Effects of Climate Change

There are numerous potential effects of climate change. Extensive research is being done around the world – a good deal within NOAA – to determine the extent to which climate change is occurring, how much of it is being caused by anthropogenic (man-made) forces, and its potential impacts. In some of these areas, there is not a consensus among scientists and in fact, there are often conflicting points-of-view and studies. However, with further research, no doubt many questions regarding impacts will be resolved in the future. Potential impacts most studied by researchers include the effects on sea level, drought, local weather, and hurricanes.

Most of our current knowledge of global change comes from General Circulation Models (GCMs). At present, GCMs have the ability to provide us with a mean annual temperature for the planet that is reliable. Regional and local temperature and precipitation information from GCMs is, at present, unreliable. Much of the global change research effort is focused on improving these models.

### The Greenhouse Effect



## Where Can I Find More Information?

U.S. Climate Change Science Program:  
<http://www.climate-science.gov/>

NOAA National Climatic Data Center site on Global Warming:  
<http://www.ncdc.noaa.gov/oa/climate/globalwarming.html>

NASA GISS recent research website:  
<http://www.giss.nasa.gov/research/>

Global Change Master Directory:  
[http://gcmd.gsfc.nasa.gov/Resources/pointers/glob\\_warm.html](http://gcmd.gsfc.nasa.gov/Resources/pointers/glob_warm.html)

Intergovernmental Panel on Climate Change (IPCC) Website:  
<http://www.ipcc.ch/>

## APPENDIX 4

### Handout 4: Climate Change

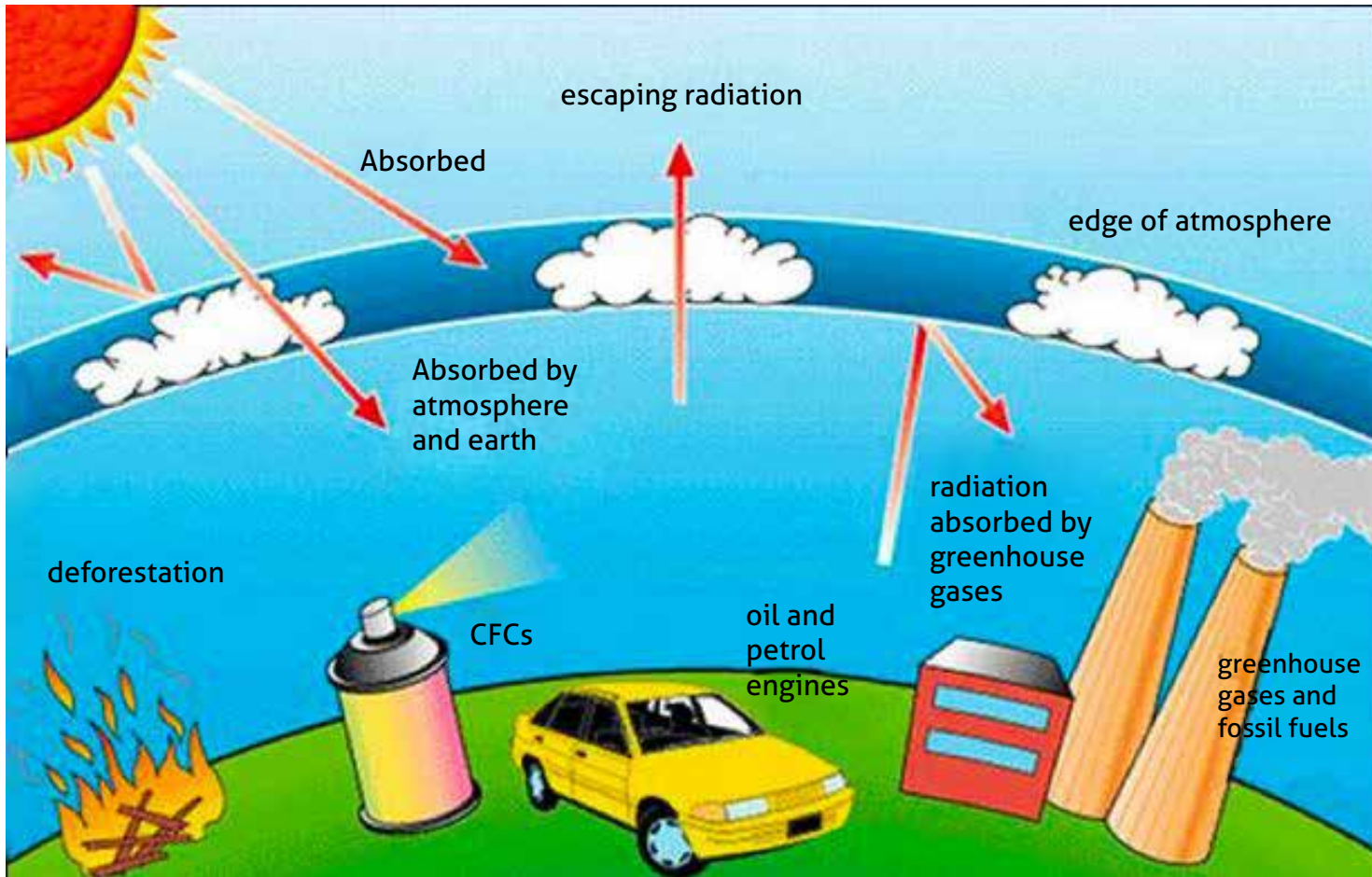
WATER VAPOR	<ul style="list-style-type: none"> <li>• Largest contributor to the natural greenhouse effect</li> </ul>	<ul style="list-style-type: none"> <li>• Atmospheric concentration: levels of concentration vary throughout the world. At the poles it is very low whereas in the tropic it can account for up to 4% of the atmosphere.</li> <li>• Atmospheric lifetime: 9-10 days.</li> <li>• Plays an important role in regulating the earth's climate.</li> </ul>	<ul style="list-style-type: none"> <li>• Human activities: have only a small influence on the concentration.</li> </ul>
CARBON DIOXIDE CO <sub>2</sub>	<ul style="list-style-type: none"> <li>• Natural sources: animal respiration, plant decay, volcanic eruption.</li> </ul>	<ul style="list-style-type: none"> <li>• Atmospheric concentration: makes up a few hundred parts per million of the atmosphere (currently around 400ppm).</li> <li>• Atmospheric lifetime: 5-200 years.</li> <li>• Global warming potential: major contributor to the Enhanced greenhouse effect.</li> </ul>	<ul style="list-style-type: none"> <li>• Human activities: the burning of fossil fuel, land-use change and deforestation.</li> <li>• Deforestation not only releases this gas stored in trees but fewer trees also reduce the Earth's ability to remove it from the atmosphere.</li> </ul>

Source: Ministry of Education and Training, Live & Learn and Plan in Vietnam (2012) Teaching Manual on Climate Change Education. Vietnam

METHANE (CH <sub>4</sub> )	<ul style="list-style-type: none"> <li>• Sources include organic material decomposition by bacteria, fugitive emissions from gas and coal mining and emissions from wetlands</li> </ul>	<ul style="list-style-type: none"> <li>• Atmospheric concentration: exists in the atmosphere at lower concentrations than carbon dioxide.</li> <li>• Atmospheric lifetime: 12 years.</li> <li>• Global warming potential: responsible for a warming effect 25 times that of carbon dioxide.</li> </ul>	<ul style="list-style-type: none"> <li>• Human activities: the majority of its emissions come from activities like mining (coal, oil, natural gases) and agriculture (flood-irrigated rice cultivation, stomach fermentation in animals).</li> </ul>
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<p style="writing-mode: vertical-rl; transform: rotate(180deg);">MITROUS OXIDE (N<sub>2</sub>O)</p>	<ul style="list-style-type: none"> <li>• Sources include: bacterial decomposition of the earth's soils and oceans</li> </ul>	<ul style="list-style-type: none"> <li>• Atmospheric concentration: less than one-thousand that of carbon dioxide.</li> <li>• Atmospheric lifetime: 114 years.</li> <li>• Global warming potential: responsible for a warming effect 298 times that of carbon dioxide.</li> <li>• Atmospheric concentration: much lower than carbon dioxide.</li> </ul>	<ul style="list-style-type: none"> <li>• Human activities: land use change, the use of fertilizers and burning fossils fuels increases its concentration in the atmosphere.</li> </ul>
<p style="writing-mode: vertical-rl; transform: rotate(180deg);">HALOCARBONS (CFA, HFC, HCFC)</p>	<ul style="list-style-type: none"> <li>• Produced by: these GHGs have no natural source, and are produced entirely by human activities</li> </ul>	<ul style="list-style-type: none"> <li>• Atmospheric lifetime: remains in the atmosphere for up to 1700 years.</li> <li>• Global warming potential: responsible for a warming effect thousands of times that of carbon dioxide.</li> </ul>	<ul style="list-style-type: none"> <li>• CFCs, an example of this group of GHGs, were common in items such as spray cans, cleaners and coolants up until the 1970s.</li> </ul>

Source: Ministry of Education and Training, Live & Learn and Plan in Vietnam (2012)  
Teaching Manual on Climate Change Education, Vietnam.



Source: <http://www.hecweb.org/issues/climate-change/understanding-the-issues/climate-change-101/> (10/11/15)





## APPENDIX 6

### Handout 6: Impacts of Human Activities

Source: Ministry of Education and Training, Live & Learn and Plan in Vietnam (2012) Teaching Manual on Climate Change ns\_-\_traditional\_knowledge. pdf ) Education. Vietnam:

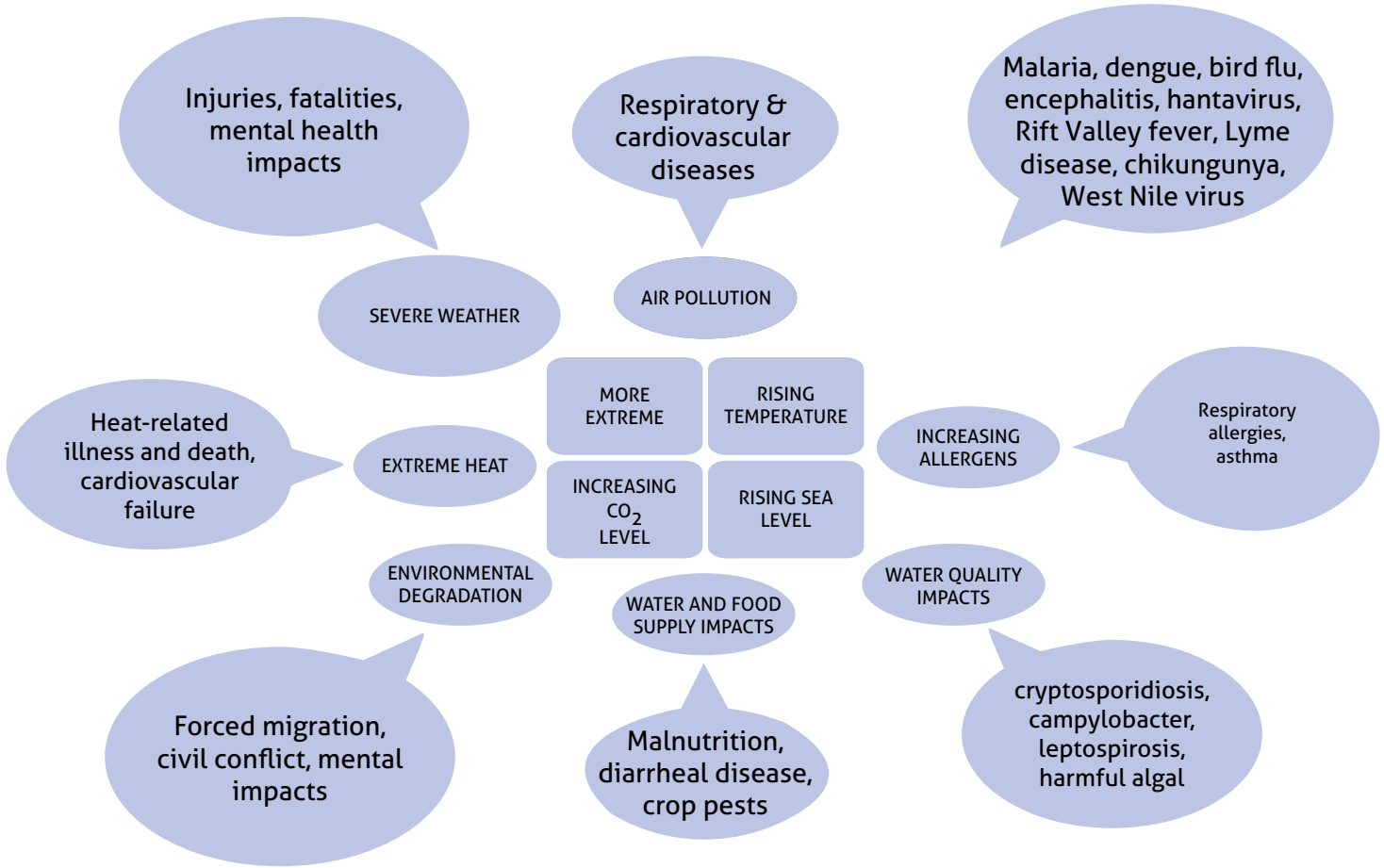
## APPENDIX 7

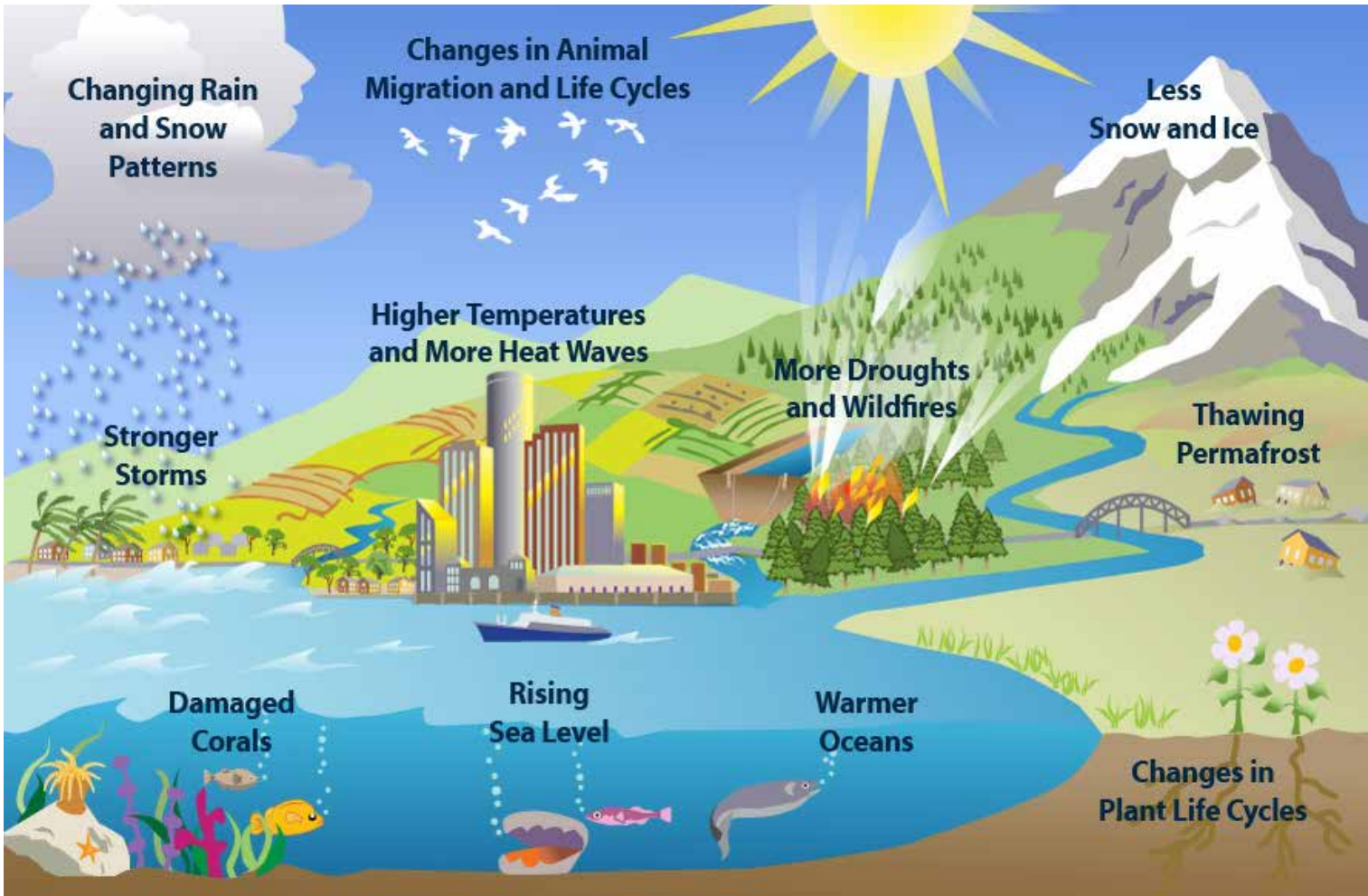
## Handout 7: Carbon Footprint



Source : <http://aboutboulder.com/blog/learners-guide-to-evaluating-your-carbon-footprint/>  
(30/11/15)

A carbon footprint is historically defined as "the total sets of greenhouse gas emissions caused by an organization, event, product or individual." The total carbon footprint cannot be calculated because of the large amount of data required and the fact that carbon dioxide can be produced by natural occurrences.





Source: Adapted from [http://www.basscoast.vic.gov.au/Services/Environmental\\_Management/Climate\\_Change\\_and\\_Sustainability/Climate\\_Change](http://www.basscoast.vic.gov.au/Services/Environmental_Management/Climate_Change_and_Sustainability/Climate_Change) (10/11/15)

# APPENDIX 10

## Handout 10: Newspaper Article

# '600,000 killed in 20 years'

## UN: Rise in weather-linked disasters, urgent need for climate deal

**GENEVA:** Weather-related disaster have grown more frequent over the last 20 years, claiming more than 600,000 lives, the United Nations said, issuing a further call for nations to strike a landmark deal on climate change.

The report from the United Nations agency for disaster risk reduction (UNISDR) said floods, storm and other extreme weather events have killed 606,000 people since 1995, "with an additional 4.1 billion people injured, left homeless or in need of emergency assistance."

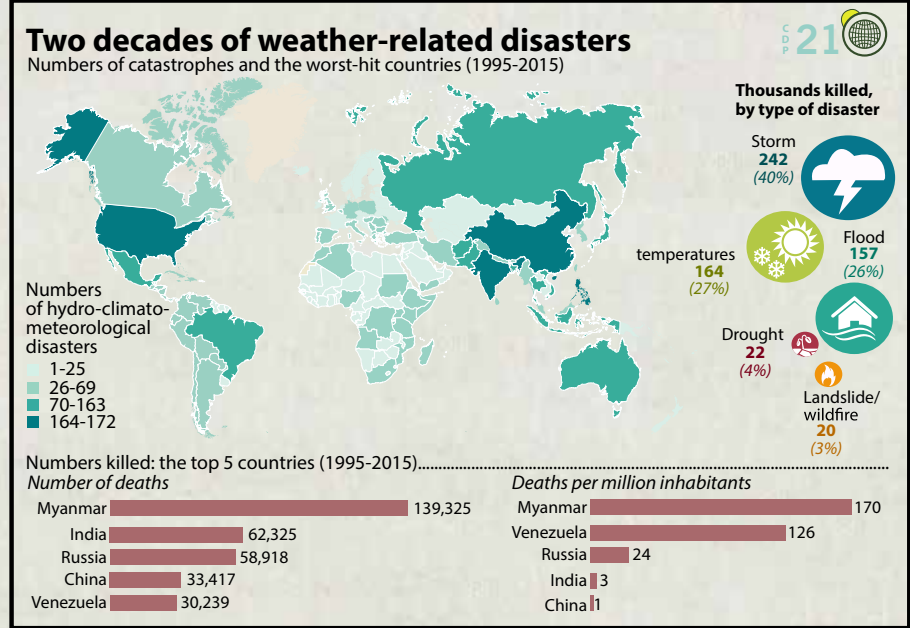
The report noted that while there was no way to establish how much of the rise in such disasters was caused by climate change, the link between the planet's changing climate and extreme weather was clear.

"The contents of this report underline why it is so important that a new climate change agreement emerge from the COP21 in Paris," said UNISDR chief Margareta Wahlström, referring to the crunch climate talks starting next week.

The talks that open in the French capital on Nov 30 are tasked with crafting a 195-nation pact to curb greenhouse gas emissions blamed for dangerous levels of climate change.

Between 2005 and last year, the leading database that tracks weather-linked disaster recorded 335 such incidents, a 14% increase compare to the previous decade and nearly double the number recorded from 1985 to 1994.

Overall, the report said, the planet has seen "a sustained rise in the numbers of floods and storms, noting that drought, heatwaves and



extreme cold were also growing concerns.

According to UNISDR data, flooding accounted for 47% of all weather disasters over the last 20 years, affecting more than 2.3 billion people, the vast majority of whom live in Asia.

A full 75% of the 4.1 billion people affected were in either China or India, underscoring the extent to which densely populated areas in those countries were disproportionately vulnerable.

Next in line in terms of the number of people affected over the reporting period were Bangladesh (131 million people) and the Philippines (130 million people), while Brazil (51 million people) led the way in the Americas and Kenya was the most affected country in Africa (47 million people).

The report also detailed the heavy damage to property and infrastructure inflicted by extreme weather.

This includes, 87 million homes

damaged or destroyed, with hundreds of thousands of schools hospitals and other key facilities affected worldwide.

In total, UNISDR data counted US\$ 1.9 trillion (RM8.17 trillion) in financial losses attributable to extreme weather events.

Given the correlation between climate change and extreme weather, the planet will "witness a continued" upward trend in weather-related disasters in the decade ahead." The report warned – AFP

Source: The Star Newspaper Malaysia, 24 November 2015.

## APPENDIX 11

### Handout 11: Pacific Island Mangroves in a Changing Climate and Rising Sea

UNEP Regional Seas Reports and Studies No. 179 (IUCN, 1989, in UNEP, 2006)

#### Group 1 : 'Pacific Island Mangroves'

##### In Brief

- Roughly 50% of the global mangrove area has been lost since 1900 and 35% has been lost in the past two decades. Due to limited monitoring, there is little information available on trends in the area and health of Pacific Island mangroves.
- The Pacific Islands, while containing only 3% of the global mangrove area, support unique mangrove community structures and provide valuable site-specific services and products.
- Papua New Guinea has the highest global mangrove diversity and supports over 70% of the region's mangrove area. Pacific Island mangroves decline in diversity from west to east, reaching a limit at American Samoa.

##### Status and trends

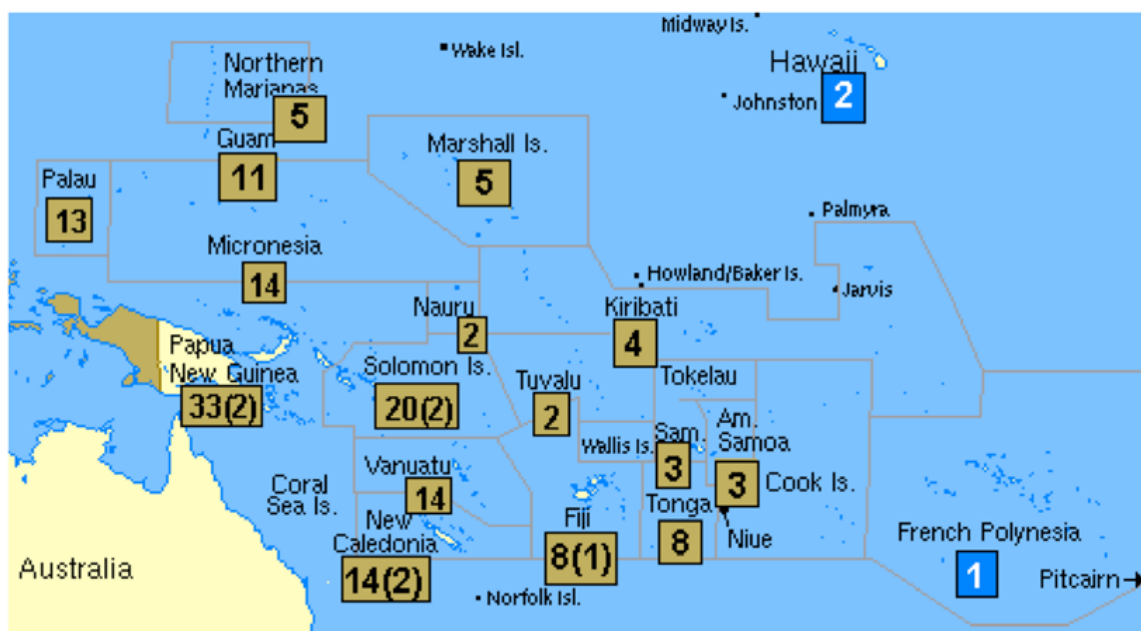
The cumulative effects of natural and anthropogenic pressures make mangrove wetlands one of the most threatened natural communities worldwide. Roughly 50% of the global area has been lost since 1900 and 35% of the global area has been lost in the past two decades, due primarily to human activities such as conversion for aquaculture (IUCN, 1989; Ramsar Secretariat, 1999; Valiela et al., 2001). Between 56 and 75% of different Asian mangroves have been lost during the 20th century primarily due to overuse and conversion for aquaculture (Primavera, 1997; Smith et al., 2001). There are roughly 17 million ha of mangroves worldwide (Valiela et al., 2001; FAO, 2003). Mangroves are declining in area worldwide. The global average annual rate of mangrove loss is about 2.1%, exceeding the rate of loss of tropical rainforests (0.8%) (Valiela et al., 2001; Wells et al., 2006).

The estimated area of mangroves in the Pacific Islands is 524,369 ha with largest areas in Papua New Guinea (372,770 ha), Solomon Islands (64,200 ha), Fiji (41,000 ha), and New Caledonia (20,250 ha). The Pacific Islands contain roughly 3% of global mangrove area, a small area in global terms, but each island group has a unique mangrove community structure (Ellison, 2000) and mangroves provide

site-specific functions and values (e.g., Gilman, 1998; Lewis, 1992). Also, while a mangrove species may have a wide range, certain portions of its range may be genetically isolated resulting in unique varietal characteristics (Duke, 1992; Ellison, 2004). There is little available quantitative information on trends in area or health of Pacific Island mangroves due to limited monitoring, and many of the above area estimates are based on dated primary sources.

### Distribution and biodiversity

The figure below shows the mangrove species distributions in the Pacific Islands region, constituting a total of 34 true mangrove species and 3 hybrids (Ellison, 1995). Pacific Island mangroves decline in diversity from west to east across the Pacific, reaching a limit at American Samoa where there are an estimated 52 ha of mangroves remaining with three mangrove species. Southern Papua New Guinea mangroves have the highest global mangrove diversity with 33 mangrove species and 2 mangrove hybrids, located at the centre of the Indo-Malayan mangrove centre of diversity (Ellison, 2000). Mangroves do not naturally occur further east of American Samoa due to difficulty of propagule dispersal over such a large distance and historic loss of habitat during Holocene sea level changes (Ellison and Stoddart, 1991). In addition, some islands may have lower number of mangrove species due to a lack of suitable intertidal habitat (Ellison, 2001). Mangroves are recent human introductions in Hawaii, USA and French Polynesia.



### Group 2: 'Mangrove Ecosystem Values'

- Pacific Islanders value mangroves for a wide range of services and products, including protecting coastlines and development from coastal hazards, supporting water quality, providing fish breeding habitats, and providing materials used in traditional practices such as dye from mangrove bark used in tapa cloth and to treat textiles, nets, and fish traps.
- The annual economic values of mangroves, estimated by the cost of the products and services provided by mangroves, have been estimated to be between USD 200,000 -- 900,000 per ha. The range of reported costs for mangrove restoration is USD 225 -- 216,000 per ha.
- The existence of functional links between coastal ecosystems, including mangroves, seagrass beds, and coral reefs, means that degradation of one habitat type will adversely affect the health of neighbouring habitats.

### Ecosystem values

Pacific Island governments have recognized the value of mangroves and the need to augment conservation efforts (e.g. South Pacific Regional Environment Programme, 1999b). Mangroves are valued by people in the Pacific Islands region, in part, because they provide numerous ecosystem services:

- **Support traditional practices.** Mangroves support traditional activities conducted by Pacific Islanders (e.g., Ellison, 2001). Mangroves are a source of (i) clams, crabs, fish, and Tahitian chestnuts (*Inocarpus fagifera*), which are collected for consumption; (ii) wood used for construction, handicrafts, and fuel; (iii) *Ceriops tagal* wood used as part of a wedding dowry in the Central Province of Papua New Guinea; (iv) materials used for fishing equipment; (v) dye from pigments in *Bruguiera gymnorhiza* mangrove bark used in tapa cloth in Polynesia and dye in Rhizophoraceae mangrove bark used to treat textiles, nets, and fish traps owing to its fungicidal properties; (vi) thatch used for mats and roofs; and (vii) plants used to make traditional medicines, such as infusion of Tahitian chestnut bark to treat stomach aches.



- **Protect coastlines and development.** Mangroves protect coastlines and development from erosion and damage by tidal surges, currents, rising sea level, and storm energy in the form of waves, storm surges and wind. Roots bind and stabilize the substrate (e.g., Krauss et al., 2003). For coastlines where relative sea level is rising, protecting mangroves is one way to slow anticipated erosion. Protecting mangroves sustains natural protection, and is less expensive than seawalls and similar erosion control structures, which can increase erosion in front of the structure and at adjacent properties.
- **Area of wildlife habitat.** Mangroves are nursery habitat for many wildlife species, including commercial fish and crustaceans, and thus contribute to sustaining local abundance of fish and shellfish populations (e.g., Lal et al., 1984; Ley et al., 2002). As fish grow and become less vulnerable to predators, they move from the protective mangrove environment to mudflats, seagrass beds and coral reefs where foraging efficiency increases due to changes in their diet (Laegdsgaard and Johnson, 2001; Mumby et al., 2004). While mangroves in the Caribbean have been demonstrated to support juvenile coral reef fish (Mumby et al., 2004), mangroves in Papua New Guinea and the Solomon Islands have been found to be important nurseries for sandy and muddy-bottom demersal and surface feeding species and not coral reef species (Quinn and Kojis, 1985; Blaber and Milton, 1990). Many migratory species depend on mangroves for part of their seasonal migrations. For instance, an estimated two million migratory shorebirds of the East Asian-Australasian Flyway, which annually migrate from the Arctic Circle through South-East Asia to Australia and New Zealand and back, stop to forage at numerous wetlands along this Flyway, including the wetlands of Oceania (Environment Australia, 2000). In addition to shorebirds, other water birds (e.g., wading birds and waterfowl), some of which are widely dispersing, and others which are more stationary, have population dynamics that make them dependent on wetlands (e.g., Haig et al., 1998).
- **Improve coastal water quality.** Mangroves maintain coastal water quality by abiotic and biotic retention, removal, and cycling of nutrients, pollutants, and particulate matter from land-based sources, filtering these materials from water before they reach seaward coral reef and seagrass habitats (e.g., Ewel, 1997; Ewel et al., 1998; Victor et al., 2004). Mangrove root systems slow water flow, facilitating the deposition of sediment. Toxins and nutrients can be bound to sediment particles or within the molecular lattice of clay particles and are removed during sediment deposition. Chemical and biological processes may transform and store nutrients and toxins in the mangrove sediment and vegetation. Some wetland plants can concentrate heavy metals in their tissues up to 100,000 times the concentration in ambient waters, and many of these plants contain substances that bind heavy metals and are involved in metal detoxification (Davies and Claridge, 1993).

- **Benefit and are connected to neighbouring ecosystems.** Mangroves are functionally linked to neighbouring coastal ecosystems (Mumby et al., 2004). For instance, terrigenous sediments and nutrients carried by freshwater runoff are first filtered by coastal forests, then by mangrove wetlands, and finally by seagrass beds before reaching coral reefs. The existence and health of coral reefs are dependent on the buffering capacity of these shoreward ecosystems, which support the oligotrophic conditions needed by coral reefs to limit overgrowth by algae (Ellison, 2004; Victor et al., 2004). Coral reefs, in turn, buffer the soft sediment landward ecosystems from wave energy (Ellison, 2004). Mangroves supply nutrients to adjacent coral reef and seagrass communities, sustaining these habitats' primary production and general health. Also, mangroves provide a natural sunscreen for coral reefs, reducing exposure to harmful solar radiation and risk of bleaching: decomposing phytoplankton detritus and decaying litter from mangroves and seagrass beds produce a coloured, chromophoric component of dissolved organic matter, which absorbs solar ultraviolet radiation, which can be transported over adjacent coral reefs and reduce coral reef exposure to harmful solar radiation (Anderson et al., 2001; Obriant, 2003).
- **Store carbon:** Mangroves are a carbon sink; mangrove destruction can release large quantities of stored carbon and exacerbate global warming trends, while mangrove rehabilitation will increase the sequestering of carbon (Kauppi et al., 2001; Ramsar Secretariat, 2001; Chmura et al., 2003).
- **Provide recreational, tourism, educational, and research opportunities:** Mangroves provide recreational and tourism opportunities, such as boardwalks and boat tours, and are important for research and education.

### Benefits as measured by market prices

Economic valuation of mangrove ecosystems needs to be treated with caution, as most cost benefit analyses included in site planning only examine costs and benefits as measured by market prices, ignoring mangrove and other coastal system values not described by established monetary indicators (Dixon and Sherman, 1990; Ramsar Bureau, 1998; Wells et al., 2006). For instance, cultural and aesthetic quality-of-life benefits derived from ecosystems are not easily assigned economic value. Furthermore, economic valuation of ecosystems can produce different results depending on the length of time being considered and whether or not future values, such as a mangroves future potential for tourism, are considered, and other assumptions (Dixon and Sherman, 1990; Ramsar Bureau, 1998; Wells et al., 2006). Having clarified these limitations, economic valuation is useful, as having a dollar value on mangrove functions is often needed to convince decision-makers of the importance of mangrove benefits, and the concomitant need for and benefits of mangrove conservation (Ramsar Bureau, 1998; Wells et al., 2006).

The annual economic values of mangroves, estimated by the cost of the products and services they provide, have been estimated to be USD 200,000 - 900,000 per ha (Wells et al., 2006). However, the location and values of the beneficiaries can result in substantial variation in mangrove economic value. For instance, mangroves fronting a highly developed coastline or located near major tourist destinations may have a higher economic value than mangroves in less developed areas with little or no tourism sector development (Wells et al., 2006).

The value of Malaysian mangroves just for storm protection and flood control has been estimated at USD 300,000 per km of coastline, which is based on the cost of replacing the mangroves with rock walls (Ramsar Secretariat, 2001). The mangroves of Moreton Bay, Australia, were valued in 1988 at USD 4,850 ha<sup>-1</sup> based only on the catch of marketable fish (Ramsar Secretariat, 2001).

Mangroves can also be provided with an economic value based on the cost to replace the products and services that they provide, or the cost to restore or enhance mangroves that have been eliminated or degraded. The range of reported costs for mangrove restoration is USD 225 to USD 216,000 per ha, not including the cost of the land (Lewis, 2005). In Thailand, restoring mangroves is costing USD 946 per ha while the cost for protecting existing mangroves is only USD 189 per ha (Ramsar Secretariat, 2001).

### **Consequences of mangrove losses and degradation**

Reduced mangrove area and health will increase the threat to human safety and shoreline development from coastal hazards such as erosion, flooding, and storm waves and surges. Mangrove loss will also reduce coastal water quality, reduce biodiversity, eliminate fish nursery habitat and fish catches, adversely affect adjacent coastal habitats (Mumby et al., 2004), and eliminate a major resource for human communities that traditionally rely on mangroves for numerous products and services (Satele, 2000; Ellison and Gilman, 2004). In some locations, loss of mangroves might also result in reduced tourism revenue (Wells et al., 2006). Furthermore, degradation of one coastal habitat can result in reduced health of adjacent coastal habitats. Neighbouring coastal ecosystems are functionally linked, although the functional links are not fully understood (Mumby et al., 2004).

### Group 3: 'Threats to Pacific Island Mangroves'

#### In Brief

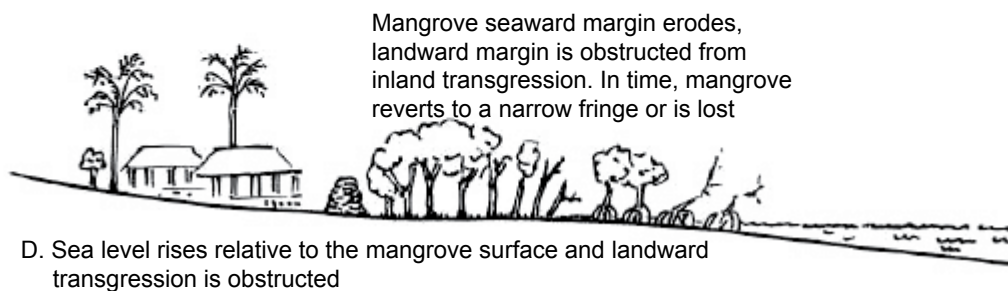
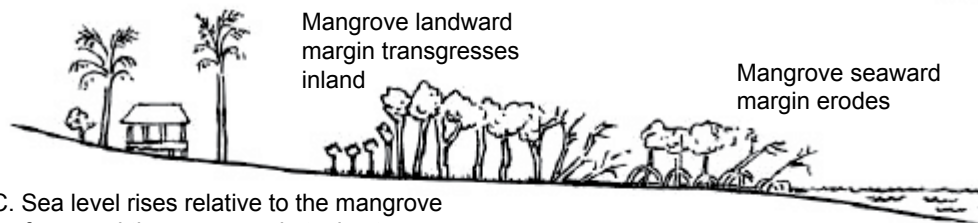
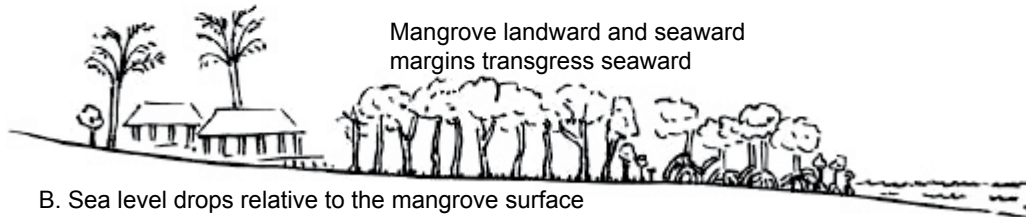
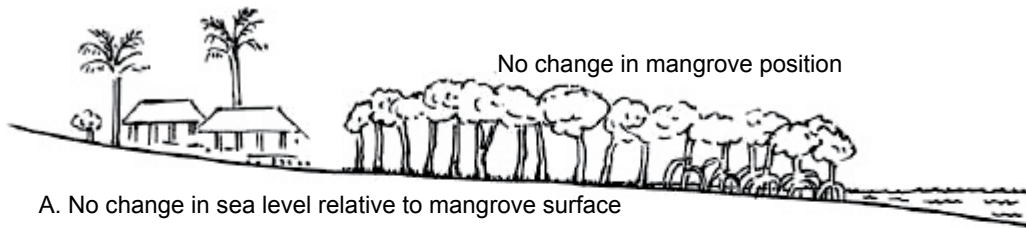
- Stresses associated with rise in relative mean sea level, increase in the frequency and level of extreme high water events, and other effects from climate change present one set of threats to mangroves and other coastal ecosystems.
- Mangroves migrate landward as a natural response to rising sea level relative to the mangrove surface. This landward migration can be obstructed by seawalls and other development, reducing the area of coastal ecosystems.
- Global sea level rise is one of the more certain outcomes of global warming, 10-20 cm occurred during the last century, and several climate models project an accelerated rate of sea level rise over coming decades. Global mean sea level is projected to rise by 0.09 to 0.88 m between 1990 and 2100 due primarily to thermal expansion of seawater and transfer of ice from glaciers and ice caps to water in the oceans, which are results of global warming.
- Some Pacific islands are experiencing a rise in relative sea level while others are experiencing lowering. Over the past few decades, the average change in relative sea level of the 10 countries and territories in the Pacific Islands region with native mangroves that are experiencing a rise in relative sea level is 2.0 mm a-1.
- Mangroves could experience serious problems due to rising sea level, and low island mangroves may already be under stress. Regionally, a reduction in area by 13% of the current 524,369 ha of mangroves of the sixteen Pacific Island Countries and territories where mangroves are indigenous is roughly predicted when employing an upper projection for global sea level rise through the year 2100.
- Increased frequency and levels of extreme high water events could affect the position and health of coastal ecosystems and pose a hazard to coastal development and human safety. Extreme high water events are projected to increase over coming decades as a result of the same forces projected to cause global sea level rise, and possibly additional forces such as variations in regional climate and changes in storminess. An assessment of trends in extreme high water events has been conducted only for American Samoa in the Pacific Islands region.
- Outcomes from global climate change other than sea level rise, such as increased air and sea surface temperatures, changes in precipitation, and changes in storminess, are less certain than global change in sea level and the response of mangrove wetlands and other coastal systems to these changes are not well understood.
- In addition to climate change effects, mangroves and other coastal ecosystems face numerous other threats, ranging from filling for development to disease outbreaks.

## Mangrove responses to changing sea level

When the force of relative sea level rise is the predominant force causing change in mangrove position, landscape-level response of mangroves to relative sea level rise, over a period of decades and longer, can be predicted based on the reconstruction of paleo environmental mangrove response to past sea level fluctuations (Ellison and Stoddart, 1991; Woodroffe, 1995; Ellison, 1993, 2000; Gilman, 2004; Gilman et al., In Press). Landscape-level response of mangroves to relative sea level rise, over a period of decades and longer, can be predicted based on (a) the sea level change rate relative to the mangrove surface, (b) the mangrove's physiographic setting (slope of the land adjacent to the mangrove, slope of the mangrove, and presence of obstacles to landward migration), and (c) erosion or progradation rate of the mangrove seaward margin (Ellison and Stoddart, 1991; Ellison, 1993, 2000, 2001; Woodroffe, 1995; Alleng, 1998; Lucas et al., 2002; Gilman, 2004). There are three general scenarios for mangrove response to relative sea level rise, given a landscape-level scale and time period of decades or longer (See Picture):

- **No change in relative sea level** : When sea level is not changing relative to the mangrove surface, the mangrove margins will remain in the same location (Picture A);
- **Relative sea level lowering** : When sea level is dropping relative to the mangrove surface, this forces the mangrove seaward and landward boundaries to migrate seaward (Picture B) and depending on the topography, the mangrove may also expand laterally; and
- **Relative sea level rising** : If sea level is rising relative to the mangrove surface, the mangrove's seaward and landward margins retreat landward, where unobstructed, as mangrove species zones migrate inland in order to maintain their preferred environmental conditions, such as period, frequency and depth of inundation and salinity (Picture C). Depending on the ability of individual true mangrove species to colonize new habitat at a rate that keeps pace with the rate of relative sea level rise, the slope of adjacent land, and the presence of obstacles to landward migration of the landward boundary of the mangrove, such as seawalls and other shoreline protection structures, some sites will revert to a narrow mangrove fringe or experience extirpation of the mangrove community (Picture D).

## Scenarios for Generalized Mangrove Responses to Changes in Relative Sea Level



The UNESCO Office in Jakarta works as a laboratory of ideas and a standard-setter, disseminates and shares information and knowledge and promotes international partnerships in the fields of education, sciences, culture and communication in the Asia and Pacific region. The Office works to reflect on the role of UNESCO as a catalyst for change by empowering people's capacities.

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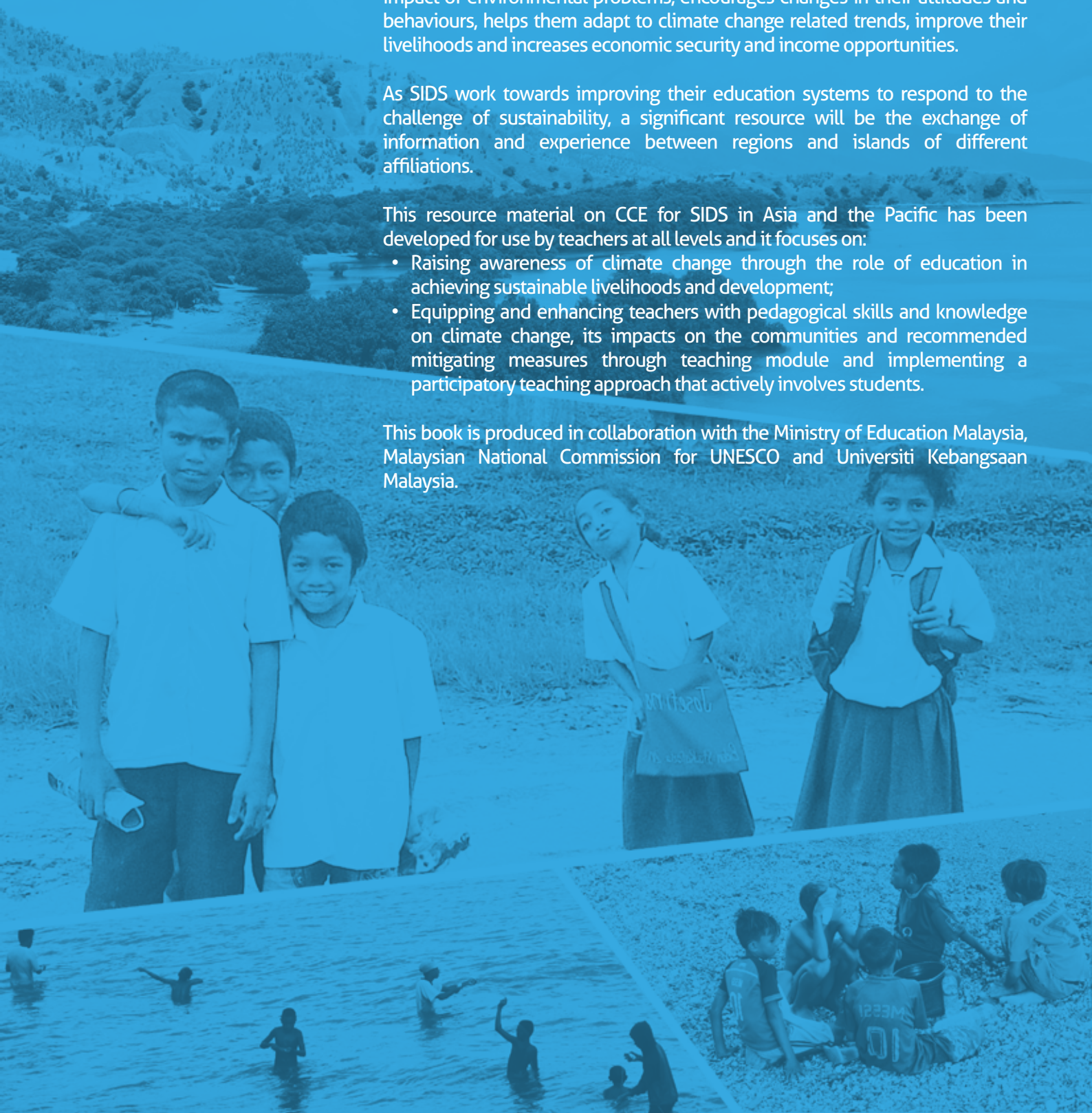
Asia Pacific Small Island Developing States (SIDS) face a number of distinctive challenges to sustainable living and development, including severe vulnerability to climate change and sea level rise, natural and environmental hazards, scarcity of freshwater resources and energy as well as fragile economic and social structures. Climate Change Education (CCE) within the framework of Education for Sustainable Development (ESD) constitutes an essential element in response to these challenges; it helps learners to understand and address the impact of environmental problems, encourages changes in their attitudes and behaviours, helps them adapt to climate change related trends, improve their livelihoods and increases economic security and income opportunities.

As SIDS work towards improving their education systems to respond to the challenge of sustainability, a significant resource will be the exchange of information and experience between regions and islands of different affiliations.

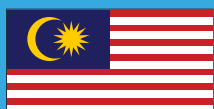
This resource material on CCE for SIDS in Asia and the Pacific has been developed for use by teachers at all levels and it focuses on:

- Raising awareness of climate change through the role of education in achieving sustainable livelihoods and development;
- Equipping and enhancing teachers with pedagogical skills and knowledge on climate change, its impacts on the communities and recommended mitigating measures through teaching module and implementing a participatory teaching approach that actively involves students.

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