

## Day / Focus

1. Climate change learning for sustainable development
2. The Future
3. Adaptation & Mitigation
4. Local Focus
5. Global Focus
6. Empowerment & Action

UNESCO COURSE FOR SECONDARY TEACHERS ON CCESD

# CLIMATE CHANGE IN THE CLASSROOM



## Day One At-A-Glance

Sample Schedule (Duration)	Session	Materials Needed
9:00 - 9:20 (20 minutes)	Introduction	<ul style="list-style-type: none"> <li>• PowerPoint slides 2-9</li> <li>• Handout 6</li> </ul>
9:20 - 9:55 (35 minutes)	Activity: Climate Change People Search	<ul style="list-style-type: none"> <li>• Handout 1</li> <li>• One flipchart and marker</li> </ul>
9:55 - 10:35 (40 minutes)	Activity: Climate Change Art Gallery	<ul style="list-style-type: none"> <li>• PowerPoint slide 9</li> <li>• Sheet of chart paper and one marker per participant</li> <li>• Pins (or adhesive tape)</li> <li>• Flipchart and marker</li> </ul>
10:35 - 10:50 (15 minutes)	Break	
10:50 - 11:05 (15 minutes)	Input: The Basic Science of Climate Change	<ul style="list-style-type: none"> <li>• Handout 2</li> <li>• PowerPoint slides 10-13</li> </ul>
11:05 - 12:00 (55 minutes)	Activity: Climate Change Webs	<ul style="list-style-type: none"> <li>• One cut-up set of Climate Change Explanations statements (Handout 3) per group of three participants.</li> <li>• One sheet of chart paper, one glue stick and two markers, (different colours), per group of three participants</li> </ul>
12:00 - 13:00 (60 minutes)	Lunch	
13:00 - 13:50 (50 minutes)	Activity: Climate Change Stories	<ul style="list-style-type: none"> <li>• Flip chart and marker (or board and chalk)</li> <li>• A few copies of each of the Climate Change Stories (Handout 4)</li> <li>• One sheet of chart paper and one marker per group</li> </ul>
13:50 - 15:05 (75 minutes)	Activity: Sustainable Development and Climate Change Collages	<ul style="list-style-type: none"> <li>• Four slips of blank paper per participant</li> <li>• One large sheet of chart paper per group of 4 participants</li> <li>• One glue stick</li> <li>• Three markers per group (different colours)</li> <li>• One cut-up set of statements from Perspectives on Sustainable Development (Handout 5) per group</li> <li>• One copy of Handout 5 per participant</li> </ul>
15:05 - 15:20 (15 minutes)	Break	
15:20 - 15:30 (10 minutes)	Input: Climate Change Education for Sustainable Development	<ul style="list-style-type: none"> <li>• PowerPoint slides 14-16</li> </ul>
15:30 - 16:00 (30 minutes)	Activity: CCESD across the Curriculum (1)	<ul style="list-style-type: none"> <li>• One sheet of chart paper and marker per group of four participants</li> <li>• Pins and/or adhesive tape for hanging charts on pin boards or walls</li> </ul>
16:00	Close	<ul style="list-style-type: none"> <li>• Handout 6</li> <li>• Day One classroom activities</li> </ul>



## Day One Facilitation Guide

This module explores Education for Sustainable Development (ESD) and Climate Change Education (CCE) in theory and practice, and their mutually reinforcing characteristics. Key concepts and dimensions of Climate Change Education for Sustainable Development (CCESD) are introduced, as is the underlying transformative nature of the approach. Participants pool understandings, perceptions and personal experiences of climate change before being introduced to the basic science. They go on to examine diverse explanations of human factors driving climate change and the interrelationship between those factors and then to consider the impacts of climate change on people's lives. The programme then brings climate change and sustainable development together and looks at the implications of present and future climate change for progress towards sustainable development. Participants learn of the knowledge, skills and dispositions to be developed in learners and, through engaging in activities and the role modelling of the facilitator, acquire an initial sense of the interactive, participatory and experiential learning processes that CCESD calls for and how such learning should be facilitated. The day closes with a sharing of initial ideas on opportunities for CCESD across the curriculum.

Click to consult  
the Summary  
of what is  
learned on  
Day One



### 9:00-9:20 Introduction

- With slide 2 showing, welcome participants; introduce yourself as facilitator; invite participants to briefly introduce themselves (who they are; where they teach)
- Introduce the overall workshop theme and purpose (using slide 3)
- Overview the themes to be covered on each workshop day (slide 4)
- Explain the plan for Day 1 and the objectives of the day's training (slide 5)
- Explain the learning approaches to be employed during the workshop and why they are important for effective CCESD (slides 6 and 7)
- Introduce and distribute the appropriate regional information pack
- Explain the daily feedback process (Handout 6) and daily homework tasks (slide 8).
- Invite participants to engage in the first activity

Click to consult  
the Powerpoint  
slides for  
Day One



Click to  
download the  
Powerpoint  
slides in pptx  
format for  
Day One



### 9:20-9:55 Activity: Climate Change People Search

#### Time Needed

- 35-40 minutes (15-20 minutes of activity; 20 minutes of discussion)

#### Objectives/Explanation

- To help participants get to know each other
- To enable participants to share personal experiences, knowledge and feelings concerning climate change
- To look for what is common across those experiences and feelings
- To bring out participants' collective experience and level of understanding of climate change and pool any initial questions they may have

#### Materials Needed

- One Climate Change People Search sheet (Handout 1) per participant
- One Flip chart and marker

#### Procedure


- Invite participants to move around the open area and join up with someone who meets one of the criteria set out in the handout.

#### Facilitation Guidance

This is a busy activity. A 'busy' classroom mood should be encouraged but not so busy that participants are bent on completing the sheet rather than really listening to each other. Possible discussion questions:

- Did you learn anything from anybody that really surprised you?
- Did you find you had experiences in common with others? What were those experiences?
- What feelings were commonly expressed?
- Did you argue? About what?
- What has the activity shown that we know about climate change?
- What has it shown that we don't know or are uncertain about? What questions has it raised in your mind?
- Any thoughts on using this activity on the classroom?

Click to consult  
Handout 1



- Ask them to write the name of the person into the space on the sheet and ask questions of their partner so as to encourage sharing of detail of their experiences and/or feelings.
- Let the group know that they can only have one positive response from any one person. They must move on to other people to fill in other lines on the handout.
- Encourage them to complete as much of the handout as possible in the time available but without rushing so they benefit from listening to each other's stories.
- Lead the group in discussion and reflection on stories they have encountered and write the group's questions about climate change on the flip chart.

### 9:55-10:35 Activity: Climate Change Art Gallery

#### Time Needed

- 40 minutes (10 minutes to draw; 15 minutes to circulate; 15 minutes for sharing)

#### Objectives/Explanation

- To continue the process of getting acquainted
- To enable participants to share their experiences and knowledge of climate change more broadly and in some depth
- To alert the facilitator and the group to participants' hopes and expectations for the course at an early stage
- To build an early sense of group ownership of the learning space by having the room decorated with participants' own work

#### Materials Needed

- Sheet of chart paper and marker per participant
- Pins (or adhesive tape)
- Flipchart and marker

#### Procedure

- Hand out a sheet of paper and marker to each participant. Ask them to fold the sheet into four quarters and draw lines along the folds as in slide 9.
- Ask participants to write some notes and sketch images of their experiences of a changing climate in the upper left quadrant (those experience should preferably be first hand but can include things they know about from others or the media).
- Ask participants to use the upper right quadrant to write notes and draw sketches on what they see as the causes of climate change.
- Ask participants to write down current or likely future effects of climate change in the bottom right quadrant, adding sketches as they wish.
- Finally, ask them to use the bottom left quadrant to note down their hopes and expectations for the workshop so they leave equipped to teach CCESD. They should add a end-workshop cartoon image with word bubbles of themselves as the 'CCESD teacher.'
- Invite everyone to pin their sheet on the wall and to take a walk round the 'climate change art gallery' to view the 'works of art', engaging in conversation as they go.
- After the viewing is finished, ask participants to stand by their artwork. Ask them to take turns to introduce themselves and briefly speak about one item they included in the bottom left quadrant of their own sheet and one item that they found particularly important in the bottom left quadrant of colleagues' artworks. Summarize the hopes and expectations emphasized by participants on the flipchart as they are shared. Beyond that, avoid further debriefing of the exercise.
- Leave the 'art gallery' on the walls for the remainder of the event for further viewing and revisiting in other activities.

#### Facilitation Guidance

This activity helps build further a sense of community across the workshop group and enables individuals to lay before the group the experiences and understandings they bring to the event. After giving guidelines for the artwork, the facilitator should join in the activity (preparing a 'work of art', viewing all the work, chatting with participants). In light of participants' hopes and expectations, the facilitator should think of any necessary adjustments to the programme and training process that might be advisable. The titles on the PowerPoint slides can be regionally adjusted. To close the activity, it is a good idea to ask for participants' views on how the activity might be used in classroom.



Click to consult  
slide 9


**10:35-10:50 Break****10:50-11:05 Input: The Basic Science of Climate Change**

- Distribute a copy of Basic Science of Climate Change (Handout 2) to each participant
- Speak about slides 10-13
- Take any questions or observations

Click to consult  
Powerpoint  
slides 10-13



Click to consult  
Handout 2


**11:05-12:00 Activity: Climate Change Webs****Time Needed**

- 55 minutes (15 to critically review the statements in Handout 3; 15 to work on interconnections between statements; 10 minutes to consider the challenge presented by each statement; 15 minutes whole group discussion)

**Objectives/Explanation**

- To critically examine a diverse range of explanations of human factors driving climate change
- To explore interrelationships between the explanations
- To reflect upon the nature and degree of the challenge that each explanation presents

**Materials Needed**

- One cut-up set of Climate Change Explanations statements (Handout 3) per group of three participants
- One sheet of chart paper, a paste stick and two markers, each of a different colour, per group of three participants [Preferably, all groups should have markers of the same two colours.]


**Procedure**

- Ask participants to form groups of three composed, if possible, of people who did not know each other before the workshop.
- Distribute a set of Climate Change Explanations statements to each group.
- Ask the group to read and critically reflect on the significance of each of the ten statements, and encourage members to share their personal views on each statement.
- Ask groups to arrange the statements on their sheet of chart paper according to a system of their mutual choice (e.g. most significant in centre, least significant to the edges), and to stick them down. Go on to ask them to look for interconnections between all the statements and to indicate them on their chart by drawing in two-way arrows using one of their markers. Explanations of an interconnection should be written along each two-way arrow.
- Now invite groups to consider each of the statements in terms of how challenging it would be to tackle the problem described in each statement and so reduce the severity of climate change. Using their second marker, they write a number against each statement according to the following: 4 = hugely challenging; 3 = very challenging; 2 = somewhat challenging; 1 = not very challenging.

**Facilitation Guidance**

- This activity takes the climate change debate beyond science and into social, economic and cultural domains. All statements have serious implications for human society, some perhaps more profound and far-reaching than others. The statements themselves are likely to trigger keen debate but consideration of the challenges they face even more so. Questions to take the discussion forward:
- Which statement did you find the most provocative (convincing, significant), and why?
- Which statement had the most emotional effect on you, and why?
- What interconnections between statements did you find that made you think about climate change in new ways?
- Did you find that significant statements were also 'hugely challenging' statements? What does that suggest?
- Do you think climate change is mainly a scientific issue?
- What has the activity suggested to you about where climate change should appear in the curriculum?
- Any thoughts on using this activity in the classroom?

Click to consult  
Handout 3



- One by one invite groups to briefly explain the main things they have learnt out of the exercise before widening into general discussion.

**12:00-13:00 Lunch**

**13:00-13:50 Activity: Climate Change Stories**

#### Time Needed

- 50 minutes (10 minutes, brainstorm; 20 minutes, considering stories in groups; 20 minutes, sharing and discussion)

#### Objectives/Explanation

- To consider the impact of climate change on peoples' lives by considering stories from around the world
- To consider where responsibility lies for helping those afflicted by climate change

#### Materials Needed

- Flip chart and marker or board and chalk
- A few copies of each of the Climate Change Stories (Handout 4) so that each participant gets a story and so that groups of three/ four can be formed of members having the same story
- One sheet of chart paper and marker per group

#### Procedure

1. Begin by inviting participants to brainstorm the effects climate change is having on their own lives or the lives of others. Write all ideas down on the flipchart or board without comment. Close the brainstorm session when ideas dry up.
2. Distribute the story copies randomly amongst participants. Then ask for groups of three or four to be formed by people holding the same story.
3. Ask individual group members to quietly read their story. Invite them to divide their chart paper into three sections titled Effects, Feelings, Who Should Do What? Following discussion, ask groups to list the effects of climate change they see in the story in the first column, the feelings they experienced on reading the story in the second, their ideas on who should take responsibility for putting things right in the third.
4. Have groups in turn summarize the story they have read before going on to identify the climate change effects they identified and to share emotions felt on reading the story.
5. Open the general issue of responsibility to the whole group, encouraging participants to share ideas from their own charts.

#### Facilitation Guidance

The facilitator should be prepared for an emotional response to the task and significant identification with those afflicted. It is important to allow for emotional release through quiet reflection, hugging, deep breathing or other modalities, as appropriate.

In facilitating the closing discussion on responsibility, the following questions can be used:

- Where does responsibility lie for the plight of people in the stories?
- Are your communities experiencing similar challenges to the people in the stories?
- Who should be helping out? The community? Regional authorities? National governments? International organizations? Wealthy nations? All, but in different ways?
- How can story be used in CCESD teaching?
- What are the implications of the stories for the prospect of sustainable communities?

 Click to consult Handout 4

## 13:50-15:05 Activity: Sustainable Development and Climate Change Collages

### Time Needed

- 75 minutes (30 minutes Stage 1; 20 minutes Stage 2; 25 minutes Stage 3)

### Objectives/Explanation

- To provide a springboard for participants for considering the nature of sustainable development
- To share participants' perceptions and understandings of sustainable development and to challenge them by introducing other perceptions and understandings
- To surface first ideas on the implications of present and future climate change for progress towards sustainable development

### Materials Needed

- 4 slips of blank paper per participant
- One large sheet of chart paper per group of 4 participants
- One paste or glue stick
- Three markers per group, each of a different colour
- One cut-up set of statements from Perspectives on Sustainable Development (Handout 5) per group
- One copy of Handout 5 per participant

### Procedure

#### Stage 1

- Ask participants to work individually, avoiding discussion, as they write four statements each beginning 'Sustainable development is...' There should be one statement on each of the four slips of paper. The four statements should capture their own understandings of what 'sustainable development' means and involves.
- Invite participants to form groups of four to share and discuss what each has written. Then ask them to create a 'sustainable development' collage by laying out their 16 slips on a large sheet of chart paper, pasting them down, writing in comments and further explanations, and adding graphics (e.g. two-way arrows, cartoons). All this should be done using a marker of one colour. They should also agree on and write down a one-sentence summary definition of 'sustainable development'.
- Ask each group to share their collage, closing their presentation with their one-sentence definition of 'sustainable development'.
- After each presentation encourage feedback and comment from the whole group on what has been said.


#### Stage 2

- Distribute a set of Perspectives on Sustainable Development statements to each group.
- Ask them to reconsider their collage in the light of the statements and in response to feedback to their Stage 1 presentation. They should add new ideas and insights they had previously overlooked, pasting in any of the statements that they wish and adding comments. For this stage, ask them to use a marker of a second colour.
- Invite each group to report back briefly on what they have added.

### Facilitation Guidance

This activity again works on the principle of encouraging a sharing of what is known amongst participants — in this case about sustainable development -before challenging participants with new information and asking them to reflect and reconsider. Potential impacts of climate change on sustainable development are then considered, the facilitator moving attention towards how climate change action is crucial for sustainability prospects. Possible general questions to conclude Stage 3 are:

- How are different aspects of sustainable development likely to be affected by climate change?
- Will understandings of sustainable development need to be re-thought as climate change impacts worsen?
- What climate change actions should we take to ensure that sustainable development is something we can continue to work with and towards?
- What are the curriculum, learning and teaching implications of what we have discussed?
- Any thoughts on using the activity in this or simplified form in classroom?

Click to consult  
Handout 5 



### Stage 3

- Ask groups to consider the implications for sustainable development of what they have learned about climate change during the day.
- Invite them to add notes to their chart in a marker of a third colour suggesting how present and future climate change is likely to affect prospects for sustainable development as variously interpreted on their chart. Also invite them to write in initial ideas on what might be done to limit or prevent negative impacts on future sustainability.
- Lead a reporting back and discussion session.

#### 15:05-15:20 Break

#### 15:20-15:30 Input: Climate Change Education for Sustainable Development

 Click to consult  
Powerpoint  
slides 14-16

- Summarize what has been said about climate change and sustainable development in the previous activity
- Draw upon what has been said to summarize the educational task, using slides 14 – 16
- Take a few questions

#### 15:30-16:00 Activity: CCESD across the Curriculum (1)

##### Time Needed

- 30 minutes (15 in groups; 15 for reporting back and discussion)

##### Objectives/Explanation

- To share and record initial ideas on opportunities for CCESD across the curriculum in the light of the day's learning

##### Materials Needed

- Sheet of chart paper and marker per group of four participants
- Pins and/or adhesive tape for hanging charts on pin boards or walls

##### Procedure

- Have participants form groups according to the subject(s) they teach.
- Ask groups to review the day through the eyes of a subject teacher and note down on the chart paper provided some initial ideas on ways in which CCESD might be introduced into the teaching of the subject(s) in question.
- Invite a brief reporting back by each group and follow the reports with a general discussion.
- Have groups display their chart on a wall or pin board.

##### Facilitation Guidance

This last activity of the day focuses attention for the first time on opportunities for CCESD across the curriculum. [It should be signalled that time will be given over on subsequent days to exploring whole school approaches to CCESD that go beyond curriculum] At this stage groups composed of teachers of a particular subject is advisable but, if not, teachers of adjacent subjects can be grouped together (e.g. science and technology teachers; teachers of social studies subjects).

In the debriefing it is important to ask if participants have so far introduced what they think of as CCESD in their classrooms and to share something of their experience.

In concluding the debriefing, it is important to encourage participants to be on the look out for curriculum opportunities for CCESD on subsequent days as the topic of disciplinary approaches to CCE will be revisited and inter-disciplinary approaches also explored.

#### 16:00 Close

 Click to consult  
Handout 6

- Ask participants to complete a feedback sheet (Handout 6).
- Distribute the classroom activity file and remind participants to read through classroom activities for the day, bringing any questions to the next day workshop.
- Remind participants to write their reflective workshop diary entry for the day and bring the diary to Day 2.



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UNESCO COURSE FOR SECONDARY TEACHERS ON CCESD

# DAY ONE HANDOUTS

## Handout 1. Climate Change People Search

Find someone who:		Name	Notes from your discussion
1	Has joined in climate change community action		
2	Is worried about what the future might bring		
3	Has heard that a warming climate will bring new diseases		
4	Is not sure what the difference is between climate and weather		
5	Feels the normal rhythm of the seasons is changing		
6	Knows of people who have had to move because of the effects of climate change		
7	Can think of changes being made to stop climate change getting worse		
8	Blames wealthy nations for climate change		
9	Can share a recent climate change story		
10	Is trying to be 'green' by cutting down on energy use		
11	Believes that climate change is not that serious		

[↩ back to Facilitation Guide: Climate Change People Search](#)

12	Knows of a farmer who is worried about climate change		
13	Feels that their lifestyle and culture are under threat from climate change		
14	Thinks that girls and women will suffer most as the climate heats up		
15	Has seen the effects of climate change where they live		
16	Can think of changes being made to adapt to climate change		
17	Feels very emotional about climate change		
18	Has heard or read of awful climate change predictions		
19	Has learned of species going extinct because of climate change		
20	Thinks that their children will not be able to live as they have		



## Handout 2. Basic Science of Climate Change

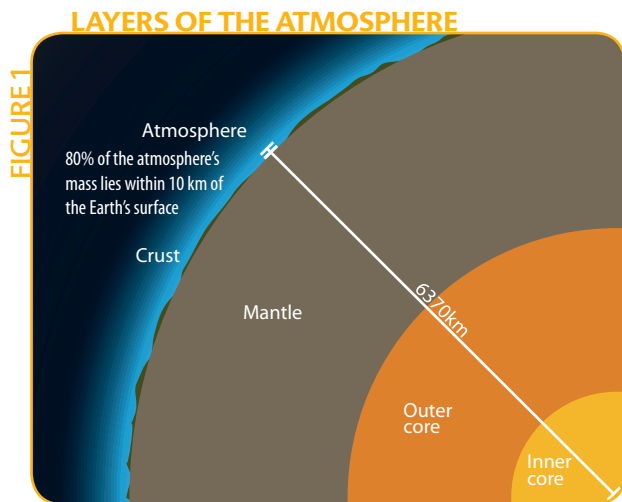
Click to consult the factsheet on climate change science for more comprehensive information.

### What is climate change?

The Earth's climate has changed many times in response to natural causes. The term climate change usually refers to man-made changes that have occurred since the early 1900s.

### What is the difference between weather and climate?

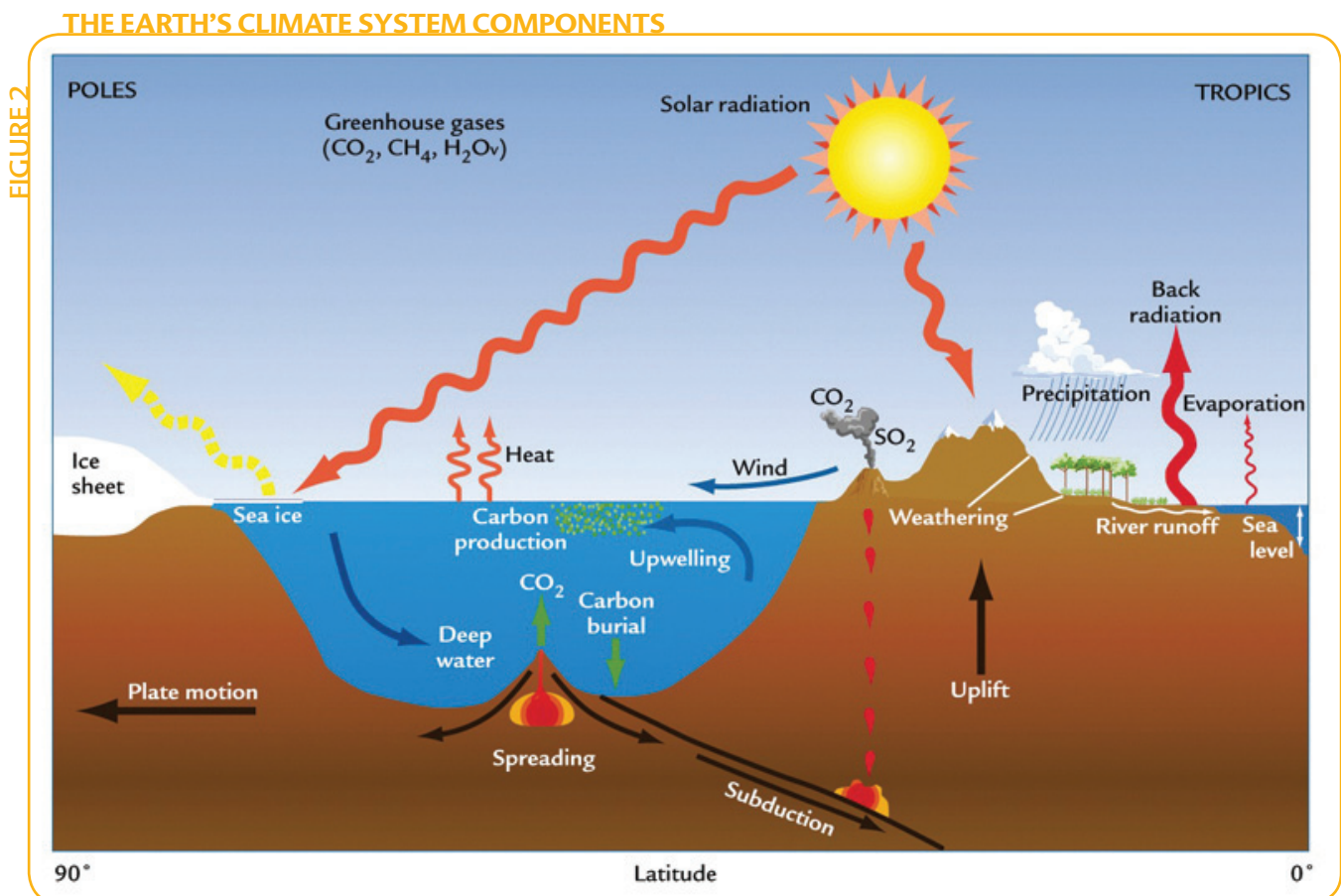
To understand climate change, it's important to recognise the difference between weather and climate. Weather is the temperature, precipitation (rain, hail, sleet and snow) and wind, which change hour by hour and day by day. Climate is the average weather and the rhythmical nature of its variations that we experience over time.



If one considers the size of a standard classroom globe, the atmosphere would be approximately as thick as a coat of paint on its surface.

The Earth's climate is affected by a myriad of drivers that operate over different time scales and result in different changes over various geographical scales and geological eras. The movement of heat around the Earth is accomplished via the global climate system, which comprises the atmosphere, the oceans, the ice sheets, the biosphere (all living organisms) and soils, sediments and rocks. The climate system is made up of numerous subsystems with many processes occurring within and between each subsystem. These complex interactions result in intermittent and constantly changing phenomena (e.g. El Niño and the North Atlantic Oscillation).

The atmosphere is a comparatively thin layer of gases which fades rapidly away with altitude and does not have a definite top. About 80% of the mass of the atmosphere is contained below 10 km of altitude (see Figure 1). Compared with the Earth's radius (6370 km) the atmosphere is just one sixth of one percent. Yet it is an extremely important multifunctional layer composed of



Clark College, 2003.



numerous gases in varying proportions in different regions, and which serve different functions. It is predominantly made up of nitrogen (78%) and oxygen (21%). Besides water vapour, several other gases are also present in much smaller amounts (Carbon monoxide (CO), Carbon dioxide (CO<sub>2</sub>), Neon (Ne), Oxides of nitrogen, Methane (CH<sub>4</sub>), Krypton (Kr), and Ozone (O<sub>3</sub>)).

### What is the greenhouse effect?

The greenhouse effect is the natural process of the atmosphere letting in some of the energy we receive from the Sun (ultraviolet and visible light) and stopping it being transmitted back out into space (infrared radiation or heat). This makes the Earth warm enough for life.

For several thousands of years the atmosphere has been delicately balanced, with relatively stable levels of greenhouse gases. Human influence has now upset that balance and, as a result, we are seeing climate change.

- Ultraviolet (UV) sunlight hits the Earth — some is reflected by the atmosphere and some UV passes through and hits the Earth's surface.
- Areas of the Earth which are covered in snow and ice reflect most UV back into space. UV that is not reflected hits the Earth and is transformed into Infrared Radiation (IR) or heat energy that is then given off by the Earth. Most IR escapes the atmosphere into outer space and has no warming effect.
- But greenhouse gases in the atmosphere trap some IR and this warms the air, water and land. The more greenhouse gases in the atmosphere, the larger the warming effect.

### How are we causing climate change?

Human activities, such as burning coal, oil and gas, have led to an increase in greenhouse gases in the atmosphere causing an enhanced greenhouse effect and extra warming. As a result, over the past century there has been an on-going increase in average temperatures. Globally, the ten hottest years on record have all been since 1997.

### What will happen if we don't reduce emissions?

If emissions continue to grow at present rates, carbon dioxide (CO<sub>2</sub>) concentration in the atmosphere is likely to reach twice that of pre-industrial levels by around 2050. Unless we limit emissions, global temperature could rise as much as 7 °C above pre-industrial temperature by the end of the century and push many of the world's great ecosystems, such as coral reefs and rainforests, to irreversible decline.

Even if global temperatures rise by only 2 °C it would mean that 20–30% of species could face extinction. We can expect to see serious effects on our environment, food and water supplies, and health.

### Which gases are causing the most change?

The main greenhouse gas responsible for recent climate change is CO<sub>2</sub>. This gas has been released in huge

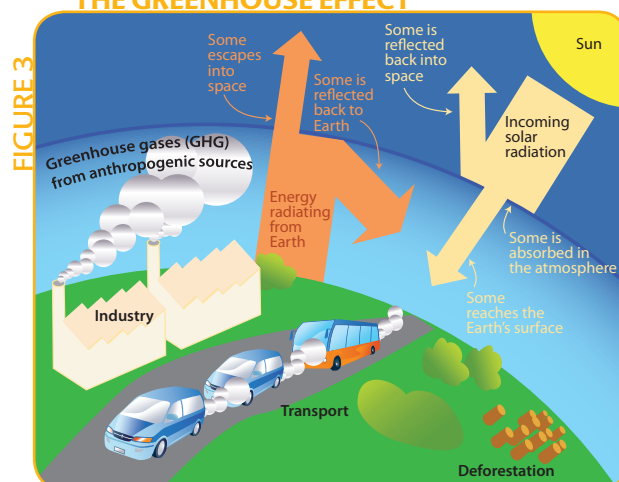
## El Niño / La Niña (ENSO) and the North Atlantic Oscillation

El Niño/La Niña-Southern Oscillation, or **ENSO**, is a climate pattern that occurs across the tropical Pacific Ocean roughly every five years. It is characterized by variations in the temperature of the surface of the tropical eastern Pacific Ocean—warming or cooling known as El Niño and La Niña respectively—and air surface pressure in the tropical western Pacific—the Southern Oscillation. Mechanisms that cause the oscillation remain under study.

ENSO causes extreme weather (such as floods and droughts) in many regions of the world. The frequency and intensity of ENSO are potentially subject to dramatic changes as a result of global warming, and is a target for research in this regard.

**North Atlantic Oscillation:** A permanent low-pressure system over Iceland (the Icelandic Low) and a permanent high-pressure system over the Azores (the Azores High) control the direction and strength of westerly winds into Europe. The relative strengths and positions of these systems vary from year to year and this variation is known as the North Atlantic Oscillation.

### THE GREENHOUSE EFFECT



### CORAL BLEACHING



RELATIVE CONTRIBUTIONS OF MAJOR GHGS TO THE GREENHOUSE EFFECT AND ATMOSPHERIC LIFETIMES

TABLE 1

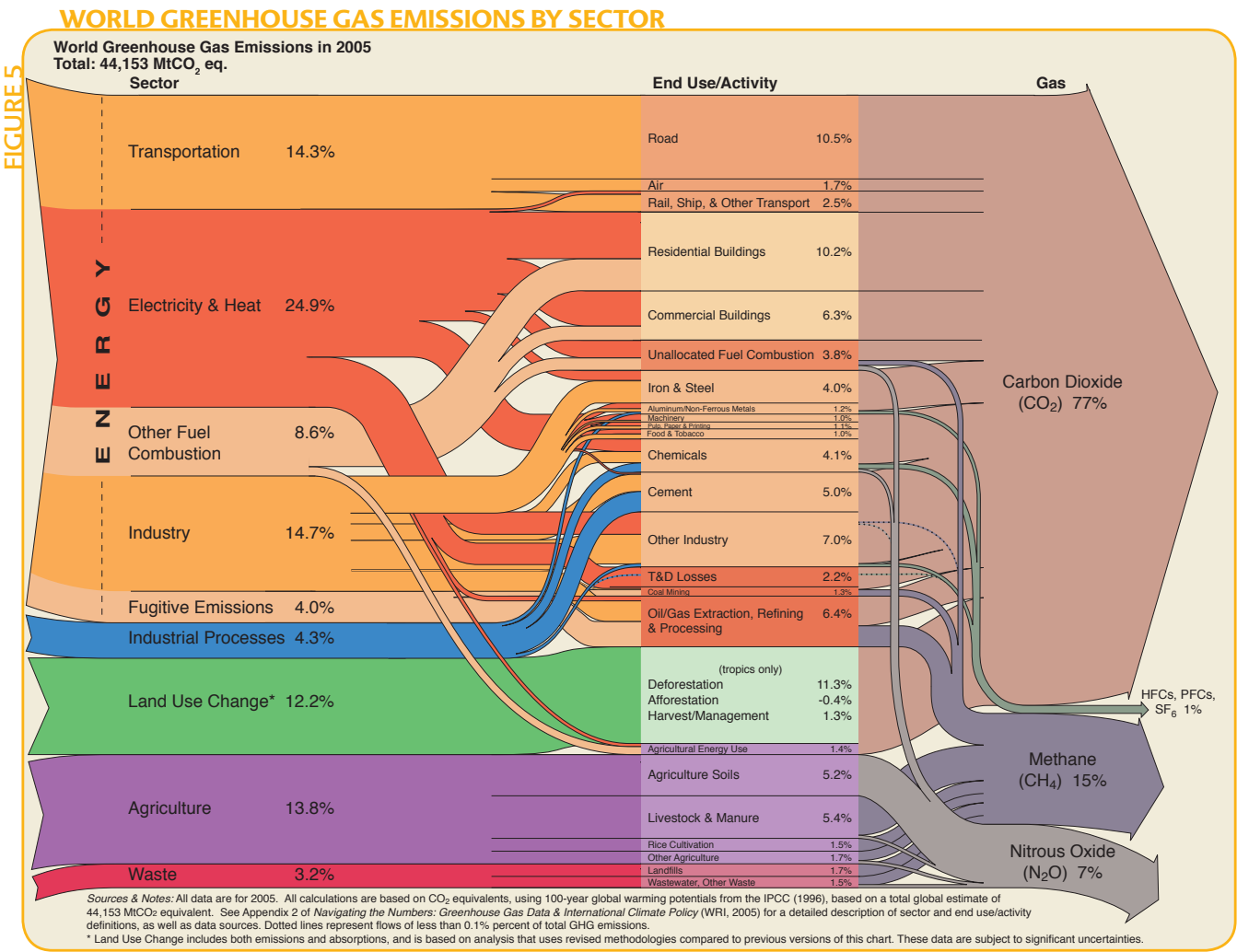
GHG	Contribution (%)	Mean lifetime
Water vapour	36% to 66%	9 days
Carbon dioxide	9% to 26%	Tens of thousands of years
Methane	4% to 9%	12 years
Ozone	3% to 7%	9–11 days

Note: ‘The determination of CO<sub>2</sub>’s atmospheric lifetime is often grossly underestimated because it incorrectly ignores the balancing fluxes of CO<sub>2</sub> from the atmosphere to other reservoirs – as it is removed by mixing into the ocean, photosynthesis, or other processes. It is the net concentration changes of the various GHG by all sources and sinks that determines atmospheric lifetime and not simply the removal processes.’ From: D. Archer, ‘Fate of fossil fuel CO<sub>2</sub> in geologic time’, *Journal of Geophysical Research* 110(C9): C09S05.1–5.6, 2005.

quantities by our modern way of life. Levels have also increased due to the destruction of rainforests, which play an important role in absorbing and storing CO<sub>2</sub>.

Human activities are increasing atmospheric concentrations of other greenhouse gases too, such as methane (CH<sub>4</sub>) and nitrous oxide (N<sub>2</sub>O). Methane is produced by bacteria that live in places like landfill sites, peat bogs and in the guts of animals like cows and sheep. Nitrous oxide is increased by the use of nitrogen fertiliser in agriculture.

Both these gases have a powerful greenhouse effect and also contribute to climate change. However, they have not been released in such large quantities as CO<sub>2</sub>, and methane does not last for as long in the atmosphere. So, while they make a significant contribution to climate change, it is man-made CO<sub>2</sub> that has by far the greatest influence.



Handout 2 text and images have been sourced from the following documents:

Met Office (2009) *Warming: Climate Change – The Facts* (pp. 1-3). Full document available from: [http://www.metoffice.gov.uk/media/pdf/p/a/quick\\_guide.pdf](http://www.metoffice.gov.uk/media/pdf/p/a/quick_guide.pdf) © British Crown Copyright 2011, the Met Office.

UNESCO/UNEP (2011) *Climate Change Starter's Guidebook*. Full document available at: <http://unesdoc.unesco.org/images/0021/002111/211136e.pdf>

## Handout 3. Climate Change Explanations

### 1. Transport

Transport currently causes 14% of global greenhouse gas emissions. Part of the problem is that wealth and carbon-based transport have tended to go hand in hand. When a nation gets richer, its citizens change from walking and cycling, through buses and local trains, to cars, high-speed trains and air travel.

### 2. Disconnection from Nature

Climate change arises from separating ourselves from nature. Urbanization and technology have isolated people from the effects of nature, especially weather. With 'progress' we have also become psychologically separated from nature, feel 'above' nature, and treat it as a 'resource' to exploit.

### 3. Population growth

Population growth typically means increased greenhouse gas emissions. The world's population is expected to grow from today's 7 billion to between 8.0 and 10.5 billion by 2050. The majority of this growth is likely to be concentrated in areas and among populations — poor, urban and coastal — that are already highly vulnerable to climate change impacts.

### 4. Deforestation

Deforestation and forest degradation, through agricultural expansion, conversion to pastureland, infrastructure development, destructive logging, and fires, account for nearly 20% of global greenhouse gas emissions, more than the entire global transportation sector and second only to the energy sector.

### 5. Agriculture

Industrial agriculture is a major contributor to climate change, and a significant portion of the greenhouse gas emissions created by industrial agriculture are generated by agricultural pesticides and chemicals, deforestation and the burning of biomass.

### 6. Consumerism

Climate change is a symptom of a larger issue — consumerism — that is to say, consumption beyond the level of dignified sufficiency. It is fuelled by human wants not needs. Advertising manufactures desire for things that we don't really need, the result being that we desire and consume more to feel good about ourselves. As the market works to produce supplies to meet the demand, the economy grows, and the planet heats up.

### 7. Urban areas

With half of the global population living in urban areas, cities are already consuming 75 per cent of the world's energy and are contributing to a similar proportion of all waste, including greenhouse gas emissions.

### 8. Economic growth

Belief in economic growth has become a faith not to be questioned. Governments tell us growth is necessary to build schools and hospitals, save the poor, and cure unemployment. But economic growth built on fossil fuel usage is the key reason the climate is changing. The term 'Green Economy' has been coined to describe economic growth based on renewable energy sources and green jobs.

### 9. About people

Population growth typically means increased greenhouse gas emissions. But unsustainable consumption and per capita emissions are generally much higher in rich, industrialized countries. So it is important to remember that population is not just about numbers, it's about people, their choices and lifestyles.

### 10. Fossil fuels

Fossil fuels (oil, natural gas, and coal) provide most of the energy used to produce electricity, run automobiles, heat houses, and power factories. Carbon dioxide from the burning the fossil fuels is the largest single source of greenhouse emissions from human activities.

### Sources:

1. Amended from: Gabrielle Walker and David King (2008) *The Hot Topic: How to Tackle Global Warming and Still Keep the Lights on*. London: Bloomsbury, 118.
2. Inspired by Clive Hamilton (2010) *Requiem for a Species: Why We Resist the Truth About Climate Change*. London: Earthscan, 134-58.
3. Taken from: United Nations Population Fund and Women's Environment and Development Organization (2009). *Climate Change Connections*, 2.
4. Taken from: UN-REDD Programme  
<http://www.unredd.org/AboutREDD/tabid/582/Default.aspx>
5. Taken from: ActionAid (2009). *Sustainable Agriculture and Climate Change: An ActionAid Rough Guide*. 2.
6. Inspired by Alastair McIntosh (2008) *Hell and High Water*. Birlinn: Edinburgh and Clive Hamilton (2010) *Requiem for a Species: Why We Resist the Truth About Climate Change*. London: Earthscan.
7. Taken from: UN General Assembly (2008). *Implementation of the outcome of the United Nations Conference on Human Settlements (Habitat II) and strengthening of the United Nations Human Settlements Programme (UN-Habitat)*. A/63/291.
8. Inspired by and Clive Hamilton (2010) *Requiem for a Species: Why We Resist the Truth About Climate Change*. London: Earthscan, 32-65.
9. Amended from: United Nations Population Fund and Women's Environment and Development Organization (2009). *Climate Change Connections*, p. 2.
10. Taken from: UNEP & UNFCCC (2002). *Climate Change Information Kit*.  
[http://unfccc.int/resource/docs/publications/infokit\\_2002\\_en.pdf](http://unfccc.int/resource/docs/publications/infokit_2002_en.pdf)

[↩ back to Facilitation Guide: Climate Change Webs](#)



## Handout 4. Climate Change Stories

### Story 1: Nguyen Thi Lahn: A Climate Change Story from Viet Nam

Life has never been easy for Nguyen Thi Lahn, 51, from Quang Tri Province in Viet Nam. Viet Nam, with some 3,500 kilometres of coastline and large populations concentrated in low-lying delta regions, is especially vulnerable to the effects of climate change. Storms have become more intense and frequent, and the storm season now lasts longer.

The toll taken by extreme weather began at least a decade ago, recall Lanh and her husband, Phi, referring to the 1999 floods. 'We lost our rice, our pigs and chickens, everything. The water came up to the window. The flood came suddenly, and we could not prepare anything in advance,' Phi says. 'We moved to the temple, looking for shelter. We did not have time to take our belongings, just the clothes we were wearing, Lanh adds. In recent years, rains have become unusually heavy, making it impossible for farmers to plant on time, and harvests have therefore been smaller.

'Now we have to work harder because there often are floods, and we are afraid that in the future the situation will be even worse,' Lahn says. She's not alone — women, especially those in poor countries — are among the most vulnerable to climate change. In Viet Nam and in many other countries affected by climate change, men migrate to the cities in search of jobs, while women are usually left behind to take on all the responsibilities for their households, often including planting and harvesting, taking care of livestock and providing for their families. 'When my husband is not at home, I have to work in the field. And in order to pay the school fees, I work extra time in construction, even though I am not in good health,' she goes on, adding that she does her best to remain prepared for floods. Her home, like many in the area, has raised lofts so she can move belongings to higher places and keep the children safe when the waters rise, she explains.

Lanh — and many other women in Quang Tri — know that weather is no longer predictable and that flooding can happen almost any time. She and her neighbours participate in meetings and workshops organized once or twice per month by the Women's Union in Hai Ba Commune, where climate change and natural disasters are recurrent topics. The villagers carry out evacuation drills, discuss emergency preparations and receive first aid training. It's a chance for women to share their experiences on how to protect themselves, their families and their livelihoods during the flood season.

#### Source

Amended from: United Nations Population Fund (2009), '*Facing the Flood: Women cope with Climate Change in Viet Nam*' reported by Maria Larrinaga, with support from Oxfam Viet Nam. For the full story, visit [http://www.unfpa.org/public/media\\_resources/swp09](http://www.unfpa.org/public/media_resources/swp09)  
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## Story 2: Lars-Anders Baer: A Climate Change Story from Scandinavia

The indigenous Saamis are feeling the heat of global warming. Some 60,000 to 100,000 Saamis spread out across Finland, Norway, Sweden and Russia, making a living partly from fishing and hunting. Many of them, however, herd reindeer —the backbone of the traditional economy. Reindeer meat is prized for its flavour, tenderness and low fat content. The hides, bones and antlers are used for clothing and handicrafts.

Warmer weather has had an immediate toll on the Saamis. Lichen, a mossy fungus on rocks, abundant in these lands, is getting trapped under a layer of ice that forms as a result of rises and falls in temperature. It is the reindeer's main source of nutrition during the long winter months; however, herds are increasingly unable to reach it. 'A reindeer can normally dig through as much as one metre of snow to get to the lichen,' says Lars-Anders Baer, President of the Saami Parliament based in Kiruna, in northern Sweden. 'But now, with less snow and more ice, the plant is no longer accessible.' Feeding reindeer that cannot find enough food on their own is putting a huge financial burden on the herders. Recently, says Lars-Anders Baer, 'around 100,000 reindeer were not able to eat the lichen, so we had to give them extra food to prevent them from dying.' Despite government subsidies, the extra cost, amplified by the latest food crisis and a decline in revenues, has forced many to sell their reindeer and quit herding, which, he says, 'is essential for the survival of our culture.'

On a wider scale, pastures are starting to shrink due to the change in weather. 'As the snow melts, we can see the tree line climbing,' he says. 'This means that the ground is becoming more hospitable for agriculture and other uses, and that less pastures are available for the reindeer.' Central governments and the private sector, which had long shied away from the bitterly cold temperatures, have taken note of the available land. The land is particularly desirable since its ownership rights have not been determined yet.

'New interests are coming into our territory,' says Lars-Anders Baer. 'For example, men working in oil and gas exploration are bringing along new symptoms associated with modernization, such as alcohol consumption, prostitution and suicides. This is putting the indigenous communities under pressure. Reindeer herders are good at adapting to normal weather fluctuations,' he says. 'However, it is these secondary consequences of climate change that are troubling the Saamis. They are trying to cope with them by adopting new methods of doing business, such as changing reindeer movement patterns, introducing extra feeding and combining traditional and modern knowledge. 'The whole Swedish society is adapting to climate change, and we have to do the same,' he says. 'However, we are very concerned about possible social and cultural consequences, and will have to work hard on preserving our rights, our language and our way of life.' 'The climate and the cold weather have been our greatest defenders,' he adds. 'But now, when the climate has changed, it has opened up the area.'

### Source

Taken from: United Nations Population Fund (2009), *'Scandinavia's Indigenous Saami Way of Life Threatened by Thawing Tundra'*.

For the full story, visit: [http://www.unfpa.org/public/media\\_resources/swp09](http://www.unfpa.org/public/media_resources/swp09)

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### Story 3: Thombi Masondro: A Climate Change Story from South Africa

According to Constansia Musvoto, researcher with the South African Council for Scientific and Industrial Research, rainfall patterns in the region have notably changed since the 1960s. Musvoto says the climate changes will have a tremendous effect on agriculture and the availability of clean water in the province. 'Southern Africa will be hit heavily by climate change over the next 70 years,' she says. 'Agricultural production is projected to be halved, a development that will threaten the livelihoods of farmers in a region where 70 per cent of the population is smallholder farmers.'

Thombi Masondo, 57, takes a rest after working under the baking sun on her 10-acre farm. Her crops are dying before they have a chance to break the soil. The area, dry at the best of times, is experiencing the longest ever rainless stretch in its history. Masondo has seen weather conditions change substantially over the past 30 years, with rains often starting a month later than they used to.

The province, long vulnerable to drought, has seen worsening dry spells. It often rains continuously for almost a week, which is bad news for the crops. Rising temperatures, delayed and unreliable rainfall, soil erosion, and severe droughts are making it difficult for small-scale farmers to continue growing food such as maize and beans in this drought-prone area.

Masondo, a gray-haired mother of five, scrapes her living growing crops which she sells at the nearest market to raise money to send her children and some of her grandchildren to school. Her husband died of AIDS in 2004, and the illness has also claimed two of her daughters, leaving her to look after their three orphaned children.

Limpopo is one of the poorest provinces in South Africa with a rural population of 89 per cent with a relatively high illiteracy and unemployment rates. It is the epicentre of South Africa's hunger but the government is responding with painful slowness. People rely heavily on agriculture for household food security. Growing malnutrition has led to reports of disease-related deaths among young children weakened by hunger. Drought has also weakened the animals and many died from hypothermia during the recent rains. The three cows dozing near to Masondo are the only ones left after more than 13 of her herd died during the droughts of the past four years. This, for her, was like losing part of her body as she used these cattle to plough her land, plant her crops and ferry her products from the field to the market. The area as a whole, she says, lost 'thousands of cows.'

#### Source

Taken from: Panos London. '*Limpopo Goes Hungry as Climate Change Bites*.'

For the full story, visit: <http://panos.org.uk/features/limpopo-goes-hungry-as-climate-change-bites/>  
Reproduced with permission.

### Story 4: Corey Marchbank: A Climate Change Story from Canada

**Corey Marchbank, 35, lives in Miscouche, Prince Edward Island, Canada. He works as a goose hunting guide, which means that he takes goose hunters out to the field. He began hunting with his father not long after he learned to walk, and his love of the outdoors led him to become a professional guide 14 years ago. He hunts with clients from the United States and other Canadian provinces.**

For decades, the grain and potato fields around his home have been the primary location for consistent, high quality goose hunting, though lately things have been changing. In recent years he has noticed a dramatic rise in temperatures, a decrease of winter snow and ice, and how these changes have been affecting the migration patterns of Canadian geese in this region.

The goose hunting season starts on the first Monday in October and ends the second Saturday in December. Usually by the season opening the weather is a bit chilly but, over the last two years, right up to November, he was still swatting mosquitoes, wearing T-shirts and sneakers — not hunting jackets as it used to be.

‘We used to get snow by 1 November, but now we’re lucky to get snow by Christmas. During the winter of 2006-07 there wasn’t more than a week of good snowmobiling weather. In years past, snowmobiling was good from Christmas through spring. And I remember when I was a kid, you’d go outside and the snow would be up to the level of the power lines and there were warnings on the radio not to let the kids out. I haven’t seen that in a long time,’ he says.

With the increase in fall temperatures, Canadian geese are migrating south much later in the year. When it eventually gets cold and they migrate through Prince Edward Island, the geese hang out in the local bays and estuaries instead of collecting spent grain and potatoes from the agricultural fields. This is happening for a couple of reasons. First, the waters have not been freezing over like they used to. Second, without the cold temperatures, the geese don’t have the same pressure to stock up on food before continuing their migration south. ‘With the hot sunny days we’ve been having, the geese tend stay out on the water and don’t come inland at all. It’s a big change,’ he says. ‘And now, some of the geese are even staying around all year. I’ve never seen geese do this. They know not to take their chances though, and if it’s mild around here, they’ll stick around and take advantage of it.’

‘Usually the first two weeks of the hunting season are the best hunting that you have the whole season. Now, most hunters are going home with nothing. During the last two years, on opening day, we haven’t shot a single goose. I have a group of four guys that come every year, and just like clock-work, they expect to get their geese. But the last two years on opening day they didn’t get any. Clients are starting to say to me, “Gee, do you remember when we used to go out and the geese were everywhere and now you can go out on opening day and not see any geese at all?” ‘

#### Source

Taken from: WWF *Climate Witness: Corey Warchbank, Canada*. For the full story, visit: [http://www.panda.org/about\\_our\\_earth/aboutcc/problems/people\\_at\\_risk/personal\\_stories/witness\\_stories/map.cfm](http://www.panda.org/about_our_earth/aboutcc/problems/people_at_risk/personal_stories/witness_stories/map.cfm) © 2007WWF (panda.org). Some rights reserved.

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## Story 5: Ben Namakin, A Climate Change Story from Kiribati and Micronesia

Ben Namakin is originally from Kiribati. He currently lives in Pohnpei (formerly known as Ponape) in the Federated States of Micronesia (FSM) and works as an environmental educator for the Conservation Society of Pohnpei (CSP), the only local environment non-government organisation on the island.

During Ben Namakin's childhood days in Kiribati, people never experienced severe sea flooding. There were storms, but they weren't that bad. As the sea levels continue to rise in Kiribati, several king tides have hit the island. Saltwater intrusion affects the quality of water in wells, floods taro (root vegetable) patches, gardens, and puts stress on plants and trees that are very important to the life and culture in Kiribati.

'Pandanus trees mean a lot to us,' he says. 'They are used for house construction, local medicine, food, traditional clothing, etc., but are dying from saltwater intrusion. Serious storm surges cause coastal erosion, floods grave yards, and in 2006, led to the collapse of the beautiful Dai Nippon causeway. This incident brought huge costs to the people of Kiribati. They had to build new homes with their own finance, and dig up their deceased relatives from their graves and bury them further inland.'

While studying for his High School Diploma in Pohnpei in 2001, during his free time, he would hang out with his friends on a small islet, Dekehtik, located on the barrier reef a couple of miles away from the school. It was his favourite camping, picnicking and snorkelling spot. In 2005, he found to his surprise that Dekehtik Islet had split into two. "I went to see for myself, with my own eyes, and there it was, badly destroyed by sea flooding. How sad to see this unexpected, sudden threat to the islanders and the landowners!", he says.

Visiting the community on the coast of Sokehs, Pohnpei, he learned that many villagers had built their houses on raised foundations as the seawater was flooding their homes during high tide. They also built walls in front of their houses to prevent flooding during heavy rains. The villagers he spoke to mentioned noticing these changes in the last five years but not in the past.

'The civil, economic, social and cultural rights that climate change abuses have strengthened my spirit to stand up for my nation, fight for our rights and to let many people know that we need to do something now to stop global warming,' he adds.

He participated at the Youth Summit during the United Nations Conference on Climate Change in 2005. He spoke at the conference plenary session which had more than 10,000 people deliver the youth's message on 'Our Climate, Our Challenge, Our Future'. In 2006, he participated in a Climate Change tour across the United States. Through seminars, he encouraged university students to join the climate change movement. He also worked hard to convince leaders in the USA to improve US policy on clean energy to address climate change, ratify the Kyoto Protocol, and most importantly make decisions that will not affect his people in the Pacific Islands negatively.

### Source

Taken from: WWF *Climate Witness: Ben Namakin: Kiribati and Micronesia*.

For the full story, visit: [http://wwf.panda.org/about\\_our\\_earth/aboutcc/problems/people\\_at\\_risk/personal\\_stories/witness\\_stories/?100800/1/](http://wwf.panda.org/about_our_earth/aboutcc/problems/people_at_risk/personal_stories/witness_stories/?100800/1/) © 2007 WWF (panda.org). Some rights reserved. Reproduced with permission.

## Story 6: The Communities of the Chacaltaya Glacier: A Climate Change Story from Bolivia

On the steep slopes leading down from the Huayna Potosi and Chacaltaya mountains lies a string of tiny communities that make a meagre living by keeping llamas, sheep and chickens and by growing small crops of potatoes and oca, a perennial plant grown in the central and southern Andes. High above them, the Chacaltaya glacier that has sustained these activities is retreating at a completely unexpected pace - three times as quickly as was predicted just ten years ago - and will be gone in a generation. The glacier that once supported a ski resort is now reduced to a small chunk of snow and ice nestled just below the 18,000-foot summit. With it, a web of life that depends on the water seeping down from the glacier is changing forever.

Many of the slopes are now farmed primarily by women, some of them in their seventies, some of them girls who should be in school. Though they manage to survive off the land, there's nothing left over to sell, so many of the men have been forced to leave the mountains to take whatever work they can find in the nearby cities of La Paz or El Alto.

Village leader Felix Quispe, for example, feels deeply connected to the land his family has worked for generations. But now he spends much of his time in the city, selling toilet paper and cleaning windows. 'It is very sad,' he says, 'Many people have left and houses are abandoned. Husbands only come home maybe twice a month. It would be great to live like before and not be heartbroken every day.'

'Young people tend to leave these areas,' says Jaime Nadal, the UNFPA, United Nations Population Fund, representative in Bolivia. 'Old women are typically left in the community having to perform harder and harder tasks to keep up the household. We already see mostly old women in many of these communities.'

Cultural traditions heighten the sadness of these changes. For one thing, a culture that values a mutual sharing of men and women's roles is being disrupted by recent changes. And the people mourn the unravelling of their deep connection with Pachamama, Mother Earth. 'This is a culture that is very much attached to the land, says Jaime Nadal. 'In our culture, the person is a person in the context of the field, the sun, the earth, the water.'

The loss of the glaciers also jeopardizes water supplies for the cities of La Paz and El Alto. 'What will the world do when two million people will not have water for drinking?' asks Jose Gutierrez, a climate change expert in Bolivia. 'The world needs to know what is happening in Bolivia,' he adds. 'We are losing something that is a human right, a source of life - water for drinking, for food, for the animals, for electricity. We also need to have a future, as any other people in this world.'

### Source

Taken from: United Nations Population Fund (2009), *'Melting glaciers alter a way of life: Adapting to harsh, new realities in Bolivia'* reported by Trygve Olfarnes and Andi Gitow. For the full story, visit: [http://www.unfpa.org/public/media\\_resources/swp09](http://www.unfpa.org/public/media_resources/swp09)  
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[↩ back to Facilitation Guide: Climate Change Stories](#)

## Handout 5. Perspectives on Sustainable Development

### Perspective 1: Green Economy

"The proximate (first to be achieved) goal in the creation of a green economy is the notion of making the economy more ecologically efficient—meeting our economic needs without compromising our ecological integrity."

Source: The Frederick S. Pardee Center for the Study of the Longer-Range Future at Boston University (2011). *Beyond Rio +20: Governance for a Green Economy*. p. 9.

### Perspective 2: Fairness and Justice for Future Generations

"Development that meets the needs of the present without compromising the ability of future generations to meet their own needs."

Source: World Commission on Environment and Development (1987). *Our Common Future*.

### Perspective 3: No Unsustainable Exploitation of Global Resources

"Sustainable development shall never be attained as long as unsustainable exploitation of the earth's resources by the North continues." [Sustainable Development should seek] "to redress existing imbalances by ensuring equity in ...the control and exploitation of global resources."

Source: *The Isiolo Declaration: Africa's Perspective on Environment and Development* (n.d.).

### Perspective 4: Gender Equity and the Empowerment of Women

(1) "Gender equality and the empowerment of women [are] effective ways to combat poverty, hunger and disease and to stimulate development that is truly sustainable."

Source: United Nations Millennium Declaration (2000).

(2) "The empowerment of women and improvement of their status are important ends in themselves and are essential for the achievement of sustainable development."

Source: International Conference on Population and Development (1994). *Summary of the Programme of Action*.

### Perspective 5: The Need for Global Partnership

"Integration of environment and development concerns and greater attention to them will lead to the fulfilment of basic needs, improved living standards for all, better protected and managed ecosystems and a safer, more prosperous future. No nation can achieve this on its own; but together we can - in a global partnership for sustainable development."

Source: United Nations Conference on Environment and Development. *Agenda 21. Preamble* (1992).

### Perspective 6: Aboriginal Perspectives

"Embedded within the Aboriginal world view is the concept of collective responsibility for tending the land and using only that which is needed for sustenance. Important, as well, is the interconnectedness and interdependence of all life forms — humankind, flora and fauna, and all that exists on the Earth. The concept of sustainability is not new to Aboriginal people; they are very aware of the growing need for all humans to show greater respect for the environment — respect for Mother Earth — if we are to continue to coexist in this world."

Source: *Aboriginal Perspectives of Sustainable Development*, p. 1 (n.d.).

### **Perspective 7: Sustainable Human Development**

“Sustainable human development aims to eliminate poverty, promote human dignity and rights, and provide equitable opportunities for all through good governance, thereby promoting the realization of all human rights, economic, social, cultural, civil and political.”

Source: UNDP (1998). *Integrating human rights with sustainable human development: A UNDP policy document*.

### **Perspective 8: Disaster Risk Reduction and Sustainable Development**

“Disaster risk is associated with unsustainable elements of development such as environmental degradation, while conversely disaster risk reduction can contribute to the achievement of sustainable development, through reduced losses and improved development practices.”

Source: UNISDR (2009). *UNISDR Terminology on Disaster Risk Reduction*, p. 29.

### **Website References**

Web links are available for some of the above documents:

- Perspective 1:  
<http://www.bu.edu/pardee/files/2011/03/Rio20TFC-Mar2011.pdf>
- Perspective 3:  
<http://www.un-ngls.org/orf/documents/publications.en/voices.africa/number5/vfa5.04.htm>
- Perspective 4:  
(1) <http://www.un.org/millennium/declaration/ares552e.htm>  
(2) <http://www.un.org/ecosocdev/geninfo/populatin/icpd.htm#chapter4>
- Perspective 5:  
[http://www.un.org/esa/dsd/agenda21/res\\_agenda21\\_01.shtml](http://www.un.org/esa/dsd/agenda21/res_agenda21_01.shtml)
- Perspective 6:  
[http://www.edu.gov.mb.ca/k12/cur/socstud/frame\\_found\\_sr2/tns/tn-41.pdf](http://www.edu.gov.mb.ca/k12/cur/socstud/frame_found_sr2/tns/tn-41.pdf)
- Perspective 7:  
<http://mirror.undp.org/magnet/Docs/policy5.html>

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## Handout 6. UNESCO Teacher Education Course on Climate Change Education for Sustainable Development: Feedback Sheet

Workshop Day No: 1, 2, 3, 4, 5, or 6 (please circle as appropriate)

This is to help the workshop facilitator(s) know how the programme is being received. They will take account of your comments in adjusting the course or their facilitation.

1. What I liked about today's workshop

2. What I think could be improved in how the workshop is being conducted

3. What questions and concerns the day has left me with

4. My other comments

Thank you very much!

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## Summary of what is learned on Day One

### 1. Pedagogies

Discovery of and familiarization with ESD issue	e.g.: Climate change (Classroom Activities & Handouts: Climate Change People Search, pp. 10-11)
Decoding & deconstruction	e.g.: Media interpretation (Facilitation Guide: Climate Change Webs, pp. 5-6)
Reflection as means of finding causal connections and interrelationships Solving climate change problems of varying complexity	e.g.: Human factors affecting climate change: interconnections (Classroom Activities & Handouts: Climate Change Webs, pp. 8-9)
Assessing responsibility	(Facilitation Guide: Sustainable Development and Climate Change Collages, pp. 7-8)
Collective reflection processes	e.g.: Sharing insight and knowledge (Classroom Activities & Handouts: SD and Climate Change Collages, pp. 12-13)
Assessing perceptions and understanding of SD	e.g.: Encouraging reinterpretation, emphasis on climate change action (Classroom Activities & Handouts: SD and Climate Change Collages, p. 13)

### 2. Definitions

Probable, feasible and preferred futures	
Zone of potential	
Personal futures, local futures, national futures, regional futures, global futures	
Mitigation	Identifying the causes of climate change and developing the knowledge, skills and dispositions required for individual and societal change
Systemic thinking	

### 3. Interdisciplinary Knowledge Systems

Knowledge from Natural Sciences	Knowledge from Social Sciences	Knowledge from Humanities
<ul style="list-style-type: none"> <li>Environment Science</li> <li>Sustainability, Climate Change, Ecosystems</li> </ul>	<ul style="list-style-type: none"> <li>Implications of Climate Change on society</li> </ul>	<ul style="list-style-type: none"> <li>Emotional causes/effects on humans</li> </ul>
<ul style="list-style-type: none"> <li>Impacts of Climate Change on SD</li> </ul>	<ul style="list-style-type: none"> <li>Problem-solving</li> </ul>	<ul style="list-style-type: none"> <li>Analyzing perceptions and personal experiences</li> </ul>
<ul style="list-style-type: none"> <li>Human Impact on Climate Change</li> </ul>	<ul style="list-style-type: none"> <li>Economics</li> <li>Weighing challenges, Recognizing Consequences and Impact of Climate Change, Desirable/Undesirable Futures</li> </ul>	<ul style="list-style-type: none"> <li>Community building</li> <li>Collective sharing</li> </ul>
<ul style="list-style-type: none"> <li>Human Vulnerability to Climate Change</li> </ul>		<ul style="list-style-type: none"> <li>Re-thinking/Changing behaviors</li> <li>Exploring possibilities to limit/reduce impacts in future</li> </ul>
		<ul style="list-style-type: none"> <li>Personal identification with ESD issue</li> </ul>

#### 4. International Frameworks

MDGs	
Human Rights	<ul style="list-style-type: none"> <li>• The right to adequate housing, right to health, etc.</li> <li>• Students assess personal responses to climate change to connect with and identify direct effects of ESD issue within their communities, families, etc.</li> <li>• Students make projections about future which include, but are not limited to, projections about health, water, food, natural disaster in relation to climate, etc.</li> </ul>
Disaster Risk Reduction (DRR)	

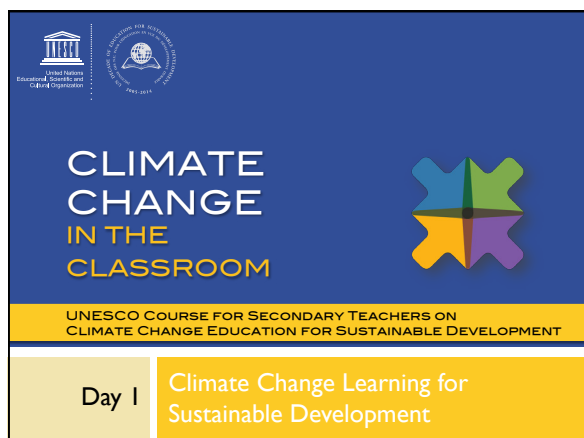
#### 5. Skills

Encouraging alertness in everyday interactions	
Futures casting	<ul style="list-style-type: none"> <li>• Opportunity-building (exploring opportunities for CCESD across curriculum)</li> <li>• Building Sustainable Communities</li> </ul>
Empowerment	<ul style="list-style-type: none"> <li>• Building empathetic understanding through sharing experiences</li> </ul>
Listening	
Problem Solving	

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## Day One Powerpoint Slides

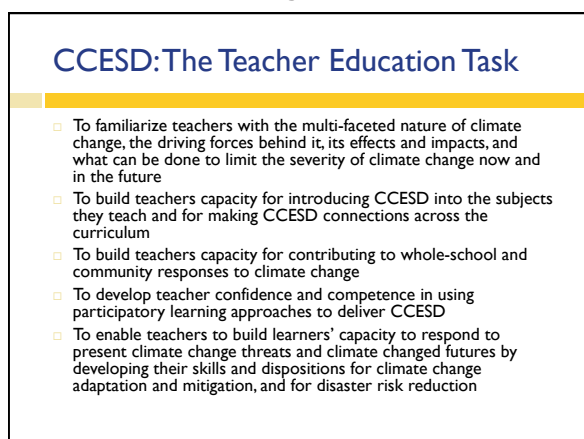
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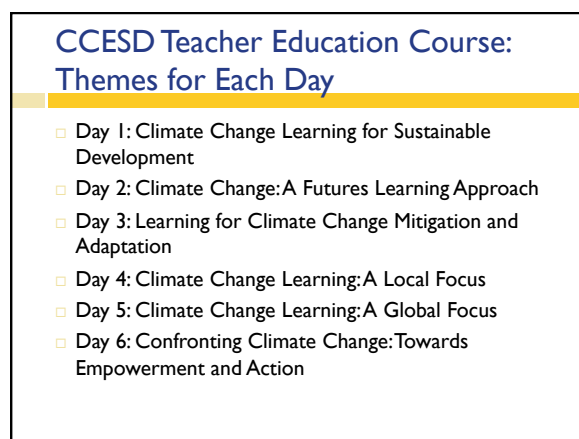
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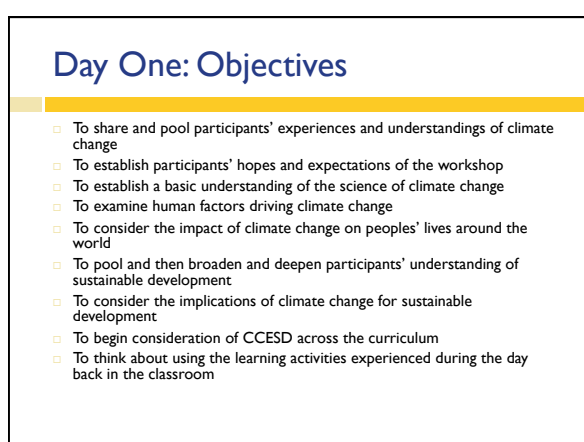
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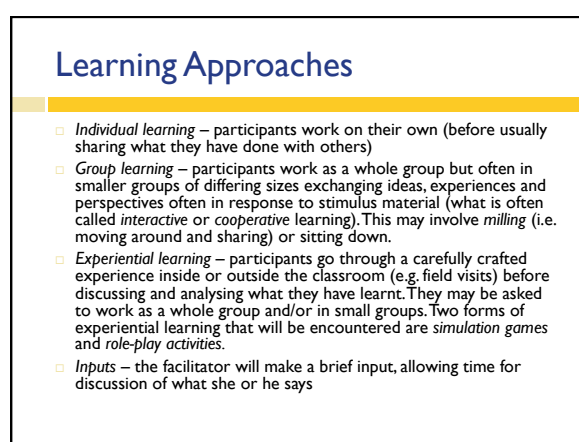
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6





7

## Why Participatory Learning?

- It allows for the fullest sharing of the ideas, experiences and perspectives that learners bring to the classroom while revealing what they don't know.
- It is informed by the core values of human rights, peace and democracy and gives everyone a voice.
- It gives practice in participation and so builds the skills and dispositions that empower young people to contribute to social change
- It provides for variety and diversity in learning programs, mixing activities for different sized groups, high energy and more slow-paced reflective activities, activities favouring all types of learner
- It offers 'whole-person learning' combining cognitive learning (e.g. problem solving, decision-making) with affective (emotional) learning, making the learning experience richer

8

## End-Of-The-Day Tasks

- Complete a *feedback sheet* on the day's activities
- Write a *Workshop Reflections* diary
- Read over the *Classroom Activities* related to the day's workshop activities

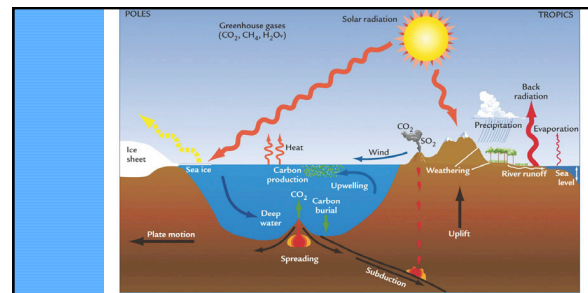
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## Climate Change Art Gallery

Climate Change Experiences	Climate Change Causes
Hopes and Expectations	Climate Change Effects

[↩ back to Facilitation Guide: Climate Change Art Gallery](#)

10



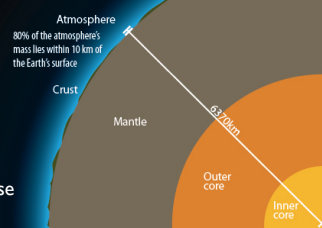
### Components of the Earth's Atmosphere

The movement of heat around the Earth is accomplished via the global climate system, which comprises the atmosphere, the oceans, the ice sheets, the biosphere (all living organisms) and soils, sediments and rocks. The climate system is made up of numerous subsystems with many processes occurring within and between each subsystem. These complex interactions result in intermittent and constantly changing phenomena (e.g. El Niño and the North Atlantic Oscillation).

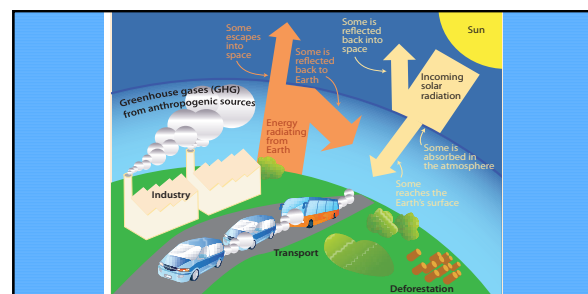
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## Composition of the Atmosphere

- Thin layer of gases; 80% of the mass is contained below 10km of altitude
- Predominantly made up of nitrogen (78%) and oxygen (21%)
- Remaining 1% is made up of water vapour, carbon monoxide, carbon dioxide, neon, methane, krypton and ozone, some of which are so-called greenhouse gases



12



### The Greenhouse Effect Illustrated

Sunlight (solar radiation) passes through the atmosphere and warms the Earth. Energy in the form of infrared radiation (IR) is given off by the Earth. Most IR escapes to outer space and cools the Earth. But some IR is trapped by greenhouse gases (GHG) emitted from industry, transport, deforestation and other sources, and this reduces the cooling effect.

13

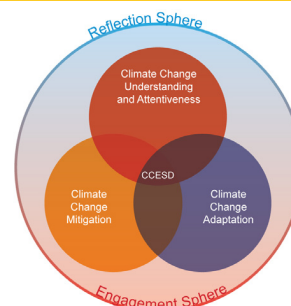
## The Greenhouse Effect

- Weather is the temperature, precipitation and wind as they change hour by hour and day by day
- Climate is the average weather and the nature of its rhythmical variations that we experience over time
- The greenhouse effect is the natural process of the atmosphere letting in some of the energy we receive from the Sun and trapping it. For several thousands of years the atmosphere has been delicately balanced
- Human activities have led to an increase in greenhouse gases in the atmosphere causing an increased greenhouse effect and extra warming
- The main greenhouse gas responsible for recent climate change is carbon dioxide (CO<sub>2</sub>). Others greenhouse gases produced from human activities include methane (CH<sub>4</sub>) and nitrous oxide (N<sub>2</sub>O).

[↪ back to Facilitation Guide: The Science of Climate Change](#)

14

## The Dynamics of Transformation



15

## Climate Change Education for Sustainable Development (CCESD) is about:

- Building understandings of climate change and the impacts it has and will have on prospects for sustainable development
- Creating alertness and attentiveness to the driving forces behind climate change and its environmental, economic, social and cultural impacts
- Developing the change skills and dispositions of learners so they can contribute to limiting the severity of climate change (*climate change mitigation*)
- Developing the change skills and dispositions of learners so they can play their part in adapting to the dangers of climate change and in reducing the risks to their community (*climate change adaptation and risk reduction*)


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## CCESD...

- Is an integrated approach to learning
- Has a place across the curriculum
- Requires a whole-school approach
- Calls for a school-in-community approach, bringing together formal and non-formal learning

[↪ back to Facilitation Guide: CCESD](#)

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### End of Day 1 – See you tomorrow

**Please don't forget to:**

- Fill out and submit your feedback form
- Read through classroom activities for the day and bring any questions to the next day workshop
- Write your reflective workshop diary entry for the day and bring the diary to Day 2

[↪ back to Facilitation Guide: Introduction](#)

# Get the Facts:

## THE SCIENCE OF CLIMATE CHANGE

Climate can be defined as ‘average weather’ and is described in terms of the mean and variability of relevant characteristics such as temperature, precipitation and wind over a period of time ranging from months to thousands or millions of years. Climate reflects how weather behaves over the long-term, and as such needs to be distinguished from weather which is a particular meteorological condition that we experience daily, characterized by precipitation, temperature, wind, and so on.

Meteorological conditions, like the annual average temperature at the Earth’s surface, change over time. Small changes in these conditions can result in ice ages, or warm periods. Over the past century an increase of the Earth’s average surface temperature of about  $+0.76^{\circ}\text{C}$  has been observed.

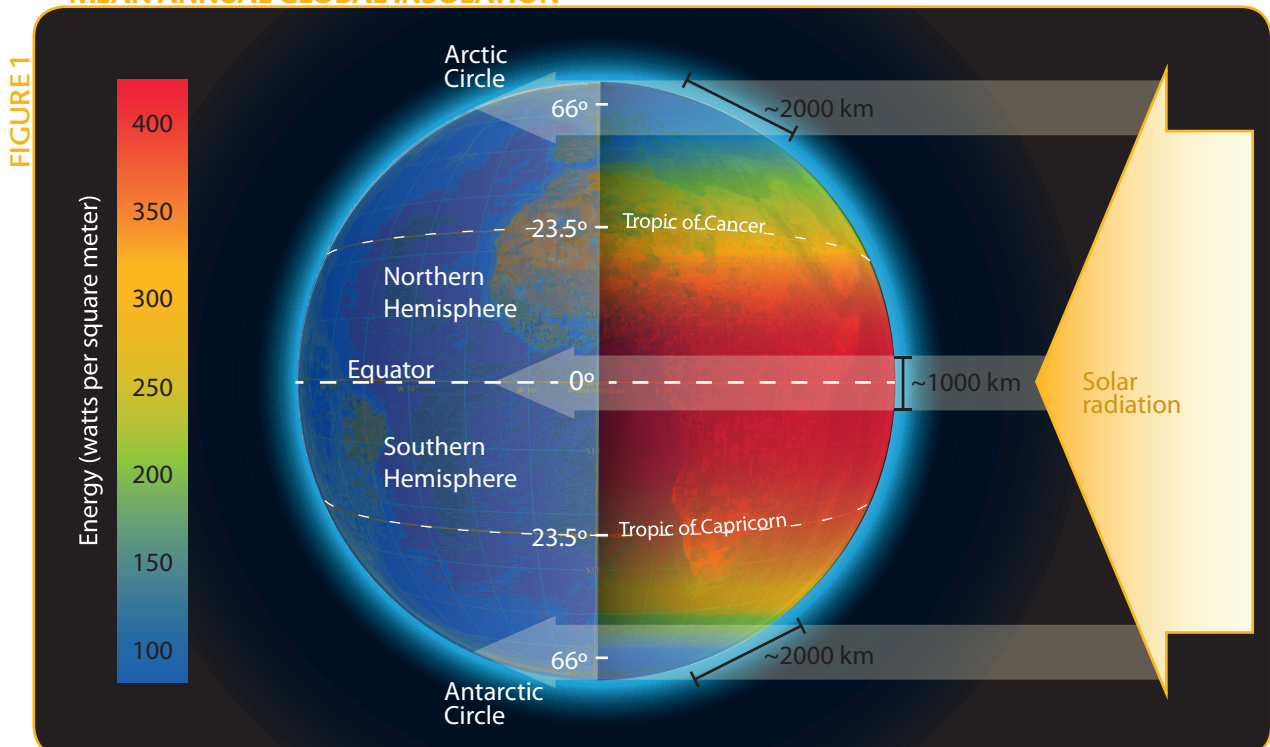
There are several natural factors that can influence the climate, such as changes in the Earth’s orbit around the sun, volcanic eruptions, or even periods of heightened or diminished solar activity. However, the current warming trend we are experiencing has been primarily linked to an increased concentration of heat-trapping greenhouse gases (GHGs) such as carbon dioxide ( $\text{CO}_2$ ), methane ( $\text{CH}_4$ ) and nitrous oxide ( $\text{N}_2\text{O}$ ) in the atmosphere.

The 2007 Intergovernmental Panel on Climate Change (IPCC) Assessment Report confirms that the warming of the global climate is unequivocal and that it is very likely due to human activities (also known as **anthropogenic** activities) and has been increasing since the dawn of the industrial age (circa 1750). These activities include, among others, the burning of fossil fuels (coal, oil and gas), clearing of forests, and agricultural practices that lead to increased GHG concentration in the atmosphere.

The impacts of global warming are already apparent today in melting glaciers, increased frequency of extreme weather events such as droughts, cyclones or heavy rainfalls, sea level rise, and changes in plant growth affecting agriculture and food production. These and other observed changes are expected to intensify and inflict a significant impact on human societies and the environment around the world especially if no drastic efforts are undertaken to reduce the emissions of GHGs into the atmosphere.

This chapter explains the components of the climate system, outlines the underlying factors of observed climate change, and concludes by presenting the climate change impacts that can be observed today.

MEAN ANNUAL GLOBAL INSOLATION



# Get the Facts:

## THE SCIENCE OF CLIMATE CHANGE

### 1.1 What is 'Climate'?

#### Weather vs. climate

In order to define 'climate' it is important to distinguish it from 'weather'. The weather that we experience on a day-to-day basis is a momentary atmospheric state characterized by temperature, precipitation, wind, and so on, and seems to vary in an irregular way, not following any particular pattern.

When one considers longer time scales, weather can be seen to vary in a recurrent way, be it on global, regional or local scale. This is what we refer to as climate. In contrast to the instantaneous conditions described by weather, climate is described with average values (e.g. annual average, or mean, temperature), but also typical variability (e.g. seasonal maximum/minimum temperatures) and frequency of extremes such as monsoons/hurricanes/cyclones. The timescale upon which climate statistics are calculated is typically thirty years (e.g. 1981–2010).

#### The function of Earth's climate system

An enormous amount of energy from the Sun in the form of solar radiation hits the Earth between the tropics of Capricorn and Cancer (see Figure 1). Without any way to move this energy

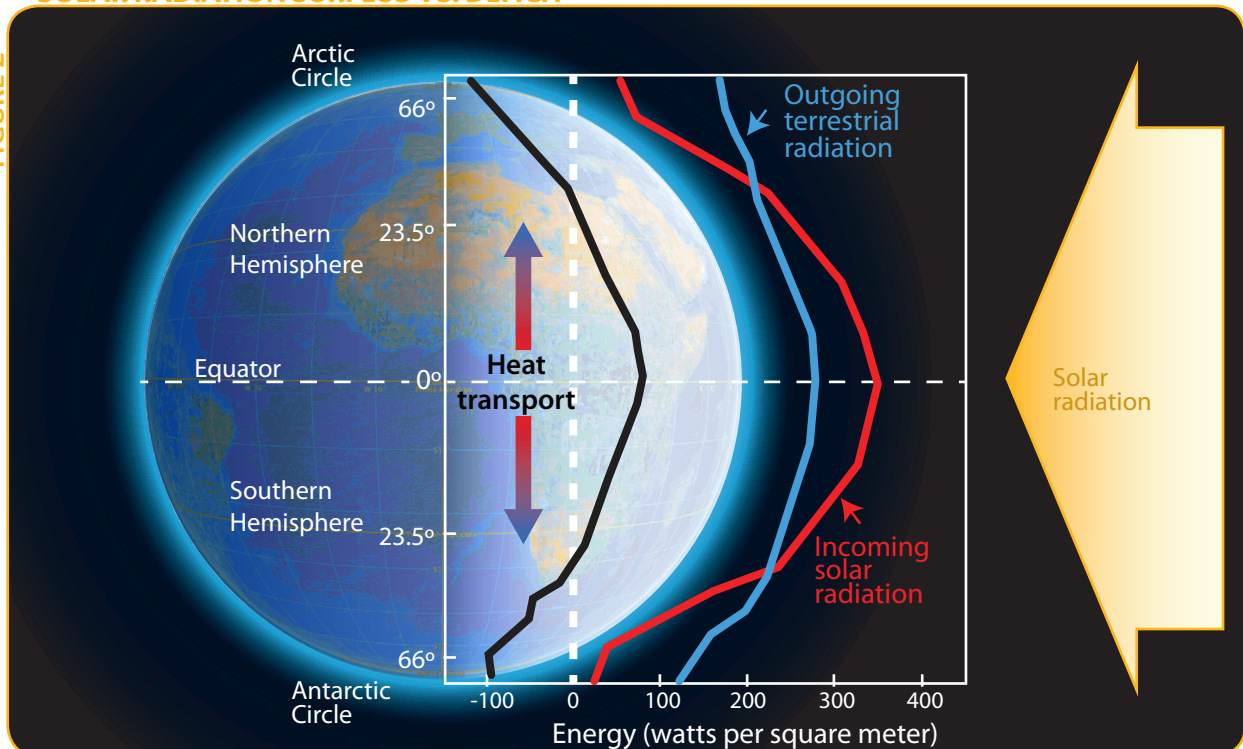
away, the equator would be incredibly hot and inhospitable to life. On the other hand, because the Earth is a sphere, at the north and south poles less solar radiation is being received and more radiation is being reflected or released back into space. Without any additional energy input, these regions would be far too cold to support any kind of life whatsoever. However, both these regions remain liveable to human, animal, and plant species.

It can thus be said that the equator region has a constant surplus of solar radiation (which makes it hot) and the poles have a constant deficit (making it cold). The Earth's climate system provides the means to balance out the surplus and deficit of energy and heat. It uses the air and vapour in the atmosphere and water of the oceans to transport the energy around the globe to somewhat balance out the regional energy imbalance within the system (see Figure 2).

Generally speaking, the climate remains stable over long periods of time if the various elements within the system remain stable. However, if one or more of the components of the system is altered, the stability of the whole system is compromised and can lead to uncharacteristic behaviour and give rise to weather which is outside the usual range of expectations. This situation can be described as climate change.

#### SOLAR RADIATION SURPLUS VS. DEFICIT

FIGURE 2





The United Nations Framework Convention on Climate Change (UNFCCC) defines climate change as “a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural variability observed over comparable time periods.”

### Additional Resources

1. 'The Climate System: An Overview', A.P.M Baede, E. Ahlonsou, Y. Ding and D. Schimel, Chapter 1 of the Working Group 1 Report of the IPCC Third Assessment Report (TAR) Climate Change 2001: The Scientific Basis. Cambridge University Press, 2001. [http://www.grida.no/climate/ipcc\\_tar/wg1/pdf/TAR-01.pdf](http://www.grida.no/climate/ipcc_tar/wg1/pdf/TAR-01.pdf)
2. Intergovernmental Panel on Climate Change. <http://www.ipcc.ch/>
3. WMO home page for basic climate information for young people. [http://www.wmo.int/youth/climate\\_en.html](http://www.wmo.int/youth/climate_en.html)
4. WMO page on climate. [http://www.wmo.int/pages/themes/climate/index\\_en.php#](http://www.wmo.int/pages/themes/climate/index_en.php#)

## 1.2 What causes Climate Change?

### How the climate works and how we know it is changing

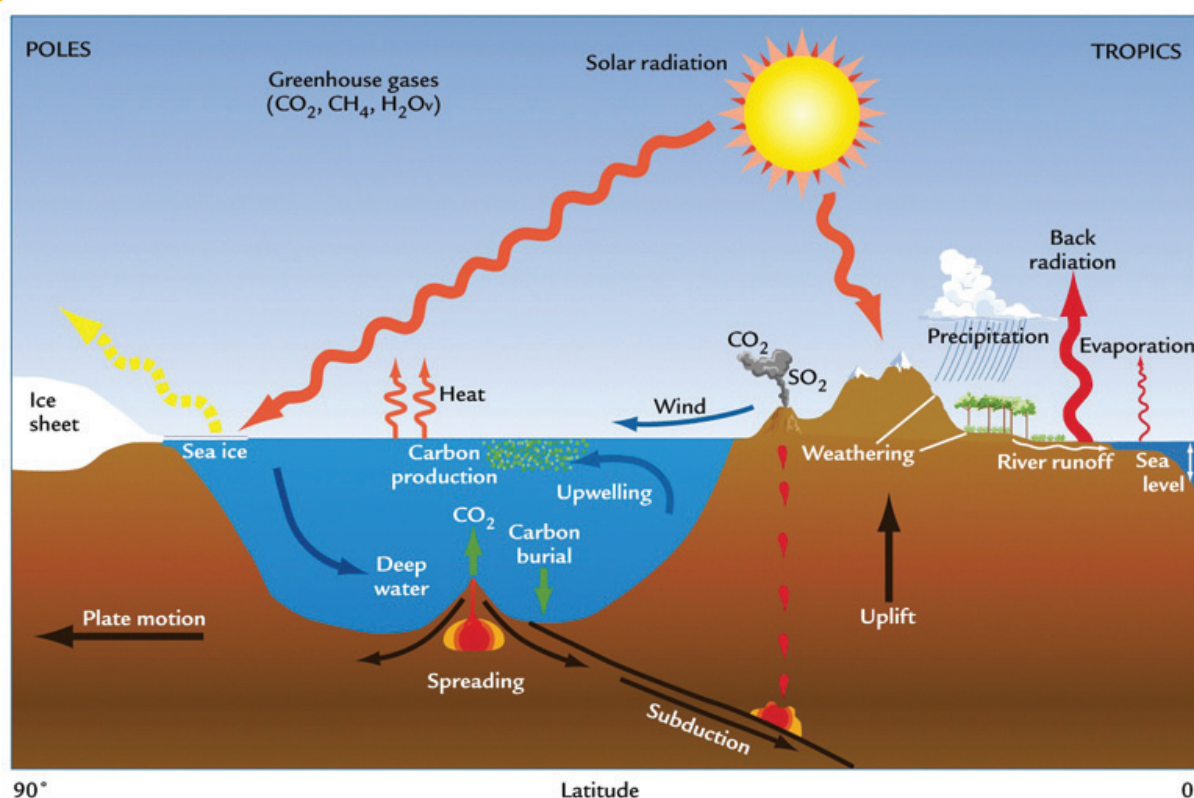
In recent centuries, there has been much debate over the influences and triggers of the Earth's radical climatic shifts from ice age to humid period and back again. Modern scientists have long suspected that human activity is capable of affecting the climate, and until recently, a comprehensive understanding of the complex processes that affect both the Earth's energy balance and the energy flows within the global climate system remained elusive.

Fortunately, the last few decades have seen significant strides in Earth system science as scientists have made advances in quantifying the energy and material fluxes that determine the dynamics of these systems. This has enabled them to obtain a clearer understanding of how the climate functions, as well as a clearer picture of the factors that influence changes in the global climate system (see Figure 3).

The Earth's climate is affected by a myriad of drivers that operate over different time scales

### THE EARTH'S CLIMATE SYSTEM COMPONENTS

FIGURE 3



Clark College, 2003.

# Get the Facts:

## THE SCIENCE OF CLIMATE CHANGE

and result in different changes over various geographical scales and geological eras. The movement of heat around the Earth is accomplished via the global climate system, which comprises the atmosphere, the oceans, the ice sheets, the biosphere (all living organisms) and soils, sediments and rocks. The climate system is made up of numerous subsystems with many processes occurring within and between each subsystem. These complex interactions result in intermittent and constantly changing phenomena (e.g. El Niño and the North Atlantic Oscillation (see text box below).

The state of the Earth's climate is determined by the amount of energy stored by the climate system, and especially the balance between energy received from the Sun and the portion of this energy which the Earth releases back to space. This global energy balance is regulated in large part by the flows of energy within the global climate system.

There are four main known influences of larger long-term changes in the Earth's climate. These are: (i) changes in the Earth's orbit

around the Sun, (ii) variations in the output of energy from the Sun, (iii) changes in ocean circulation resulting mainly from fluctuations in the upwelling of deep cold waters in the tropical Pacific Ocean, and (iv) changes in the composition of the atmosphere. Though the first three influences are beyond the control of humankind, the composition of the atmosphere has been altered by human activities for over 200 years.

### Composition of the atmosphere

The atmosphere is a comparatively thin layer of gases which fades rapidly away with altitude and does not have a definite top<sup>1</sup>. About 80% of the mass of the atmosphere is contained below 10 km of altitude (see Figure 4). Compared with the Earth's radius (6370 km) the atmosphere is just one sixth of one percent. Yet it is an extremely important multifunctional layer composed of numerous gases in varying proportions in different regions, and which serve different functions. It is predominantly made up of nitrogen (78%) and oxygen (21%). Besides water vapour, several other gases are also present in much smaller amounts (Carbon monoxide (formula CO), Carbon dioxide (CO<sub>2</sub>), Neon (Ne), Oxides of nitrogen, Methane (CH<sub>4</sub>), Krypton (Kr), and Ozone (O<sub>3</sub>)).

This mix of gases facilitates the multifunctional nature of the atmosphere, on the one hand allowing a portion of the solar radiation directed at the Earth to reach the surface, and on the other, inhibiting the escape of longwave radiation (in the form of heat) back out into space. This

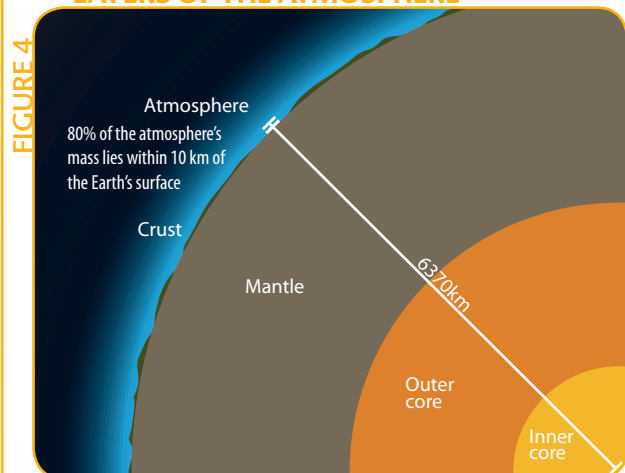
### El Niño / La Niña (ENSO) and the North Atlantic Oscillation

El Niño/La Niña-Southern Oscillation, or **ENSO**, is a climate pattern that occurs across the tropical Pacific Ocean roughly every five years. It is characterized by variations in the temperature of the surface of the tropical eastern Pacific Ocean—warming or cooling known as El Niño and La Niña respectively—and air surface pressure in the tropical western Pacific—the Southern Oscillation. Mechanisms that cause the oscillation remain under study.

ENSO causes extreme weather (such as floods and droughts) in many regions of the world. The frequency and intensity of ENSO are potentially subject to dramatic changes as a result of global warming, and is a target for research in this regard.

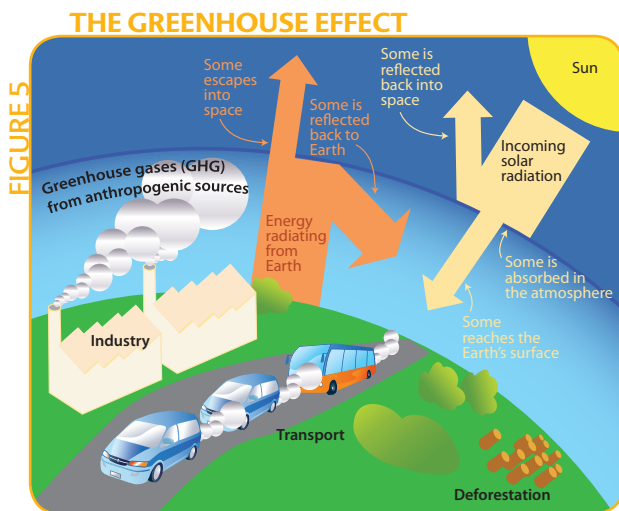
**North Atlantic Oscillation:** A permanent low-pressure system over Iceland (the Icelandic Low) and a permanent high-pressure system over the Azores (the Azores High) control the direction and strength of westerly winds into Europe. The relative strengths and positions of these systems vary from year to year and this variation is known as the North Atlantic Oscillation.

### LAYERS OF THE ATMOSPHERE



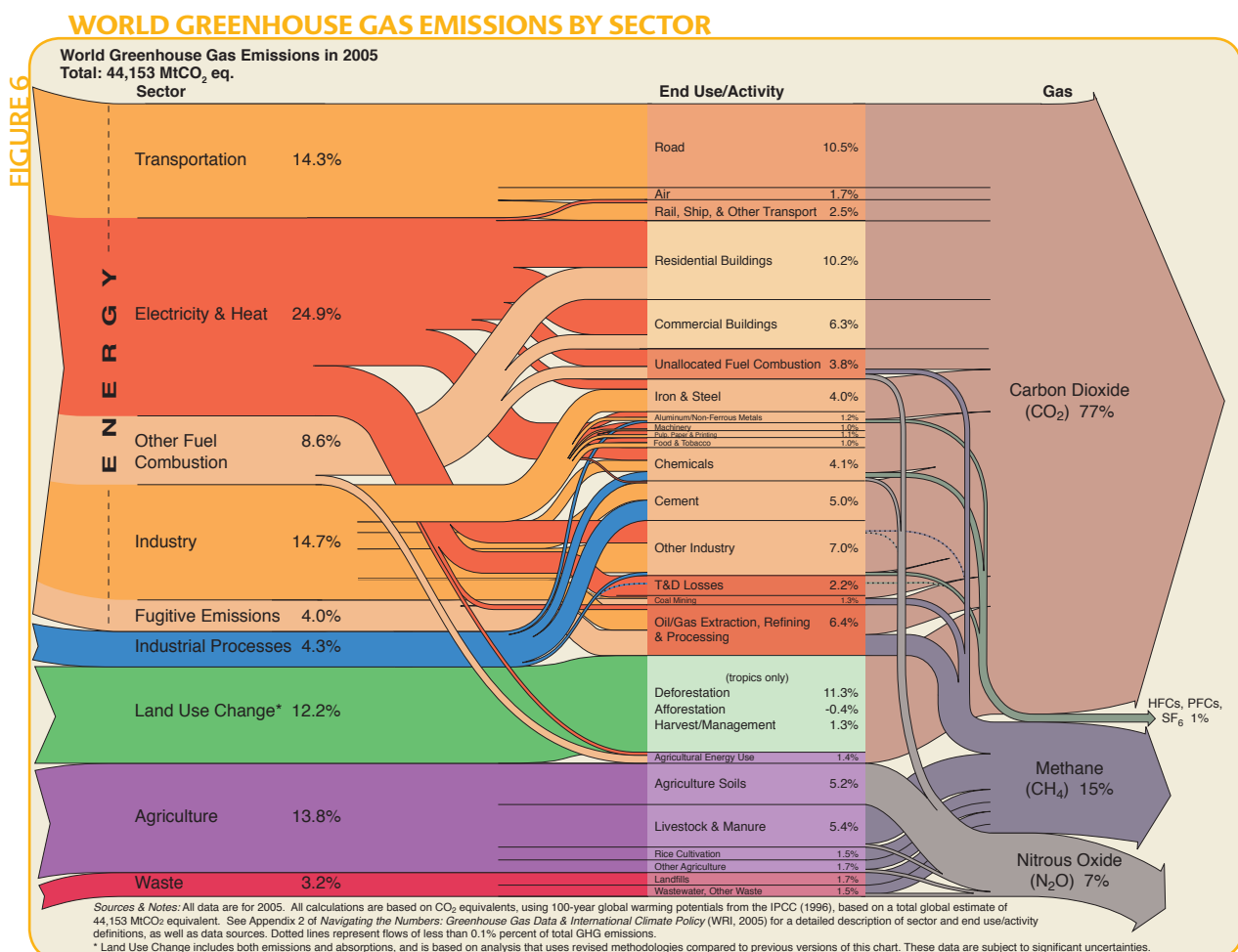
<sup>1</sup> If one considers the size of a standard classroom globe, the atmosphere would be approximately as thick as a coat of paint on its surface.

heat trapping function is what is known as the 'greenhouse effect' and is what keeps the Earth's surface in a suitable temperature range to sustain life as we know it (see Figure 5). After water vapour, the most important 'greenhouse gases' (GHG) are carbon dioxide, methane, and ozone.



These GHGs remain active in the atmosphere over long periods of time (see Table 1). Over shorter periods, gases and particles emitted in large volcanic eruptions, such as Mt. Pinatubo in 1991, can also affect the global climate (see 'The Effects...' text box). In contrast, the relative position and movement of continents, among other factors, also affects global climate but over millions of years.

Many GHG-emitting activities are now essential to the global economy and form a fundamental part of modern life. Carbon dioxide from the burning of fossil fuels is the largest single source of GHG emissions from human activities. The supply and use of fossil fuels accounts for about 80 percent of mankind's carbon dioxide (CO<sub>2</sub>) emissions, one fifth of the methane (CH<sub>4</sub>), and a significant quantity of nitrous oxide (N<sub>2</sub>O). In summary, the main contributing sectors to anthropogenic GHG emissions are electricity and heat (24.9%), industry (14.7%), transportation (14.3%) and agriculture (13.8%) (see Figure 6).



World Resources Institute, 2005.



# Get the Facts:

## THE SCIENCE OF CLIMATE CHANGE

### Measuring temperature changes

Since the late nineteenth century, various land and sea instruments have been used to measure, in a fairly accurate manner, the air temperature near the surface of the Earth. Over the last forty years, the addition of satellite instruments has provided extremely accurate temperature readings. Given that such direct measurements and records of temperature and other climate variables exist for only a fraction of the Earth's history, longer perspectives on the evolution of climate must be studied through climate-dependent natural phenomena, the clues of which can be found in tree rings, ice cores and sea floor sediments (see Figure 7).

During the twentieth century, the accelerated rate of discoveries and controversies surrounding Earth System complexities provoked increasing interest among scientists, particularly regarding a significant trend in global warming. Scientists began investigating the extent to which human activity could have provoked this and other large changes in the Earth's system. For the last twenty-five years, tens of thousands of researchers and leading scientists have lent their expertise toward the intensive investigation and scientific analysis of these phenomena — facilitated and inspired by the Intergovernmental Panel on Climate Change — in an attempt to determine the sources of GHG, monitor ongoing changes to the global climate, and understand their potential environmental and socio-economic impacts.

Over the past century, the Earth's surface and the lowest part of the atmosphere have witnessed a warming of about  $+0.76^{\circ}\text{C}$ . In fact, since records began in the early 1860s — the height of the industrial revolution — globally averaged surface temperatures have been continuously rising. In the past two decades, the pace at which average global temperatures have risen has accelerated to an equivalent rate of  $1.0^{\circ}\text{C}$  per century. Nine of the warmest years on record have occurred in the last decade (see Figure 8, next page). During this period of recorded global warming, the concentration of greenhouse gases in the atmosphere has also increased. This increase is directly associated with human activities, namely the burning of fossil fuels for energy and transportation, as well as deforestation and other land-use changes. In the last twenty years, concern has grown that these two phenomena are, at least in part, highly correlated. The warming of the Earth's surface that has taken

place since the 1970s is now considered explicable only as the result of humanity's greenhouse gas emissions.

### Current scientific consensus

In 2003, the American Geophysical Union concluded that 'It is scientifically inconceivable that — after changing forest into cities, putting dust and soot into the atmosphere, putting millions of acres of desert into irrigated agriculture, and putting greenhouse gases into the atmosphere — humans have not altered the natural course of the climate system.'<sup>2</sup> While the subject of climate change remains a very complex and highly debated matter (both publicly and politically), global warming is an undeniable fact. Moreover, the balance of evidence now firmly indicates that there is a discernible

2 American Geophysical Union, *Eos* 84(51), 574 (2003).

### The Effects of Volcanic Eruptions

In 1990, Mt. Pinatubo injected 20 million tons of sulfur dioxide into the stratosphere, which was observed around the globe in the equatorial region. The result of this was that average hemispheric temperatures dropped by  $0.2\text{--}0.5^{\circ}\text{C}$  for a period of 1-3 years.



### ICE CORE SAMPLES

FIGURE 7





human influence on the global climate; put simply, humans have contributed to observed global warming.<sup>3</sup> The current consensus of the scientific community is that the following fundamental conclusions provide only a glimpse of the changes that future generations will have to accept and face:

- The planet is warming due to increased concentrations of heat-trapping gases in our atmosphere.
- Most of the increase in the concentration of these gases over the last century is due to human activities, especially the burning of fossil fuels and deforestation.
- Natural causes always play a role in changing Earth's climate, but are now being overwhelmed by human-induced changes.
- Warming the planet will cause many other climatic patterns to change at speeds

3 R.K. Pachauri and A. Reisinger (eds) Climate Change 2007: Synthesis Report, IPCC, p. 104.

### RELATIVE CONTRIBUTIONS OF MAJOR GHGS TO THE GREENHOUSE EFFECT AND ATMOSPHERIC LIFETIMES

TABLE 1

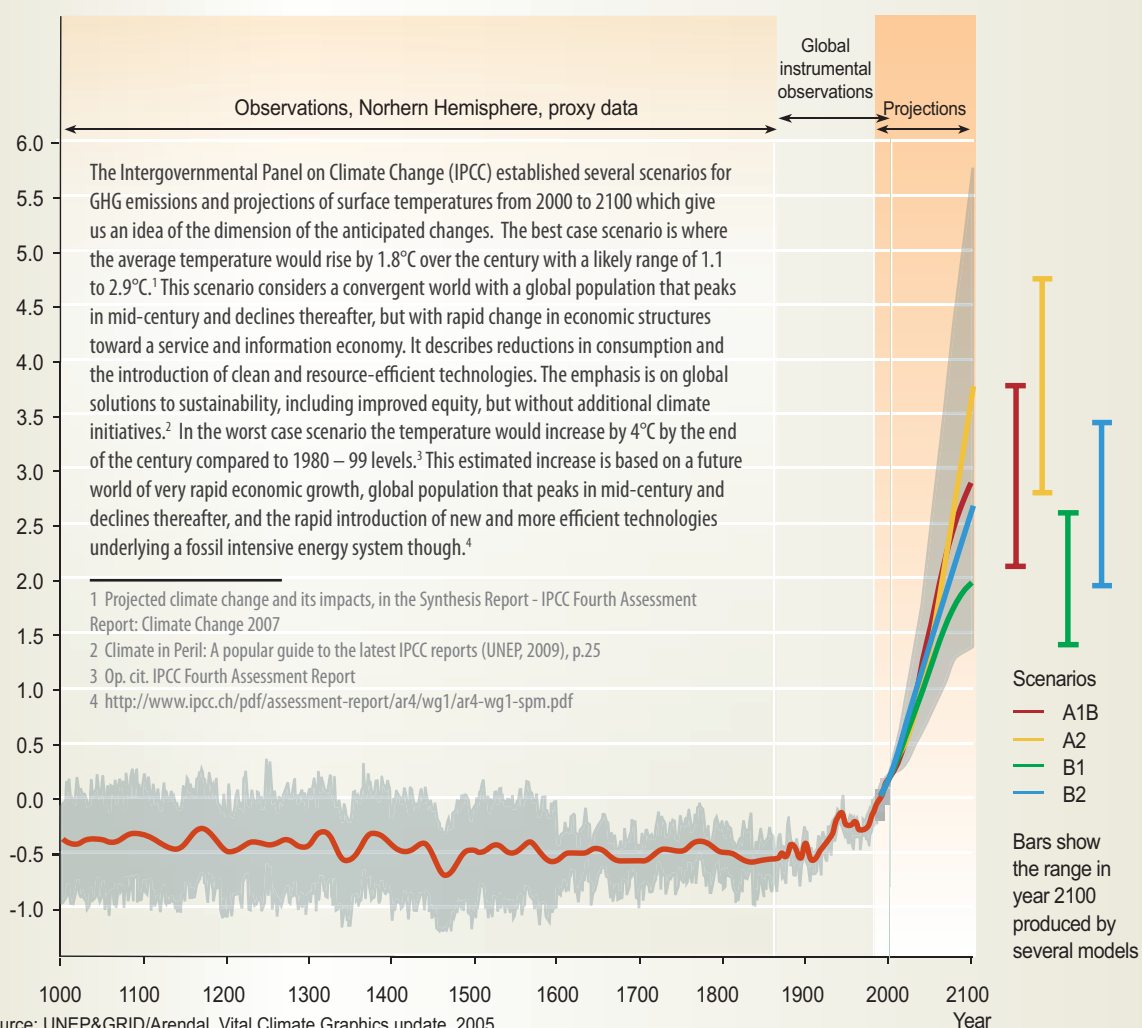
GHG	Contribution (%)	Mean lifetime
Water vapour	36% to 66%	9 days
Carbon dioxide	9% to 26%	Tens of thousands of years
Methane	4% to 9%	12 years
Ozone	3% to 7%	9–11 days

Note: 'The determination of CO<sub>2</sub>'s atmospheric lifetime is often grossly underestimated because it incorrectly ignores the balancing fluxes of CO<sub>2</sub> from the atmosphere to other reservoirs – as it is removed by mixing into the ocean, photosynthesis, or other processes. It is the net concentration changes of the various GHG by all sources and sinks that determines atmospheric lifetime and not simply the removal processes.' From: D. Archer, 'Fate of fossil fuel CO<sub>2</sub> in geologic time', Journal of Geophysical Research 110(C9): C09S05.1–5.6, 2005.

### VARIATIONS IN THE EARTH'S AVERAGE SURFACE TEMPERATURE YEAR 1000 TO 2100

FIGURE 8

Deviation in °Celsius (in relation to 1990 value)



Zoi Environment Network and GRID-Arendal 2009

# Get the Facts:

## THE SCIENCE OF CLIMATE CHANGE

unprecedented in modern times, including increasing rates of sea level rise and alterations in the hydrologic cycle. Rising concentrations of carbon dioxide are also making the oceans more acidic.

- Climate change impacts are already being observed, including more frequent and extreme weather patterns, changes in plant growth affecting agriculture and food production, loss of plant and animal species unable to adapt or migrate to changing conditions, changes in the spread of infectious diseases in terms of the rate and the expansion of ranges, changes in the flow of ocean currents, and changes in seasons.
- The combination of these complex climate changes threatens coastal communities and cities, our food and water supplies, marine and freshwater ecosystems, forests, high mountain environments, and far more.<sup>4</sup>

### Additional Resources

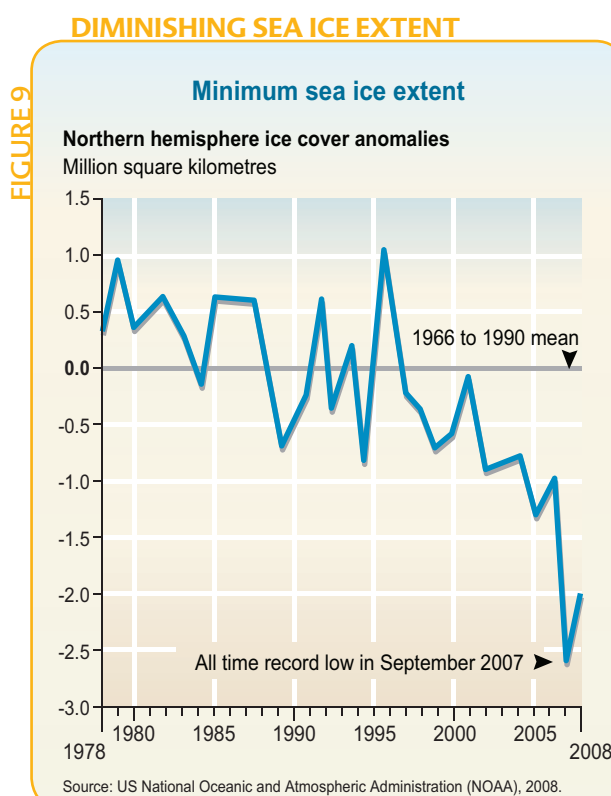
1. Climate Change 2007: Mitigation. Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC). Cambridge University Press, 2007.
2. Climate Change Science Compendium 2009, C. McMullen and J. Jabbour (eds) United Nations Environment Programme, EarthPrint, 2009. <http://www.unep.org/compendium2009/>
3. Understanding Climate Change: A Beginner's Guide to the UN Framework Convention and its Kyoto Protocol. UNEP, 1999. <http://www.unep.org/dec/docs/info/ccguide/beginner-99.htm>

### 1.3 What has changed so far?

Observations show that warming of the climate is unequivocal. The global warming of the past fifty years is due primarily to human-induced increases of greenhouse gas (GHG) emissions. These emissions come mainly from the burning of fossil fuels (coal, oil and gas), with additional contributions from the clearing of forests, agricultural practices, and other activities. The effects of human activities have also been identified in many other aspects of the climate system, including changes in ocean heat content,

precipitation, atmospheric moisture and Arctic sea ice.

This conclusion rests on multiple sources of evidence. First, the examination of records of climate changes over the last 1,000 to 2,000 years show that global surface temperatures over the last several decades were higher than at any time during at least the past 400 years (1,000 years for the Northern Hemisphere). A second source of evidence is our increased understanding of how GHGs trap heat, how the climate system responds to increases in GHGs, and how other human and natural factors influence climate. As result of this knowledge, there is a broad qualitative consistency between observed changes in climate and the computer model simulations of how climate would be expected to change in response to human activities. Finally, there is extensive statistical evidence. The community of scientists reporting to the IPCC in 2007 identified 765 significant observed changes in the physical system (snow, ice and frozen ground, hydrology and coastal processes) of which 94 per cent were consistent with climate change. Similarly, observations of biological systems (terrestrial, marine and fresh water) produced 28,671 significant observed changes with a 90 per cent agreement with expected impacts of climate change.



<sup>4</sup> 'Climate Change and the Integrity of Science', J. Sills, Science 328: 691–92, 2010.

## Increasing warming

As already mentioned, the global average surface temperature has risen by about 0.76°C since the year 1900, with much of this increase occurring since 1970. The estimated change in the Earth's average surface temperature is based on measurements from thousands of weather stations, ships and buoys around the world, as well as from satellites. These measurements are independently compiled, analysed and processed by different research groups. The warming trend that is apparent in all of these temperature records is confirmed by other independent observations, such as the melting of Arctic sea ice (see Figure 9, next page), the retreat of mountain glaciers on every continent, reductions in the extent of snow cover, increased melting of the Greenland and Antarctic ice sheets, and earlier blooming of plants in spring.

The temperature increase is spread across the globe and is greater at higher northern latitudes. Average Arctic temperatures have increased at almost twice the global average rate in the past 100 years. Land regions have warmed faster than the oceans. Observations show that the average temperature of the global ocean has increased to depths of at least 3,000 metres and that the

ocean has been taking up over 80 per cent of the heat being added to the climate system. Satellite measurements of air temperatures at high elevations show warming rates similar to those observed in surface temperature.

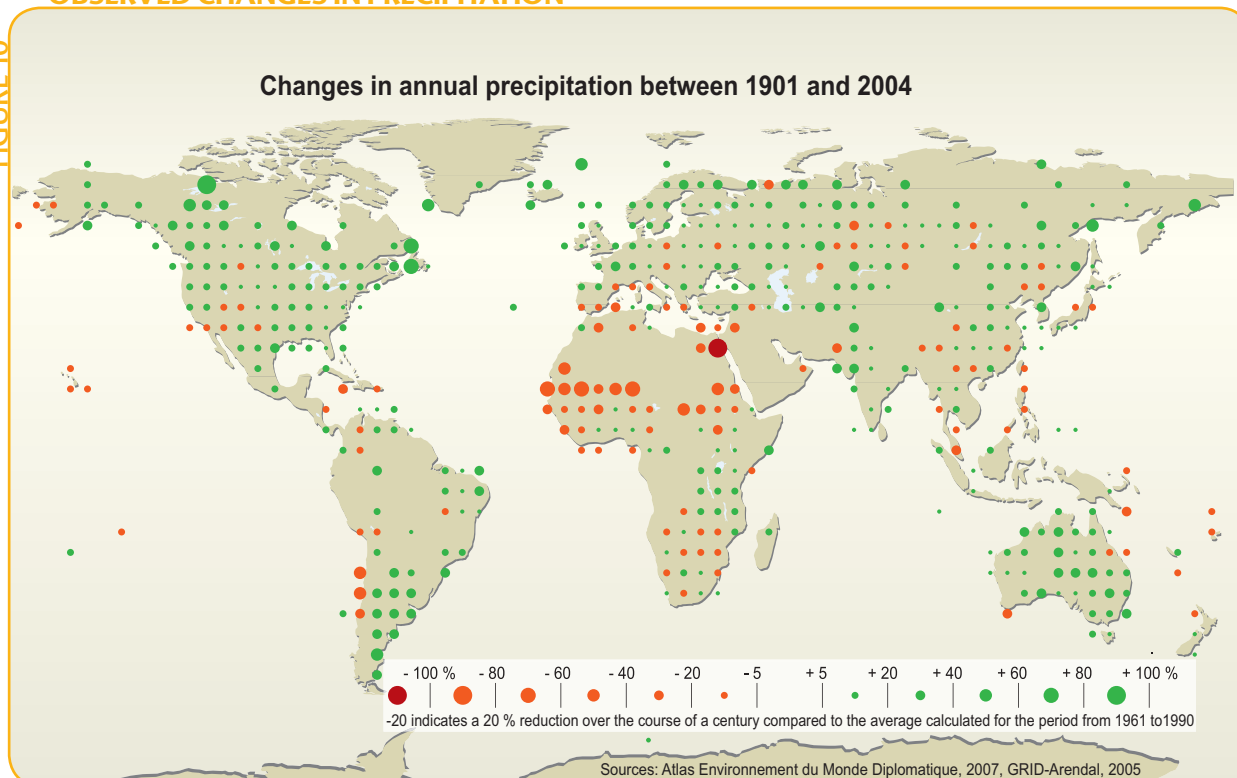
## Changing precipitation patterns

Globally, precipitation shows a minor upward trend with most of the increase taking place during the rainy season. On a regional basis, increases in annual precipitation have occurred in the higher latitudes of the Northern Hemisphere and southern South America and northern Australia. Decreases have occurred in the tropical region of Africa, and southern Asia. The measured changes in precipitation are consistent with observed changes in river flows, lake levels and soil moisture (where data are available and have been analysed) (see Figure 10).

Scientists have also noted changes in the amount, intensity, frequency and type of precipitation. Pronounced increases in precipitation over the past 100 years have been observed in eastern North America, southern South America, Asia and northern Europe. Decreases have been seen in the Mediterranean, most of Africa and southern Asia. The amount

### OBSERVED CHANGES IN PRECIPITATION

FIGURE 10



Zoi Environment Network and GRID-Arendal 2009



# Get the Facts:

## THE SCIENCE OF CLIMATE CHANGE

of rain falling in the heaviest downpours has increased approximately 20 per cent on average in the past century, and this trend is very likely to continue, with the largest increases in the wettest places. Evidence of increasing cyclone and hurricane strength has been documented and linked to rising sea surface temperatures and warming air (see Figure 11).

Changes in the geographical distribution of droughts and flooding have been complex. In some regions, there have been increases in the occurrence of both droughts and floods. As the world warms, northern regions and mountainous areas are experiencing more precipitation falling as rain rather than snow. Widespread increases in heavy precipitation events have occurred, even in places where total rain amounts have decreased.

### Widespread water concerns

Climate change has already altered the water cycle, affecting where, when and how much water is available for all uses. Further, it will likely

be the case that there will be too little water in some places, too much water in other places, and degraded water quality — and some locations are expected to be subject to all of these conditions during different times of the year. Water cycle changes are expected to continue and to adversely affect hydroelectricity production, drinking water availability, human health, transportation, agriculture and ecosystems.<sup>5</sup>

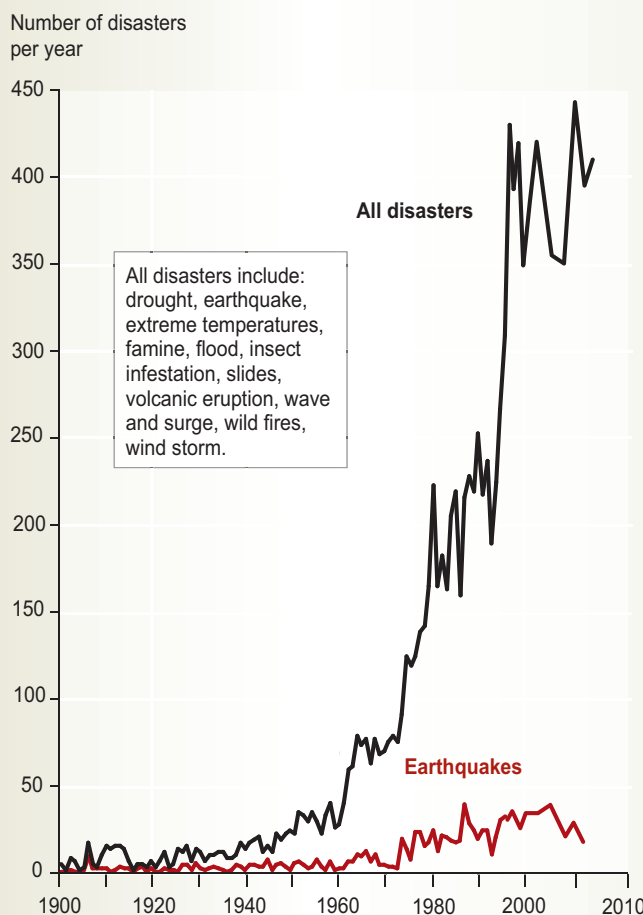
### Vulnerable ecosystems

Climate change is affecting many ecosystems around the world. Perhaps the most publicized of all the impacts of global warming are Arctic ecosystems that rely on sea ice, which is vanishing rapidly and is projected to disappear entirely in summertime within the twenty-first century. Algae that bloom on the underside of the sea ice form the base of a food web linking

<sup>5</sup> These changes are associated with the fact that warmer air holds more water vapour evaporating from the world's oceans and land surface. This increase in atmospheric water vapour has been observed from satellite measurements.

### INCREASED NUMBER OF WEATHER-RELATED DISASTERS

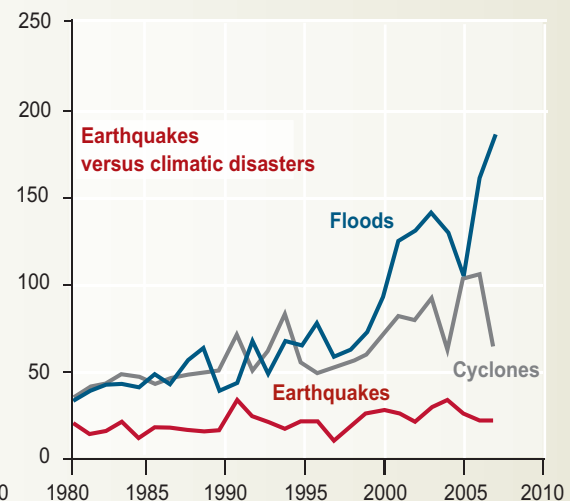
FIGURE 11



Source: CRED Annual Disaster Statistical Review 2006, 2007.

### Trends in number of reported disasters

Much of the increase in the number of hazardous events reported is probably due to significant improvements in information access and also to population growth, but the number of floods and cyclones reported is still rising compared to earthquakes.



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microscopic animals and fish to seals, whales, polar bears and people. As the sea ice disappears, so too do these algae. The ice also provides a vital platform for ice-dependent seals (such as the ringed seal) to give birth, nurse their pups and rest. Polar bears use the ice as a platform from which to hunt their prey. The walrus rests on the ice near the continental shelf between its dives to eat clams and other shellfish. As the ice edge retreats away from the shelves to deeper areas, there will be no clams nearby.

Observed and documented impacts of climate change include sea level rise that threatens coastal habitats and human settlements; increased sea surface temperature with more frequent ocean heat waves that cause coral bleaching and death (see Figure 12); ocean acidification (due to increased absorption of carbon dioxide (CO<sub>2</sub>) by sea surface waters) hampering shell formation and coral reefs (see Figure 13); melting of glaciers and snow caps, including rapid retreat of tropical glaciers and loss of natural water regulation function (see Figure 14); higher frequency of forest fires; spread of disease and pests to areas naturally protected by climate conditions; changes in plant productivity and potential mismatch of interlinked symbiotic life cycles and many more.

### Forests: Climate change beneficiaries?

The climate has a strong influence on the processes that control growth and development in ecosystems. Increases in temperature generally speed up plant growth, rates of decomposition, and the speed at which the cycling of nutrients occurs, although other factors, such as whether sufficient water is available, also influence these rates. Forest growth has risen over the past several decades as a consequence of a number of factors: young forests reaching maturity, temperature

increases, an increased concentration of CO<sub>2</sub> in the atmosphere, a longer growing season, and increased deposition of nitrogen from the atmosphere. Separating the effects of each factor remains a challenge.

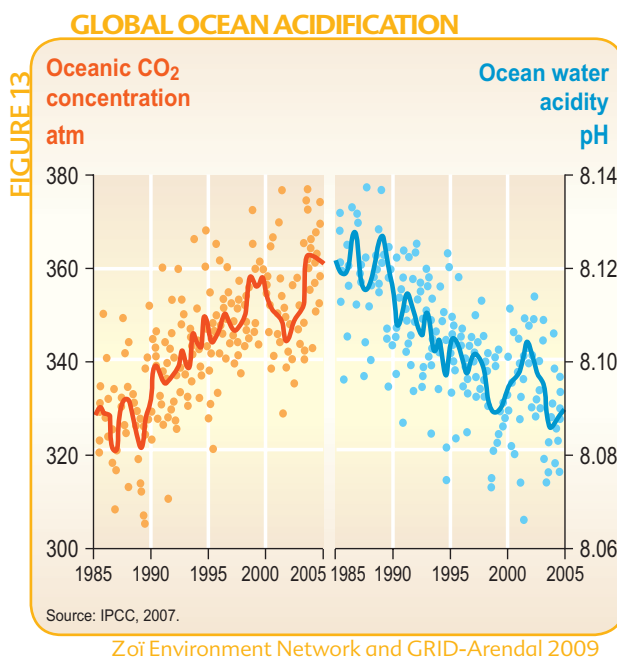
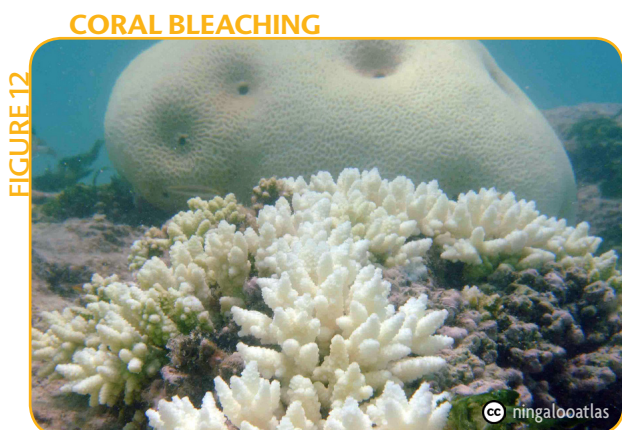
A higher concentration of atmospheric CO<sub>2</sub> causes trees and other plants to capture more carbon from the atmosphere, but experiments show that trees convert much of this extra carbon into producing fine roots and twigs rather than new wood. The effect of CO<sub>2</sub> in increasing growth thus seems to be relatively modest, and is generally seen most strongly in young forests on fertile soils where there is also sufficient water to sustain this growth. Wherever droughts increase, forest productivity will decrease and tree death will increase.

### Additional observed impacts

Other changes that are consistent with the warming observed over the past several decades and which are not mentioned above include:

- Reductions in lake and river ice
- Changes in soil moisture and runoff
- Changes in the extent of permafrost
- Changes in food chains in marine ecosystems
- Massive extinction of species
- Early flowering
- Increase weather variability.

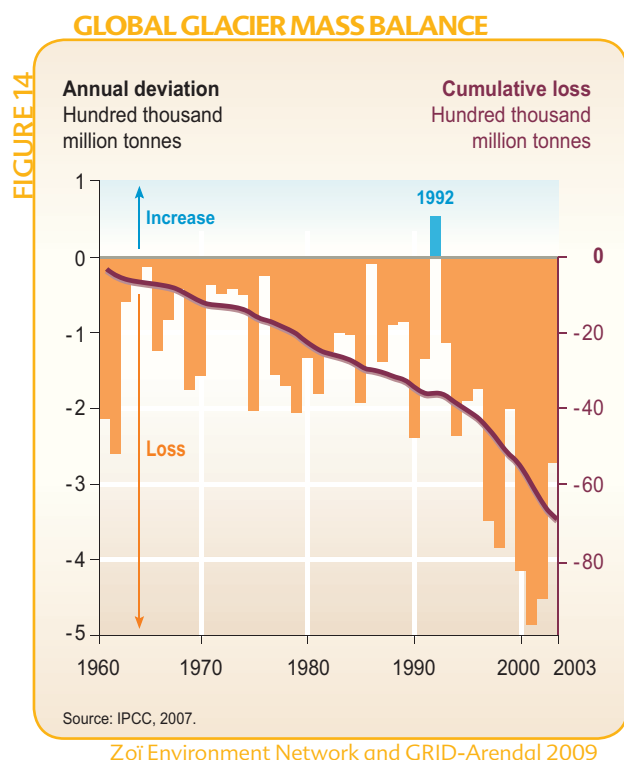
Though many uncertainties remain and surprises are expected, it is evident that each of the impacts listed above are not occurring in isolation. Each one has consequences that can





# Get the Facts:

## THE SCIENCE OF CLIMATE CHANGE



### Additional Resources

1. National governments have reported local observations of climate change, as well as their vulnerabilities to the effects of global warming, to the United Nation Framework Convention on Climate Change (UNFCCC). [http://unfccc.int/national\\_reports/items/1408.php](http://unfccc.int/national_reports/items/1408.php)
2. Contribution of Working Groups I, II and III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Core Writing Team, Pachauri, R.K. and Reisinger, A. (Eds.) IPCC, Geneva, Switzerland. [http://www.ipcc.ch/publications\\_and\\_data/publications\\_ipcc\\_fourth\\_assessment\\_report\\_synthesis\\_report.htm](http://www.ipcc.ch/publications_and_data/publications_ipcc_fourth_assessment_report_synthesis_report.htm)
3. Climate in Peril: A Popular Guide to the Latest IPCC Reports. UNEP/GRID Arendal, 2009. <http://www.grida.no/publications/climate-in-peril/>

and likely will induce a chain of impacts, small or large, between the interlinked ecosystems in every region and on every continent. Similar to tracking disruptions upward in the food chain, these consequences will filter their way up through the flora, fauna and diverse species to ultimately exert their combined impact on human society. The question remains as to how humankind will react to the climate change threat and what preparations will be made to meet the challenges posed by an uncertain and unpredictable future climate.

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