fundisa for change

Teaching **Climate Change**

Geography Grades 10–12

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environment * society * science * sustainability

This is a teacher education text. Its purpose is to expand educators' knowledge of environmental topics to support the teaching thereof in the curriculum. Teachers and teacher educators should consult CAPS documents and textbooks for specific curriculum content, as these units are not a textbook, but rather a resource for teacher education.

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Contents

Orientation

Introduction

What is climate change?

Global warming refers to a rise in the Earth's temperature, and is just one aspect of climate change.

Climate change refers to significant and lasting changes in long-term weather patterns in a specific region or across the whole Earth. It describes changes in overall weather patterns, including precipitation, temperatures, cloud cover, and so on. It can cause an increase or a decrease in the number of extreme weather conditions in an area, or result in a shift in an area's traditional weather patterns.

These changes are caused by both human activities and natural phenomena, which alter the chemical composition of the atmosphere through the build-up of greenhouse gases.

Why is climate change important?

Climate change has become an important topic all over the world – especially as we begin to feel the physical effects of these changes on our daily lives. Most people accept that climate change is happening, and that we need to deal with it in some way. Some of the effects of climate change may include more extreme weather events, increased floods and droughts, reduced agricultural yields, melting polar ice caps and extinction of plant and animal species. These changes may have further significant impacts on both the natural world and our human societies. Learners will need the geographical knowledge and skills that are fundamental to understanding climate processes AND climate change in order to respond effectively to these changes.

Climate change and its impacts are very broad, complex and highly debated. Although there is a large amount of scientific data available about climate change, there are also many beliefs, assumptions, and emotional reactions affecting the way that people think and speak about the changes that are happening. This means that learning about climate change is about MORE than learning the FACTS – it is also about questioning what people are saying, finding new perspectives and exploring how climate change affects our lives.

In these three Climate Change units, we will introduce you to a number of ways of teaching and learning about climate change.

How these units support teaching about climate change

These units have been developed to support FET phase Geography teachers to meet the requirements for CAPS teaching about climate change. The units here cover core content knowledge taught in Grades 10-12 with a particular focus on those sections dealing with climatology.

The focus on these units is on the Grade 10 curriculum, with a forward-looking approach to Grades 11 and 12. The broader aims of Geography (as described in CAPS) are used as the central themes in these three units. These include:

- Enabling learners to interpret the physical and human elements and processes of Geography;

- Explaining and understanding inter-relationships between the physical and the human and being able to make critical decisions; and
- Making informed judgements on issues.

Through these units on climate change we hope to enable you to better answer the following key questions:

- ***What does climate change mean?***
- ***How can I contribute to addressing climate change?***
- ***How can I measure progress in the sustainability journey to promoting a healthier self and planet?***

In these three units, we support you as a teacher and facilitator or interested reader to:

- Strengthen your subject content knowledge of climate change;
- Enhance your teaching practice; and
- Support your assessment practice.

The different FET Geography climate change units in the Fundisa for Change programme integrate with each other to assist teachers to:

- Understand the climate system as a large energy complex; and to
- Provoke critical thinking about the idea that people are actors and agents in the Earth System.

The science of climate change is dynamic, uncertain and contested. This means that all information about climate change is based on certain assumptions. In these units we have chosen to view the issue of climate change from a perspective that accepts that:

- The global climate is changing;
- Human actions are contributing to global climate change; and
- Humans can choose to address the causes, impacts and risks associated with climate change.

The units provided also support learning through both 'knowing' and 'being'. This means that they are designed to strengthen *knowledge about* climate change, and to encourage *informed action* in response to climate change. Because climate change is already affecting our lives today, it is important for learners to both understand what climate change is, and to be able to take action to both reduce the causes of climate change and respond to the effects it has on our lives. These units aim to help teachers support learners to become informed, active agents of positive change in the world.

In addition, these units aim to support teachers to develop teaching and learning practices that view and explore climate change critically, and that will help to develop learners who are able to think more critically about the processes 'driving' the climate system.

These Climate Change units and the CAPS

A special edition of *Enviroteach* magazine focusing on "Teaching Climate Change: Energy Exchange" is available on www.enviroteach.co.za or from Delta Environmental Centre in Johannesburg, 011 888 4831, delta@deltaenviro.org.za

These three Climate Change units have been developed to expand teachers' knowledge and expertise in ways that also support teaching the CAPS Geography curriculum for Grades 10-12 (details provided in the tables below). The sections do not follow the sequence of the CAPS; instead the progression is from energy creation, to energy use and change, to saving energy.

The units, outlined in detail below, focus on:

1. Energy exchange,
2. Resource use and change, and
3. Responses to energy exchanges and climate change.

Energy is used as a cross-cutting theme because it is the main factor affecting climate and climate change (see CAPS Grade 10 "Heating of the Atmosphere" and Grade 11 the "Energy Balance"). The role of how solar and terrestrial energy is distributed (e.g. through changes in water vapour content in the atmosphere, Grade 10) and ultimately through the circulation of air and water (General Circulation – Grade 11) are all linked to energy.

Together, these units provide teachers with a broad orientation to knowledge and teaching and assessment practice so that they can teach the specific requirements of what the CAPS curriculum requires from Grade 10 through to Grade 12. They provide Geography teachers with tools to enhance their teaching and their own learning and development about climate and climate change.

The units are presented as part of a story line that suggests how to teach about climate change. Background information plus examples of learning and assessment activities are provided in each unit to assist teachers.

The units cannot provide all the information or perspectives on climate change, so teachers also need to consult other knowledge resources. It is also important to review carefully what is presented in textbooks and other climate change information sources. A list of these is provided at the end of this resource. You will find links to key concepts in the side bars.

The same is true for the methods and assessment practices suggested here. A more extensive learning resource *Methods and Processes to support Change-Oriented Learning* is provided as part of the Fundisa for Change materials.

In line with the CAPS, each of the three units relevant to teaching climate change in FET Geography includes sections that cover:

- Subject knowledge,
- Teaching practice, and
- Assessment practice.

The Climate Change Units and their relationship to teaching the CAPS

The Geography curriculum is generally divided into two major areas of study, namely the bio-physical (e.g. climate, geomorphology) and socio-economic/political dimensions (e.g. development, economics, sustainable development). Environmental themes are usually incorporated in both of these streams. The theme of climate change is closely related to the study of energy and energy systems in the Geography curriculum.

Table 1 below shows both the relevant climate elements identified in the CAPS, as well as broader curriculum topics that have relevance to climate change through the integration of complex Earth systems and processes. For example, with population change (Grade 10, Term 3) people may, in some cases, move as a result of prolonged climate stress, etc. This shows that teachers will need a wider view of climate change for engaging across different CAPS topics.

Table 1: Climate Change related content and some additional examples in the CAPS Grade 10-12 Geography curriculum

TERM	GRADE 10	GRADE 11	GRADE 12
1	**The atmosphere** Composition and structure; Heating of the atmosphere; Moisture in the atmosphere; Synoptic maps	**The atmosphere** The Earth's energy balance; Global air circulation; Africa's weather and climate; Drought and desertification; Synoptic charts	**Climate and weather** Mid-lat cyclones; Subtropical cyclones; Valley and urban climates; Urban climates; Synoptic charts
2			**Rural settlement** Urban settlements and issues
3	**Population** Population distribution; Population movements	**Development geography** The concept of development; Frameworks of development; Development issues and challenges; Role of development	**Economic Geography of SA** Structure of the economy; Agriculture; Various sectors tertiary and secondary
4	**Water resources** Water in the world; The world's oceans; Water management in South Africa; Floods	**Resources and sustainability** Using resources; Conventional and non-conventional energy sources; Energy management	**REVISION**

One way to try to understand the story of climate change is through viewing the Earth and its climate as parts of a large, complex system. In this case, we are interested in the whole story of climate change, stretching back millions of years into the past – through the present – and into the future.

The Earth System and climate change are influenced not only by obvious interactions, like the impact of humans, but also by less visible relationships and feedbacks (e.g. the role of clouds and gases). These interactions between the physical and human systems and dimensions are key to the aims of geography (see CAPS Assessment Policy Statement, page 6).

These units also support the development of attitudes and values in learners, as described in the CAPS (see FET Geography CAPS, p. 9) as well as enabling learners to critically assess the content they are learning. Attitudes and values include:

- The development of concern for the sustainable and fair use of resources for the benefit of all;
- Recognising the significance of informed decision making;
- The application of geographical knowledge and skills in learners' personal lives;
- Respect for the rights of all people; and
- Developing a sense of fairness, sustainability and equality.

In Tables 2a, 2b and 2c some of the key concepts and processes covered in each unit are shown as well as background knowledge for teaching aspects of climate change topics, with some guidance on when they could be taught, according to CAPS.

This focus of each unit relates to some of the topics in the CAPS as shown in the tables below. Teachers and teacher educators should consult CAPS documents and textbooks for specific curriculum content, as this unit is not a textbook, but rather a resource for teacher education.

Unit 1: Energy exchange

The first Climate Change unit focuses on the basic energy exchanges that drive the global climate system. The key question addressed by this unit is: ***How is energy added to and withdrawn from the Earth System?***

Table 2a: Unit 1 related topics within the CAPS, showing relevant grades and terms

KEY CONCEPTS AND PROCESSES	GRADE	TERM
How is energy supplied and added to the system? *	10	1
How is energy transformed through various processes? (e.g. moisture in the atmosphere)	10	1
How is energy transferred across the system? (e.g. Earth's energy balance and the global air circulation) *	11 12	1 1
Energy transfer (e.g. pressure belts, cold and warm fronts, high and low pressures) *	12	1

Note: Not all aspects are dealt with in detail in this unit; only those with * are covered here.

Unit 2: Resource use and change

This unit focuses on how energy is used and changed in the Earth System. The key questions addressed by this unit are: ***How do various parts of the Earth System interact and use energy? What impacts may occur?***

Table 2b: Unit 2 related topics within the CAPS, showing relevant grades and terms

KEY CONCEPTS AND PROCESSES	GRADE	TERM
The role of people as actors in the climate system (population interactions; movement as a cause and consequence of climate change; climate change, population migration and greater pressure on resources)	10	2
Why some people use more of the global energy bundle than others; impacts of this	11	3
Hazards – droughts and floods; how the atmosphere responds to changes in energy flows	11	1
Resource and sustainability – energy use; conventional and non-conventional energy flows	11	3

Unit 3: Responses to change

The third unit focuses on our responses to such changes in the overall Earth System. The key questions addressed by this unit are: ***What can we do to make positive improvements to the energy system? How does the system, including humans, respond to changes in the system?***

Table 2c: Unit 3 related topics within the CAPS, showing relevant grades and terms

KEY CONCEPTS AND PROCESSES	GRADE	TERM
A narrative of change; Geomorphology: change through time	10	3
How do people respond to climate changes? Droughts and floods	10 11	4 1
How do humans interact with climate change? Responses and interventions; population movements, settlements; governance, climate policy	10	2

Key discourses and concepts

Knowledge is constructed and can be informed by various beliefs, ideas, paradigms and then packaged in a variety of ways. This section briefly explores some of the knowledge discourses that feed into and shape the climate change landscape. We also look at some definitions of various climate change terms.

Climate change and climate variability are some of the most pressing challenges faced by people and the Earth. Climate change and variability will result in various winners and losers, a situation that may intensify the current differences between rich and poor, developing and developed economies and the overall well-being of both the person as an individual and the wider collective (e.g. the health of the planet).

As a teacher, you have the task of guiding a learner through this very exciting and ever-changing subject. Increasingly it is becoming very clear that knowledge (while valuable) on this subject will not be enough. Profound thinking and reflection of HOW we all live on this planet and how we IMPACT on the planet and its resources will also be required in order to reduce risks to climate change and variability.

These units therefore are not only about 'the Earth System', 'green development' and 'carbon accounting' (although these are important issues). Understanding climate change is also about understanding some key science (e.g. **knowledge about energy budgets and climate as a complex system**) AND also includes reflection on some of the **cognitive issues linked to and underpinning climate change** (e.g. values and value-based choices that we make every day; issues of equity and the fundamental power relations in the world that construct the 'rules of the game' of how and what we produce, consume and use to develop and grow).

So for you as a teacher and facilitator, these units are NOT ONLY about communicating and sharing knowledge and information on climate change. They are ALSO about enabling your learners and yourself to journey on a path of deep introspection and reflection. The learners and the teacher are therefore going on a journey together to learn about climate change. Questions such as: "How does my daily lifestyle impact on those around me?" "Who and what is shaping and influencing my daily choices of how I eat, work and move around?" "Am I becoming an insatiable consumer or am I conscious of what impacts my actions have on my neighbours and on myself?" These are not trivial questions. They cut to the heart of the matter about climate change and sustainability, and include critical ethical and value dimensions of climate change, human security concerns and other aspects that continually frustrate a smooth set of international negotiations on climate change.

Key content knowledge questions in these units therefore include:

- What is climate?
- What is weather?
- What 'drives' climate and weather?
- How do both human and physical factors 'drive' and shape climate change and climate variability over time?

Before you start to teach this series of units, it is important for YOU as the resource person to reflect on some of the deeper issues linked to climate change.

Forms of knowledge integrated into the three Fundisa for Change *units on climate change*

The content covered in Units 1 and 2 is related to 'exterior/external' systemic issues or knowledge from the external world. Unit 3 focuses on what are sometimes called 'interior issues' or knowledge (for example, values, equity, fairness). We can separate these different knowledge types into four general areas:

"For citizens to address the complex problems of modern society, educators must help learners to develop higher level skills, for example:

1) **meta-cognition** (thinking about thinking) (see Wilber, 2000; Esbjörn-Hargens, 2010);
2) **meta-knowledge** (knowledge about the nature and limitations about knowledge);
3) **meta-learning** (learning how to learn); and
4) **meta-dialogue** (dialogue about how we engage in dialogue) (see Willow-Dea, 2011, pp. 29-30 and Murray, 2008).

All the elements above (meta-cognition, meta-knowledge, meta-learning and meta-dialogue) are key for both learners and teachers.

Linked to these various levels of understanding is the understanding that knowing **ABOUT climate change** is not enough; we also need to reflect on **what climate change means to us** i.e. issues of transformation. Transformative learning includes developing indicators of, in this case knowledge **for and about climate change**, including:

1. Experiencing an enhanced level of awareness of the context of one's belief and feelings (in this case about climate change)
2. Questioning and critiquing one's own assumptions and particular premises (again about climate change)
3. Performing an assessment of alternative perspectives (on climate change if required)
4. Taking action based on a new perspective, and
5. Cultivating a desire to fit the new perspective into the broader context of one's life (Shambhala Institute, 2004).

Finally, linked to the issue of climate change is the notion of sustainability or moving on a pathway to sustainability (see, for example, International Alliance of Leading Educational Institutes, 2009 and Burns and Weaver, 2008):

"The urgency of climate change policy and sustainable development risks narrowing the role of education to communication of expert-defined advice to citizens. This will be counter-productive in the long term.

We strongly recommend maintaining and implementing the more ambitious aims of Education for Sustainable Development providing people with the competences to take part in the shaping of sustainable development at all levels." (International Alliance of Leading Educational Institutes, 2009, p. 5)

Influences on national curricula

This expanded view of various epistemologies (nature and scope of knowledge) and constructions of knowledge is also being reflected in developments at a national level. Recently the Department of Science and Technology (DST) published its Ten Year Global Change Plan (see Table 3) to guide science and technology in the field of global change of which climate change forms a critical part.

Table 3: Outline of key elements of DST Plan adapted from DST

A Understanding a changing planet	B Reducing the human footprint	C Adapting the way we live	D Innovation for sustainability
1. Observation and monitoring	1. Waste minimisation methods and technologies	1. Preparing for rapid change and extreme events	1. Dynamics of transition at different scales – mechanisms of innovation and learning
2. Dynamics of the oceans around southern Africa	2. Conserving biodiversity and ecosystem services	2. Planning for sustainable urban development in a South African context	2. Resilience and capability
3. Dynamics of the complex internal Earth systems	3. Institutional integration to manage ecosystems and ecosystem services	3. Water security for South Africa	3. Options for greening the developmental state
4. Linking the land, air and sea	4. Doing more with less	4. Food and fibre security for South Africa	4. Technological innovation for sustainable social ecological development
5. Improving model predictions at different scales			5. Social learning for sustainability, adaptation, innovation and resilience.

Source: DST / Van Wilgen, B., 2009: Global Change Grand Challenge, National Research Plan, South Africa

Teachers and educationalists play a critical role in this plan. Here the focus is on a number of core themes clustered around a number of key issues:

1) **Understanding a changing planet (the WHAT?):** Observation and monitoring; Dynamics of the oceans around SA; Dynamics of the complex internal Earth System; Linking land, air and sea; Improving model predictions.

2) **Reducing the human footprint (the WHY?):** Waste minimisation; Conserving biodiversity and ecosystems; Institutional integration to manage ecosystems; Doing more with less.

3) **Adapting the way we live (WHY?):** Preparing for rapid and extreme events; Planning for sustainable urban development; Water security for SA; Food and fibre for SA.

4) **Innovation for sustainability (the HOW?):** Dynamics of transition at different time scales – mechanisms of innovation and learning; Resilience and capability; Options for greening and the developmental state; Technological innovation for sustainable social-ecological systems; Social learning for sustainability, adaptation and resilience

   (DST, 10-Year Global Change Research Plan for South Africa, no date) (parentheses added).

Understanding a complex interacting system with a view to climate change mitigation (e.g. cutting down on carbon) and adaptation (e.g. reducing the risks and living with climate change) and building resilience (e.g. making systems and humans stronger in the face of change) is clear from the DST Plan.

Essentially, the DST Plan (now influencing tertiary-level science and higher education training and teaching) has a strong focus on the WHAT, WHY and HOW of climate change. These can also be rephrased into more **actionable items** (pers. comm., L. Boraldino) as:

WHAT? – Understanding the complex interactive Earth System;

SO WHAT? – Ensuring sustainable living by mitigation and adaptation;

NOW WHAT? – Innovating technology and social learning for resilience.

Relating knowledge influences to teaching and learning

It is useful to start each unit by asking: Why do we teach our learners about climate change? Why is it in the curriculum? and Why do so many people in the world who are concerned about climate change focus their work on supporting schools and learners to learn about climate change?

The answer is that we are interested in growing and educating a new type of learner – one who can deal with the complex issues of climate change, and even more importantly, one who can act, respond and change the world by addressing climate change issues.

See for example Biggs et al., 2010. All references listed in side bars can be found in the reference list at the end of this book.

We are hoping to grow learners who are **flexible, nimble and smart thinkers and decision makers – learners who are able to make complex decisions in what has always been an uncertain science.**

This means that learners need to be grounded in 'good' science (Units 1 and 2 focus on this aspect), but they also need to be able to think and act flexibly (Unit 3 helps to develop these abilities).

Proust (as cited in Ferrer et al., 2011, p. 79) noted that:

> *"The real voyage of discovery consists not in seeking new landscapes, but in having new eyes".*

This means that what and how we know about something can change if our perspective or the way we think about it changes.

How is climate change being viewed? What changes in seeing have and are occurring when dealing with climate change?

Several changes have occurred in the climate change discourse. The most marked difference in 'view' has been the notion that climate change is not only a physical phenomenon driven by the chemistry and physics of the atmosphere. Rather the climate change field is now also seen as the product of human interactions both in *shaping* climate change and in *responding* to climate change. A similar change in view has also occurred in the disaster risk reduction community with an expanded focus that includes an examination of a disaster from both the perspective of the 'hazard' to that also of the 'vulnerability' of the impacted 'community/ecosystem etc'. In the climate change field the focus has thus

expanded to include both climate as biophysical driver that can produce a range of impacts to an examination of the receptor community. Thus if a community (either human of physical) is vulnerable (unable to cope with a climate risk) then a small change in climate (e.g. change in rainfall) may result in a major outcome.

See Fussel, 2006

'Approaches' that are receiving much international attention have thus grown from this notion of vulnerability to include a focus on transformability and resilience. Briefly resilience is:

> *"… the capacity of a system to absorb disturbance and reorganize while undergoing change so as to still retain essentially the same function, structure, identity, and feedbacks."*
>
> (Walker et al., 2004 cited in Folke et al., 2010, p.20)

These Fundisa for Change Climate Change units adopt an approach to better understand the complexity of the Earth System, at various scales, to draw out lessons and ways to better manage change through enhanced and more resilient adaptive capacity. What this will require is:

Folke et al., 2010

> *"Deliberative transformation requires resilience thinking, first in assessing the merits of the current versus alternative, potentially more favourable stability domains, and second in fostering resilience of the new development trajectory".*

For additional sources on this very interesting topic as linked to education, training and teaching see also Cundill et al., 2005 and Fazey, 2010.

It is clear that the WHAT and WHY of climate change are relatively easier to grapple with than the HOW … from the international thinking on resilience right down to the DST Plan that focuses on the Earth System, Mitigation and Adaptation.

This means that we, as teachers, should be aiming to inform ourselves and our learners about the complexity of the social and ecological dimensions of climate change. We need to ensure that our learners do not view climate change as something static. Rather they need to know that even though the science is uncertain, the 'system' is changing rapidly and is also being impacted by complex financial and social change (e.g. global financial crisis and social uprisings). We need to, as a matter of urgency, find a pathway through this complex set of issues so that future generations can live with the changes and yet be resilient (able to bounce back from such change and hopefully also bounce forward).

What one ultimately does about climate change depends on one's perception of the issue. If trained as a physical scientist one is invariably given a very thorough training in science but often through a positivist or factual lens. If one is trained more in the social sciences then the lenses (ways of seeing) may be more of the critical theory type of approaches (interpretative and ideographic).

See Table 4 below, adapted from Guba and Lincoln, 1994.

See Cundill et al., (2005) for a very interesting paper that shows how different perspectives in natural resources management can influence how you understand, communicate and intervene on climate change and resource use.

Table 4 below outlines elements of the image of positivist and critical theory. Often, because of time constraints, cultures of practice, or a lack of understanding, we are tempted to focus on the *first column* in the table.

The teacher presents a lesson from a distance, and is concerned with facts and knowledge content transfer only, without considering how this **may impact on how a learner 'feels' about such information**. The more informed a teacher becomes and the greater their understanding of complex learning processes, the greater their willingness to include critical theory dimensions and their sensitivity to the following:

- Context of the learner; what influences the learner's view on the issue;
- How has history shaped how something is understood and taught? (etc.)

So, for example, when teaching climate change, the role of carbon dioxide in the atmosphere as a major factor driving climate change MUST be presented as a challenge. The reasons for the accumulation of carbon dioxide (HOW the carbon ended up in the atmosphere) are as important to understand as the **SO WHAT AND NOW WHAT** issues: Why is society so carbon intensive? Carbon dioxide in the atmosphere is therefore not accepted as an unchallenged fact.

Table 4: Elements of the image of the positivist and the critical theory

ISSUE	POSITIVISM (NOMOTHETIC)	CRITICAL THEORY (INTERPRETATIVE, IDEOGRAPHIC)
Epistemology	Naïve realism – real reality but apprehendable	Historical realism – virtual reality shaped by social, political, cultural, economic, ethnic and gender values crystallised over time
Methodology	Dualist/objective; findings true	Transactional, subjectivist; value mediated findings.
Nature of knowledge	Verified hypotheses established as facts or laws	Structural/historical insights
Values	Excluded – influence denied	Included – formative
Inquirer posture	'Disinterested scientist' as informer of decision makers, policy makers and change agents	'Transformative intellectual' as advocate and activist
Action	Not responsibility of researcher; viewed as 'advocacy' or subjectivity, and therefore a threat to validity and subjectivity	Found specially in the form of empowerment; emancipation anticipated and hoped for; social transformations, particularly toward more equity and justice, is end goal

Adapted from Guba and Lincoln, 1994

While the ideas presented in this section are complex and draw heavily on theory, engaging with them meaningfully contributes to our development as teaching professionals and greatly enhances the depth and complexity with which we are able to present complex climate change-related discussions with our learners.

Some key concepts in climate change

A number of key ideas or concepts are especially important when teaching and learning about climate change. We have highlighted these here:

To help people to understand and discuss climate change, scientists and government representatives belonging to the IPCC (Intergovernmental Panel on Climate Change) have drawn up a set of agreed definitions relating to climate change. The following definitions have been adapted from the IPCC definitions. You can find the definitions that have been agreed upon by governments and scientists on the IPCC website: www.ipcc.ch

Climate:
We usually refer to climate as the average of daily weather over about 30-50 years (Richardson et al., 2011). This includes fluctuations in, amongst other variables, daily temperature, rainfall and air pressure. To observe a change in climate requires several years of data observation, e.g. changes in rainfall over the last 30 years.

Climate change:
Climate change refers to long-term changes in climate. Climate change usually also refers to significant changes in long-term weather patterns in a specific region or across the whole Earth.

Climate variability (e.g. floods, El Niño events) could be compared to a coach on the climate change train. What happens to the train (climate change) will also influence the journey of the individual coaches (see IPPC SREX Report, 2011).

Scientists generally look at 30 years of data (e.g. changes in rainfall over the last 30 years) before accepting that a climatic event is due to climate change or not.

Climate variability:
Climate variability refers to shorter-term changes in the climate compared with what is considered 'normal'. Various atmospheric factors can influence climate in the short term.

It is important to distinguish between climate change and climate variability. It is not accurate to consider weather events like a storm or hurricane as 'simply' part of climate change before we have examined the long-term weather data for a region to see if this event is 'normal' or if there is a notable, new emerging trend. Remember that while it is possible for storms to become more intense because of climate change, this is not always the case – so we cannot assume this before examining the data.

Climate adaptation:
The ability to adapt or change in response to changing climate.

Climate mitigation:
Efforts to reduce, limit and respond to the causes of greenhouse gases and other factors 'driving' climate change.

Greenhouse effect:
Gases in the atmosphere absorb, reflect and re-radiate energy in the climate system.

Enhanced greenhouse effect:
The greenhouse effect is a natural process that has operated over several thousands of years. Humans are adding to or 'enhancing' this process, so it is important to try to distinguish between the way in which humans contribute to the greenhouse effect compared to the Earth's natural processes.

Climate change drivers:
These are the factors that change the energy balance of the Earth System, causing climate change and climate variability. They include both human and natural effects on the climate, and are also known as 'forcing' factors (e.g. solar forcing).

Anthropogenic drivers of climate change:
Anthropogenic means 'caused by humans'; anthropogenic drivers are the human activities that are increasing climate change, e.g. land-use changes that influence the reflectivity (or albedo) of the Earth, and the addition of greenhouse gases into the atmosphere caused by the burning of fossil fuels.

Vulnerability:
This describes how 'weak' or strong a community or ecosystem is to stress or shock caused by climate change and its impacts on the Earth System (e.g. floods or droughts).

Resilience:
This describes how easily a community and/or ecosystem can 'bounce back' or adapt to stresses and shocks cause by climate change. Part of this is understanding what makes them stronger or more adaptable than other communities in similar situations.

Unit 1

Energy exchange

This Fundisa for Change Unit focuses on the basic energy exchanges that drive the global climate system. The key question addressed by this unit is:

How is energy added to and withdrawn from the Earth System?

This relates to some of the topics in the CAPS as shown in the table below. Teachers and teacher educators should consult CAPS documents and textbooks for specific curriculum content, as this unit is not a textbook, but rather a resource for teacher education.

Unit 1 related topics within the CAPS, showing relevant grades and terms

KEY CONCEPTS AND PROCESSES	GRADE	TERM
How is energy supplied and added to the system? *	10	1
How is energy transformed through various processes? (e.g. the hydrological cycle)	10	1
How is energy transferred across the system? (e.g. Earth's energy balance and the global air circulation) *	11 12	1 1
Energy transfer (e.g. pressure belts, cold and warm fronts, high and low pressures) *	12	1

Note: Not all aspects are dealt with in detail in this unit; only those with * are covered here.

Subject Content Knowledge

> *"When we refer to 'climate', we mean average patterns in weather. … To understand changes in the climate system, the changes in the heat energy content of compartments other than the atmosphere also need to be considered."*
> (Richardson et al., 2011, p.3, emphasis added)

Introduction

Climate change and climate variability, are caused or 'driven' by a range of factors including human activity and natural Earth processes and human activity.

The effects of the sun, the rotation of the Earth on its axis, and the Earth revolving around the sun act together with processes related to the atmosphere, lithosphere (e.g. volcanic eruptions), and terrestrial and ocean ecosystems. All these natural systems and processes drive and configure aspects and contribute to climate.

Humans contribute to climate change in two main ways:

a) The mix of driving factors. Many of our activities enhance the greenhouse effect. On the one hand, we release greenhouse gases into the atmosphere by burning fossil fuels;

b) On the other hand, we diminish the ability of natural systems to absorb greenhouse gases by changing the absorbing and reflecting potential (albedo) of various places by changing the surface cover and composition e.g. through deforestation, desertification and the acidification of the oceans.

Humans are therefore important agents of change, as we influence both the 'sources' and the 'sinks' of carbon.

The oceans are absorbing huge amounts of CO_2 from the atmosphere. This is dissolving in sea water forming an acid, which is dissolving the shells of phytoplankton, which absorb CO_2 for photosynthesis.

Key Carbon Concepts

Carbon Sources, Carbon Sinks & Carbon Sequestration

Carbon sources are sites and processes that release carbon-based gases (in particular carbon dioxide and methane) into the atmosphere. Carbon sources include anything that releases carbon into the atmosphere – for example, carbon dioxide emissions from cars or carbon released because of natural decomposition processes.

Carbon sinks are sites and processes that remove these gases from the system by converting them into forms of carbon that do not contribute to climate change. The process of holding carbon in this way is known as **carbon sequestration**.

Oceans, rainforests and grasslands are usually regarded as carbon sinks because they absorb more carbon dioxide than they produce.

It is essential to understand the 'total' carbon package (budget) of carbon (what is being added and what is being taken out of the system) by regions and various activities. Understanding this 'balance' or 'budget' is therefore very important as we will see in the next section.

How energy is added to and removed from the Earth System

Energy from the sun enters the Earth System in the form of short-wave radiation. The wavelength of transmission is determined by the temperature of the emitting body, in this case the sun. When it enters the atmosphere, some of this solar energy is reflected, scattered and changed (or attenuated, or shortened). Only about half of the radiation arrives at the Earth's surface.

For a very good explanation of the role of radiation in the energy balance, including some basic physics, see Focus Geography Learner Book, Grade 10, 2011, 88-89).

Because the Earth is much colder than the sun, it radiates some of this absorbed energy back into the atmosphere in the form of long-wave radiation. The atmosphere, which is made up of various gases including carbon dioxide and water vapour, selectively absorbs this longer wavelength radiation. These gases in turn re-radiate this energy back into the atmosphere and then back towards the Earth. This exchange of energy is usually referred to as the 'greenhouse effect' because it causes the warming of the Earth. The naturally occurring greenhouse effect is what helps the Earth to maintain a suitable temperature of around 15 degrees centigrade on average, without which life as we know it would not exist.

The word 'greenhouse' describes a shed made of glass panels that traps heat, making it warmer inside than in the surrounding environment.

See Oliver and Hidore, 1984; Platinum Geography Grade 10 Learner Book, 2011, 78-82; Focus Geography Learner Book, Grade 10, 2011, 90-96.

When more greenhouse gases are added to the atmosphere – either naturally or as a result of human activity – the composition of the atmosphere is changed, while the ability of the atmosphere to absorb and re-radiate energy back into space or down towards the Earth is increased, and the greenhouse effect becomes stronger. It is this 'enhanced greenhouse effect' that is often used to explain climate change (see Figure 1.1).

The role of energy in climate and climate change

We can see that there is a direct link between energy and climate.

Although the science is not exact or precise, the following quotes show us that many scientists agree that there is enough evidence that anthropogenic climate change (or climate change caused by humans) is already taking place:

> *"Warming of the climate system is unequivocal, as is now evident from observations of increases in global average air and ocean temperatures, widespread melting of snow and ice, and rising global average sea level."*
>
> (IPCC, 2007, p.2)

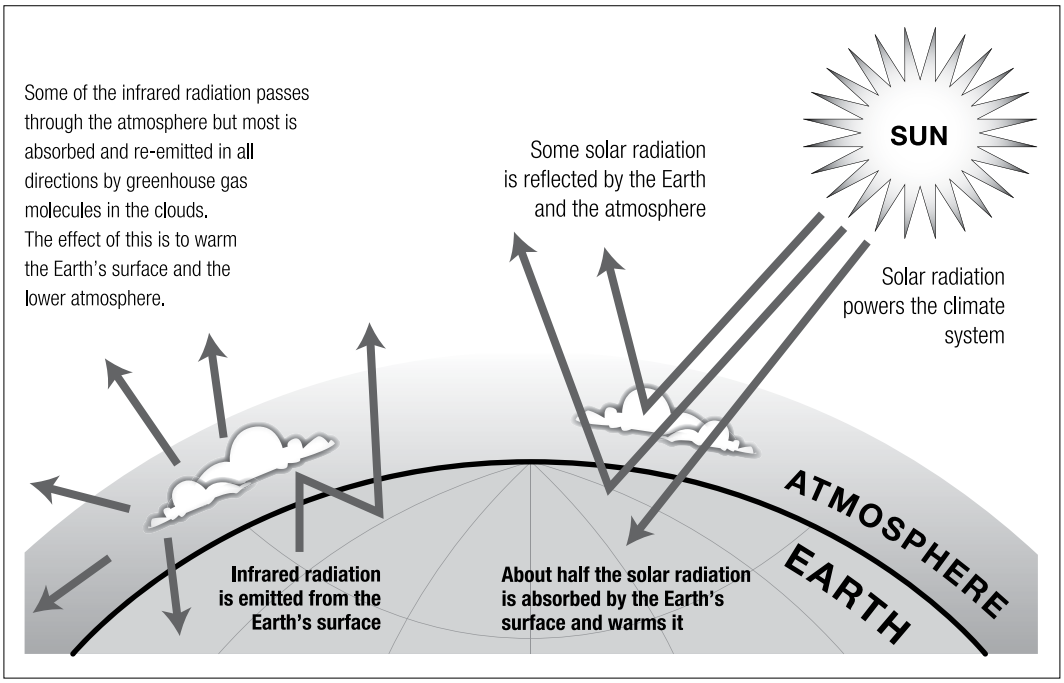
> *"Anthropogenic warming over the last three decades has likely had a discernible influence at the global scale on observed changes in many physical and biological systems."*
>
> (IPCC, 2007, p.6)

There are very good diagrams in the Platinum Geography Grade 10 Learner Book, 2011, 78-82; and Focus Geography Learner Book, Grade 10, 2011, 90-96.

The key factor to remember when teaching this section is that the greenhouse effect results from energy (usually energy in the form of long-wave radiation) being absorbed by a range of gases in the atmosphere.

Climate is a result of this energy input into the atmosphere as well as the distribution (spreading out and transfer) of energy across the globe.

Figure 1.1: The climate-energy system showing how energy is transferred by the sun, the Earth and various gases, resulting in the enhanced greenhouse effect



Source: *EnviroTeach*, Vol 20, Dec 2012, p.7

The role of global circulation in the Earth's energy balance

The energy coming into and leaving our atmospheric system is spread across the Earth in various ways and areas (e.g. locally and regionally). The amount of energy transferred is not the same over space and time. More solar energy is received at the equator and less at the poles. The movement of the Earth around the sun also affects when and where different amounts of energy are received (e.g. seasons and hours of daylight). These are further affected by the movement of the Earth around the sun (e.g. seasons). Climate is therefore the result of many factors including latitude, altitude, ocean currents and distance from the oceans.

The energy received and used is always undergoing change. Energy transformations or changes take place both vertically and horizontally in the atmosphere. Energy is usually transformed vertically, moving up into and out of the atmosphere via the water cycle and weather systems. For example, energy contained in water vapour is changed into other forms, such as latent heat energy, through condensation in weather systems such as storms.

Energy is also spread horizontally across the Earth via large weather, atmosphere and ocean circulation systems (e.g. mid-latitude frontal systems and tropical systems). The overall energy budget comprises energy entering and leaving the atmosphere. It is usually carefully balanced and makes up what we refer to as climate.

When you begin to teach about climate and climate change, it is important to remember that there are two dimensions that influence the provision of energy into the atmosphere:

a) Energy is added to the Earth by the sun. It is then transformed, with some of the energy being scattered, absorbed or reflected. Some of the energy that reaches the

Earth's surface is radiated back into the atmosphere, where it is selectively absorbed by greenhouse gases and transferred back into the atmosphere, out into space, or back to the earth. We may refer to this as the vertical transformation of energy (that is energy being transformed on a 'journey' through the atmosphere).

See figure 2.12 in Platinum Series, 2011 Learner's Book, page 76.

Energy is also not distributed evenly across the globe and there is also a horizontal transfer of energy.

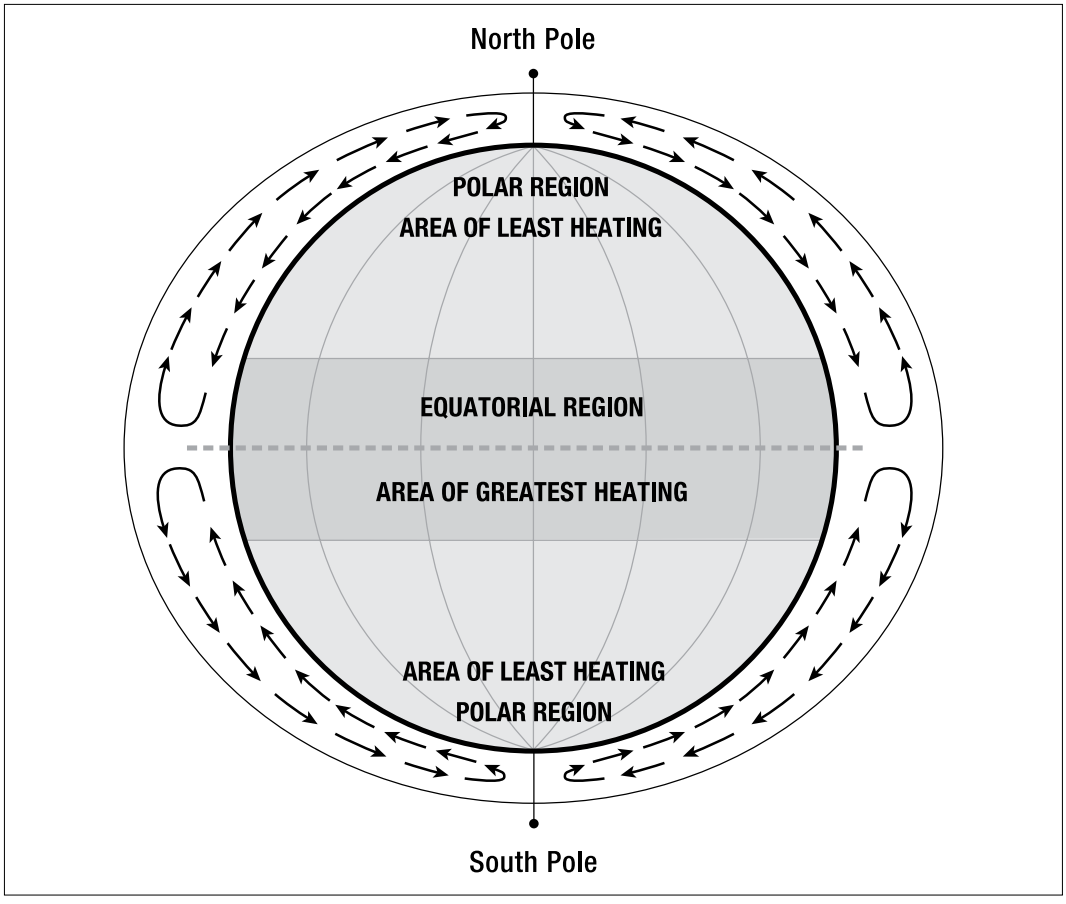
b) On large spatial scales, some places like the equator receive more heat energy, while other places like the poles receive less heat energy This process causes a global circulation system. Warm air rises at the equator (the Hadley circulation cell), and then travels to about 30 degrees latitude where it cools and sinks creating the Ferrel circulation cell or on a more local scale High Pressure systems (see Figure 1.2).

The Hadley cell is a tropical atmospheric circulation in which warm air rises near the equator to about 10–15 km above the Earth's surface, flows towards the poles and sinks in the subtropics, flowing near the surface back towards the equator.

The general circulation of the atmosphere is therefore made up of smaller features embedded within a broader circulation. Each of these plays a major role in distributing energy (e.g. tropical cyclones, storms). Various atmospheric circulation features, such as high pressure and low-pressure systems, are important products of the larger global energy balance and energy transfer in the atmosphere and larger Earth System.

Understanding how energy is distributed through the Earth's air circulation system will help learners to understand both the different climatic effects affecting the Earth and how they influence the build-up and regulation of greenhouse gases.

Figure 1.2: The fundamental driving mechanisms of the general circulation



Source: *EnviroTeach*, Vol 20, Dec 2012, p.10

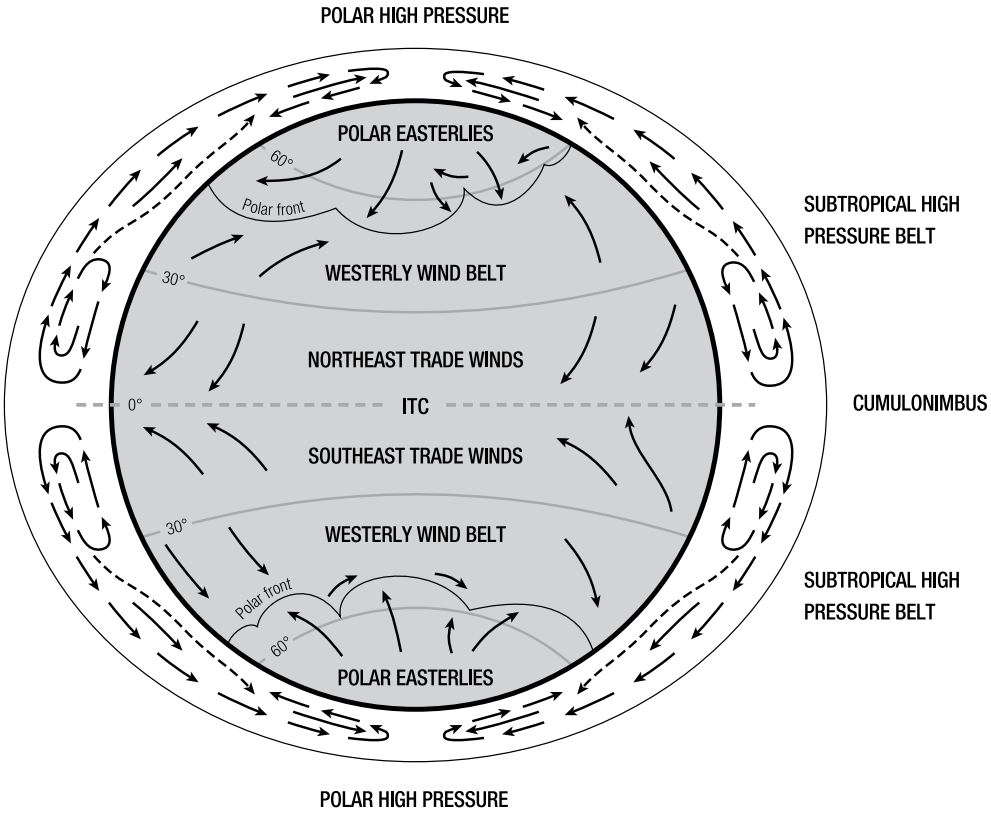
An example

How do pressure cells affect climate?

High Pressure features are caused by air sinking around 30 degrees north and south on the globe; they usually produce dry sinking air and produce clear and stable conditions. Much of the weather we experience in many interior places in South Africa (e.g. the Highveld) is as a result of this circulation feature.

Low Pressure features are products of heat imbalances produced by the interaction of cold polar air masses meeting warmer, moister air masses (around 60 degrees latitude). See Figure 1.3 below. In South Africa the weather associated with this circulation is usually associated with rain (e.g. a cold front and or a cut-off low feature).

Figure 1.3: The three cell model that results from differential heating, the Earth's rotation, and the fluid dynamics of the atmosphere.



Source: *EnviroTeach*, Vol 20, Dec 2012, p.12

Once we understand these processes (why they occur and what weather they can bring) the spatial dimension of energy distribution should become clearer.

More curriculum links

You can teach about the physical drivers of climate change by making links to other sections of the CAPS Geography curriculum, for example:

- The Earth's changing structure (Grade 10, term 3) – Volcanic eruptions emit large quantities of ash, which can add to the greenhouse effect (through particles and ash scattering or reflecting energy, or by absorbing some of the energy and re-radiating it). You can briefly reflect on the impact of volcanic eruptions on past climates and climate variability.

- The role of water in the energy balance in the atmosphere (Grade 10, Term 1) – Energy transfer by water occurs in two dimensions: Firstly, the *vertical transfer* of energy by evaporation, condensation and cloud development, and latent heat transfer when energy changes phases from gas-liquid-solid and the *horizontal transfer* of energy through large ocean bodies by warm and cold currents, and how they influence climate (e.g. El Niño) (Grade 11 Africa's weather and climate).

In the next section we will look at different ways of teaching about Energy Exchange in the context of the CAPS Geography Curriculum.

Points to remember:

Energy is added to the Earth's system by the sun. It is then transformed, with some of the energy being scattered, absorbed or reflected. Energy that reaches the Earth's surface is re-radiated back into the atmosphere, where part of it is selectively absorbed by greenhouse gases and either reflected and re-radiated back into the atmosphere or back to the Earth.

See Figure 2.12 in Platinum Series, 2011 Learner's Book, page 76.

Teaching Practice

In this section, we present a variety of ways in which you can teach learners about climate change. The aim is not to provide pre-determined set of activities that you can use in your classroom. Instead, we will be working with you to help you integrate different methods of learning into your classroom practice depending on which knowledge and skills you aim to develop in your learners (or your educational intent).

Skills cannot be learnt through reading a textbook or a worksheet. Skills development requires an opportunity to think and practice learning in different ways. This means that we need to think creatively about different ways of teaching that will help us to give learners the opportunity to develop these skills while they are learning about climate change.

Learning can and usually does occur in various ways (e.g. more shallow or surface learning is usually associated with factual recall). Deeper learning usually requires a learner to test the information being received against a required value system, belief system and also to enable a learner to question assumptions. This type of learning is not easy and requires a creative teacher and facilitator and a receptive learner.

Experiential learning: Using our senses to experience our environment

Experiential learning includes both activities that use the senses, and those that engage the emotions. They provide an opportunity for learning by providing different ways for learners to experience the world around them.

When you develop an experiential learning task, it is important to identify *WHAT* you want learners to experience, and *HOW* this contributes to their understanding of climate change. We have developed two examples for you below.

Different experiential methods are described on pages 17-22 in the *Methods and Processes* resource included in your materials (Rosenberg et al, 2008).

ACTIVITY 1

EXPERIENCING ENERGY TRANSFER

Activity outcome/purpose

To provide learners with the opportunity to experience and experiment with energy transfer.

Link to CAPS

This activity helps to develop the following knowledge and skills as described in CAPS

- Making decisions and judgements
- Working co-operatively and independently
- Collecting and structuring information
- (Processing, interpreting and evaluating data)

Core knowledge

How is energy transferred across the Earth System?

One of the major processes that assists with the transfer of energy is radiation (others include heating of the atmosphere, moisture in the atmosphere, latent heat transfer, and sensible

heat transfer – conduction and convection). The science of energy and energy transfer can be fairly complicated to understand. A good place to start is to use experiential activities to find out how the learners perceive and understand the basic concept of heat transfer.

Forms of assessment

Conducting fieldwork, recording and interpreting findings; drawing, analysing and interpreting graphs; working with data.

How is this activity experiential learning?

This activity gives learners the opportunity to experience and experiment with energy transfer at a personal level. It helps them to understand the broader concepts of heat transfer and how it is related to different conditions on the Earth by providing smaller examples of global phenomena.

Activity outline

Step 1: Take the learners outdoors and to allow them to sit in a warm part of the playground, preferably on a concrete surface on a hot day.

Step 2: Give each learner a time sheet with time noted in one column and the learner's observations in the other column.

Step 3: Ask the students to note how their bodies respond to sitting in the hot sun. This is often better if students close their eyes and the teacher guides them through a 5-minute observation period. Learners should observe that as they remain in the sun, their comfort levels change.

Step 4: Assign various areas in the school to the learners as observation stations (e.g. paved area, grassy area, shaded area, sunny area). Ask learners to describe or take measurements of their environments in terms of temperature and humidity readings.

Ask them to use their own data to investigate various questions, such as:

1. Why are some places in the school hotter or colder?
2. How does this very local example relate to the planet?
3. What areas of the Earth are hotter and colder? What may be causing this variation in temperature?
4. If some places are hotter and some colder, how does 'surplus' heat get distributed across time and space?

Step 5 is an extension of this activity that builds learners experiential, data collection and data analysis skills. See pages 17-22 in the *Methods and Processes* booklet.

Step 5: Once learners are back in the classroom, rearrange them into groups so that each group has learners who took measurements from different sites. Ask the learners to develop a data-sheet comparing their findings from the different areas. They should also summarise what their data means with regards to energy transfer.

Step 6: Have a class discussion on learners' findings and how they are related to energy transfer. You can then unpack the concept of heat transfer, beginning with radiation. Ask learners for examples from their own experiences of radiation, or heat transfer by means of electromagnetic waves (e.g. sitting around a fire, those closest to the fire usually warm up very rapidly but they do not need to 'touch' the fire to feel its warmth. They are heated by 'radiation' – heat that is transferred without a medium for the transfer).

Another example: Record changes in the temperature in a car that is left standing in the sun for some time. Reference – see Platinum Series, 2011, page 81.

Developing your Teaching Practice

Working with one of the core knowledge or skills areas in unit 1, develop an activity for the learners in your class using experiential learning methods. Your activity should involve the learners directly.

Investigative methods: Investigations and experiments

Using investigative methods allows learners to research and explore a subject in various ways. Good investigations help learners to collect information from different sources (such as reference books, informative websites, interviews with people who know something about a specific topic and observing examples of a particular subject in their own environment. Conducting an investigation is an alternative way to help learners to both accumulate information about a topic, and to get a wider variety of views, ideas and conclusions about that topic than a more direct form of information transfer would allow. It also supports learners in developing their research, data collection and analysis, and communication skills.

See pages 23-26 in the *Methods and Processes* booklet.

ACTIVITY 2

ENERGY TRANSFER ACROSS THE EARTH SYSTEM

Activity outcome/purpose

To provide learners with the opportunity to investigate how water affects energy transfer within the Earth System.

Link to CAPS

This activity helps to develop the following knowledge and skills as described in CAPS

- Identifying questions and issues
- Collecting and structuring information
- Processing, interpreting and evaluating data
- Making decisions and judgements

Core knowledge

Energy transfer within the Earth System

Energy is transferred in different ways within the Earth System. Water within the Earth System affects energy transfer in very specific ways.

Links to assessment

Working with a variety of data; and writing up research; writing paragraphs and essays; evaluating arguments and expressing and supporting a point of view.

How is this activity investigative learning?

This activity requires learners to investigate a topic by finding different information sources and investigating what they say about a specific topic. It requires learners to make use of all the skills listed above to make sense of the information they have found.

Activity outline

Step 1: Give the learners an area to focus on – you may want to split your class into different focus areas. For example, 'how do oceans affect energy transfer within the Earth System' or 'how does humidity in the air affect energy transfer within the Earth System?'

Step 2: Describe different ways of investigating the topic to your learners. Refer to your *Methods and Processes* book for guidance. Learners should use at least four different sources in their investigation. These could include, but are not limited to reference books, the Internet, documentaries and interviewing scientists or climate change and energy transfer specialists.

Step 3: Ask the learners to develop a poster and a four-page report showing their investigation findings. Their poster and report should include illustrative charts, carefully researched information and a list of the sources of information they have used.

Developing your Teaching Practice

Work together in pairs to develop an investigative activity for your learners focusing on an area related to the core knowledge described in Unit 1. Your activity should be different to Activity 2 described above. Remember that your chosen topic should be focused (so that learners know precisely what it is they are meant to research, and should be documented in various information sources so that learners have the opportunity to do more than simply copy information from one source.

ACTIVITY 3

EXPERIMENTING WITH THE GREENHOUSE EFFECT

Activity outcome/purpose

To provide learners with the opportunity to investigate how greenhouse gases are created and affect energy transfer.

Because the Earth System is very complex, it is useful to use different games and models to help us to understand it. These two sites provide a useful starting point:

www.openabm.org – Arizona State University provides a number of examples of how to teach in cross- and interdisciplinary ways;

www.vensim.com – provides activities to explore real-life issues.

Link to CAPS

This activity helps to develop the following knowledge and skills as described in CAPS

- Identifying questions and issues
- Collecting and structuring information
- Processing, interpreting and evaluating data
- Making decisions and judgements

Core knowledge

Many texts explain the greenhouse effect as a 'trapping' of energy and/or 'trapping reflected energy' from the Earth. This is not fully correct. The Earth radiates long-wavelength energy that is selectively absorbed and re-radiated by greenhouse gases (e.g. carbon dioxide, methane, ozone, etc.).

Links to assessment

Conducting fieldwork, recording and interpreting findings; using models; working with a variety of data; analysing and synthesising information.

How is this activity investigative learning?

This activity requires learners to investigate the effect of the greenhouse effect by simulating the effect in a small scientific experiment. The use of both a control and experiment box allows the learners to compare and draw conclusions about the effect of the greenhouse effect on the Earth System, as well as to collect and understand a specific set of data on the effect of greenhouse gases on energy transfer.

Activity outline

An excellent investigation or experiment (by Lueddecke et al., 2001) to illustrate the 'greenhouse effect' is provided below. Such activities can make the greenhouse effect very real for the learners. They can be scheduled over a few periods and form part of the learner's assessment portfolio as either an individual or group assessment.

Step 1: Investigating the greenhouse effect

Encourage learners to consult and compare the different sources of information is provided, as well as finding other information sources about the greenhouse effect. You will see that there are conflicting ideas about what the greenhouse effect is, and how it affects the Earth System. They should summarise their findings before doing the experiment.

Step 2: Experiment – Greenhouse effect in the classroom

(This activity is based on an article in the *Journal of Geoscience Education*, May 2001, titled "Greenhouse Effect in the Classroom: A project- and laboratory-based Curriculum", Susan B. Lueddecke et al.).

- Stimulation of the greenhouse effect utilises two fish tanks, heat lamps and temperature probes.
- Experiments are run by creating CO_2 enriched environments and measuring the differential heating of that experimental apparatus compared to an identical control.
- Provides an opportunity for the learner to understand more about the increase in temperature owing to CO_2 increase.
- It is important for the learner to understand that the greenhouse effect is not, in itself, an anthropogenic phenomenon. It occurred on Earth long before humans appeared on the scene.

Did you know?
Learners often think that the issue of ozone depletion is the major cause of global warming. The role of ozone as a greenhouse gas is clearly important. Ozone, both in its creation and depletion as a gas absorbs short-wave energy. It therefore plays a role in the energy balance but it is not the only gas playing a role in the greenhouse effect.

- Greenhouse Effect Demonstration:
  Two tanks are placed side by side. Black substrate, e.g. course sand, is distributed evenly over the bottom of both tanks. Mount one thermometer (about 3cm above substrate) inside each tank, orientated in such a way that they can be read. Place dishes face up, in the centre of each tank. Dishes should be shallow and made of glass or a dark-coloured material. Mount heat lamps above the tanks (150W or 250W) at such an angle that each tank receives the same amount of light and heat. Measure 15 grams of bicarbonate of soda into the dish of Tank A. Turn on the heat lamps and add 75ml of vinegar to the dish of Tank A – add slowly. Stir to make sure all of the bicarbonate of soda is used up. Light a match and lower into Tank A – the level at which the match is extinguished is the top of the CO_2 layer. When the match test is completed, begin timing the experiment. At the start of the experiment, note the temperatures in both tanks. Repeat these measurements every 30 seconds until the temperatures start to plateau.
- Results:
  - The experimental tank A should heat faster and to a higher peak temperature than the control tank. The differential heating can be attributed to the effect of the CO_2 in Tank A.
  - Notes to learners: the vinegar-bicarbonate of soda reaction itself is not analogous to the processes that put CO_2 into the Earth's atmosphere.

Step 3: After the experiment is over, learners should summarise their findings from the experiment, and then revisit their summaries from Step 1.

Developing your Teaching Practice:

Work in pairs to develop an investigation activity. Your activity should focus on an area you have not focused on in the above activities. Your investigation needs to be focused on a specific knowledge or skills area.

Tip for the teacher: Ensure that the text you are using is supported by other information sources. Use a process of triangulation – cross-check your data and information by using at least three sources.

Information transfer

Information transfer is one of the most commonly used ways of teaching learners in schools. It is also a method that is often integrated into and combined with most other methods of learning. Information transfer can take a number of forms, including class notes, a lecture, a brochure or poster or even a field trip or experiment.

The information transfer method can become a meaningless exercise if it is reduced to a one-way transfer of information from teacher to learners. If you are struggling to find new and creative ways for information transfer, have a look at the *Methods and Processes* book included in your materials – there are lots of good ideas to help you get started in there.

The Focus and Platinum series books have very good information on energy transfer.

Remember that information transfer includes listening with intent, reading and writing to learn, and using mathematical and scientific concepts to learn.

ACTIVITY 4

SIMPLE WAYS TO MAKE ENERGY TRANSFER MORE INTERACTIVE

Activity outcome/purpose

To transfer core knowledge and information about energy transfer to learners.

Link to CAPS

This activity helps to develop the following knowledge and skills as described in CAPS

- Collecting and structuring information
- Processing, interpreting and evaluating data
- Using verbal, quantitative and symbolic data forms such as text, pictures, graphs, tables, diagrams and maps.

Core knowledge

Energy enters and is transferred through the atmosphere in specific ways

In this section we try and enable learners to understand how energy is transferred through the atmosphere. As explained previously, energy can either be 'circulated' through the atmosphere and to various areas of the globe via large atmospheric features e.g. the Hadley cell etc. Energy can and is also transferred around the globe and through the atmosphere via exchanges of energy (e.g. conduction, convention and radiation).

Conduction: method of heat transfer from one stationary molecule to the next.

Convection: method of heat transfer in moving air or water.

Radiation: method of heat transfer by mean of waves.

Activity

Some good sources include: Platinum Geography Series and Focus Geography, Learners Books for Grade 10.

Ask learners to find definitions for Heat and Energy. Discuss the definitions found in class, noting similarities/and or differences. Expand the exercise by asking learners to show how each process fits in with the theme of this edition namely energy transfer in the atmosphere.

In the next teaching activity we explore how such processes can be demonstrated.

Links to assessment

Factual recall.

How is this activity information transfer?

This activity presents pieces of core knowledge directly, and in a straightforward manner. It does not draw on learners' senses or experiences directly, in the way that investigative or experiential learning does. While it does attempt to make information transfer more active and engaging, its aim is to transfer a pre-determined block of knowledge to learners.

Activity outline

Design a worksheet that asks learners to complete a diagram showing various energy flows (e.g. radiation and condensation). Rather than providing learners with a completed set of notes, design them with questions and gaps for the learners to fill in. This will help to engage learners, and will require them to think about the context and knowledge instead of simply reading it.

Completing a simple set of notes using the worksheet approach (above) could be followed by filling in the labels on a diagram, such as one of the figures in the earlier part of this unit. Provide a copy of the diagram with all the important labels and notes deleted and ask the learners to fill them in. Alternatively ask learners to draw their own model to explain how the greenhouse effect operates. They can then compare it with Figure 1.

Step 1: Completing a worksheet on energy flows

Ask learners to complete the worksheet on energy flows. They should fill in the missing words and complete the labels on the energy flow diagrams.

Step 2: Summarising the greenhouse effect

Next, ask them to develop a summary on the greenhouse effect. Their summary should focus on the natural causes of the greenhouse effect, and include information on how the greenhouse effect affects energy transfer in the Earth System.

Extract from a worksheet designed to encourage active information transfer:

> Energy from the sun enters the atmosphere system and is ultimately returned to space. It enters as short-wave radiation and is radiated by the Earth as .....-wave radiation. The reason for the difference in wavelength is linked to the temperature of the radiating body.
>
> Gases in the atmosphere such as ....., ... and ..... selectively absorb the long-wave radiation and this contributes to an overall warming of the atmosphere.

Developing your Teaching Practice

Select a core knowledge area from the core knowledge section of Unit 1. Develop a knowledge transfer worksheet or presentation for your learners. Your activity should be focused on a specific process. Think about the following when planning your worksheet or presentation:

- What is the core knowledge that you want to transfer?
- How are you going to make the transfer more interactive and engaging for the learners?
- Do you have opportunities to develop deeper learning and higher order thinking in your worksheet or presentation?
- If you are doing a presentation, what are the guiding questions you will ask the learners to support their engagement?

Deliberative Methods: Scenario-planning and backward mapping

See page 35 in the *Methods and Processes* book.

Deliberative teaching methods provide different viewpoints, scenarios or possible futures for the learners to think about and deliberate about. Deliberative methods do not present a "right answer" that learners need to memorise. Instead, by using such methods a number of alternative possibilities are raised that require learners to think about, predict or debate about. This allows learners to draw on their own experiences and understanding of an issue and to understand how it can be changed in the future.

ACTIVITY 5

HOW DO CHANGES WITHIN THE EARTH SYSTEM AFFECT ENERGY TRANSFER?

Activity outcome/purpose

To develop the skills to backward map and to future map or hypothesise about changes in the Earth System with learners. By doing these exercises one can develop an understanding of how the Earth System is affected by climate change.

Link to CAPS

This activity helps to develop the following knowledge and skills as described in CAPS

- Identifying questions and issues
- Collecting and structuring information
- Processing, interpreting and evaluating data
- Making decisions and judgements
- Working co-operatively and independently
- Using verbal, quantitative and symbolic data forms such as text, pictures, graphs, tables, diagrams and maps.

Core knowledge

Energy enters and is transferred through the atmosphere in specific ways

Links to assessment

Drawing analysing and interpreting graphs; using models; working with a variety of data; analysing and synthesising information from different sources; working with concepts, data and procedures related to GIS; evaluating arguments and expressing and supporting a point of view

How is this activity deliberative?

This activity requires learners to think about and deliberate how a single and specific change within the Earth System will affect the whole system. It requires learners to think about effects and results, rather than presenting a set and definitive block of information with a predictable result. The activity is used to create and assess alternate futures in a systematic way.

Activity outline

Step 1: Backward mapping

Working in groups of four, ask the learners to review historical data about temperatures and weather in South Africa over the last 30 years.

Weather data could be obtained from the South African Weather Service (SAWS), www.weathersa.co.za

Learners should complete the following activities:

1. Using the data, plot a graph to show the change in rainfall amounts over time (you could also use temperature data);
2. Calculate the average amount of annual rainfall for this data series;
3. Using the graph, determine the following:
   a) Which periods had particularly heavy rainfall (above average)?
   b) In which periods was the rainfall particularly reduced (below average)?

Summarise two patterns and causes of rainfall in South Africa (e.g. tropical cyclone, usually rainfall over the eastern parts of the country).

Step 2: Still working in groups of four, ask the learners to summarise how these weather patterns affect and are affected by energy transfer within the Earth System.

Step 3: Scenario planning – Now ask the learners to plot a rough graph where the average rainfall for each period is 5 mm of rainfall higher. Brainstorm with learners what such rainfall may mean? What would be the impacts if each storm was bigger?

Developing your Teaching Practice

Select a core knowledge area to work with. Working in groups of four, design a deliberative learning activity. Your activity should engage learners in higher order thinking, and should get them to reflect on possible or probable changes in the Earth System as they affect the learner. You may want to design an activity that draws on different learning methods, as we have in Activity 5 above.

ACTIVITY 6

OUR PREFERRED FUTURE
(Example of transformative or deeper learning)

In this classroom-based exercise, provide each learner with a set of pictures taken from magazines and a piece of cardboard. Ask the learners to divide their sheet of cardboard into two halves. Entitle the first half 'How I see the world today'. Learners need to arrange pictures and draw if necessary to illustrate what their world looks like today. Entitle the other half 'The world I want to see in 2030'. This also needs to be illustrated.

On the back of the cardboard learners should draw two columns, headed 'Problems preventing us from reaching our desired future' and 'Positive things we can do to reach our desired future'. They should then list ideas and suggestions in the two columns.

This future scenarios exercise is popular with learners and can produce very interesting outcomes. You could get the class to present their ideas to the school at an assembly, and exhibit their posters on the walls of the school. Learners should explain both their posters and future visions.

You can find more examples of this in the Climate Change *Enviroteach* magazine.

A special edition of *Enviroteach* focusing on "Teaching Climate Change: Energy Exchange". *Enviroteach* is available on http://www.enviroteach.co.za or through Delta Environmental Centre in Johannesburg, delta@deltaenviro.org.za

Assessment

Evaluating arguments and expressing and supporting a point of view.

In addition to this, you could require that the learners write a brief essay about climate change.

Assessment Practice

In this final part of Unit 1 we suggest a few ways to assess what has been learnt about climate change, both in terms of *knowledge* and in terms of *values* or 'deeper' thinking and learning. In the introduction, we stated that knowledge *about* climate change is not enough; we also need to encourage *action to address* climate change. It is relatively easy to determine whether or not learning of facts, or even understanding of content, has taken place. But how does a teacher assess that learners have transformed their learning and 'themselves'? A question that may help us to assess this deeper aspect of learning is: *How can I measure my progress in the sustainability journey towards a healthier self and planet?*

The assessment examples given in this section include both 'simpler' and 'deeper' types of assessment. Neither approach is better than the other, for each has its purpose. The teacher should aim to assess both factual recall (remembering) and higher order cognitive and affective learning (e.g. analysing, evaluating and creating).

Assessments need to be focused and guided by our overall aims, which include the skills and knowledge outlined in the CAPS Geography Curriculum.

Assessing knowledge of curriculum content

In this unit, we have been aiming to develop relevant skills and knowledge of curriculum content.

Knowledge to be assessed includes:

- Understanding the large energy complex that is the climate system;
- Distinguishing between weather and climate;
- Understanding and applying the basic science of energy transfer in the Earth System (including the greenhouse effect, the role of solar radiation and the role of the Earth's surface radiation);
- Differentiating between climate change and climate variability;
- Understanding how human activities can affect the climate.

Key knowledge questions include:

- What is climate?
- What is weather?
- What 'drives' climate and weather?
- How does climate change over time ?
- How do human and physical factors drive climate change?

Assessment methods may include:

- Explaining complex processes simply;
- Interpreting graphs; and
- Compiling diagrams that synthesise processes.

Assessments include both factual recall and assessment of 'deeper' or 'higher' learning.

Examples of some central questions for Geography

(see CAPS)

What is happening? – What is climate change?

Why is it happening? – Why is climate change happening?

How is it changing? – How is climate changing?

What are the effects of the changes? – What are the effects of such climate changes?

What are the benefits and costs of the change? – What are some of the benefits and costs of climate change – not ALL of climate change is and will be BAD!

What decisions must be made? – What decisions must be made – nationally, regionally, locally and personally?

What is MY position?

What action can I take?

1. Assessing factual recall

These assessments focus on how much learners can remember, for example:

- Find out if learners understand how energy flows through the system by providing them with figures or diagrams with some of the labels and arrows left out (see figures above that you can use). Let them fill these in to show that they understand the flows of energy and the role of the gases.

- Test understanding of the greenhouse effect by asking learners to identify key components of the system each the role of the sun and short-wave radiation and the role of the Earth – long-wave radiation and the role of greenhouse gases.

- To assess learning about the general circulation of the atmosphere, learners can complete a drawing of the globe that illustrates the major circulation types. They need to understand all the basics concepts of 'what makes air move' and use this knowledge to draw the major global air circulation patterns. Aspects to be assessed include:

  a) the major circulation features and resultant surface air flow across the globe;

  b) the major winds (e.g. westerlies), which must be indicated correctly;

  c) the major pressure systems (e.g. high and low pressures, and major circulation systems such as the Hadley, Ferrel and Polar cells), which must be drawn correctly.

A number of long-term weather data sets are available on the Internet.

ACTIVITY 7

TESTING KNOWLEDGE

A very common way to examine content is via a test. Before setting a test you should always be aware of the types of learning you are trying to examine e.g. facts, deeper and transformative knowledge acquisition etc.

Here is an example of a test divided into various learning assessments:

Test Example:

WARMSTAD HAPPY SCHOOL

Subject: Social Sciences / Geography **Assessment:** Examination

Examiner: Mrs Makhuba **Moderator:** Mrs Smith

Date: ..... **Time:** 1 hour

Grade: ..... **Total marks:** 55

Surname: .....

First Name: ..... (print neatly please).

Question 1 (Clouds):

Complete the following table:

Cloud Name	Illustration	Type of precipitation (e.g. rainfall)	Description of cloud
Stratus			
Cumulonimbus			
Cirrus			

(9 marks)

Question 2 (The greenhouse effect):

Provide the names for three MAJOR greenhouse gases. Give the dominant function or role these gases play in energy transfer in the atmosphere e.g. absorb solar radiation; reflect solar radiation etc. ***(6 marks)***

.....

.....

.....

Question 3:

Give 3 advantages and 3 disadvantages of adaptation to climate change to either humans or the environment:

Advantages:

.....

.....

.....

Disadvantages:

.....

.....

.....

(6 marks)

Question 4:

Complete the following paragraph by **selecting and circling or inserting the missing word** in the spaces provided:

The Earth between latitudes ..... receives more incoming solar radiation than it emits. This surplus of energy is carried to other areas of the globe via the ..... circulation cell. Here it then sinks and usually brings with this sinking ..... weather. Major deserts e.g. the ..... in northern Africa are located in this zone of major subsidence. At the ITC, moist air from the easterlies results in large thunderstorms in the form of ..... clouds. ***(5 marks)***

Question 5:

Draw a neatly labelled diagram showing some of the key features of the atmospheric circulation. On your diagram fill in the major winds and circulation features. ***(8 marks)***

Question 6:

In a detailed paragraph, no more than 10 lines explain what is meant by climate change and climate variability. ***(6 marks)***

Question 7:

Complete the following paragraphs by inserting the correct words:

A m..... is a person that studies the weather.

They usually study air currents or w..... and are interested in large air pressure systems like cyclones, and t..... storms.

Large hurricanes produce heavy r..... and strong w.....

The devices that measure weather e.g. wind are called a w..... s..... for wind direction or a w..... v.....

A climate ..... is someone who does not agree with human induced climate change.

(10 marks)

Question 8 (Water in South Africa):

True or false:

a) South Africa is a water scarce country. .....

b) The average annual rainfall of South Africa is 1000 mm/year. .....

c) The western part of South Africa is the wettest part of the country. .....

d) It is estimated that we may run out of water by 2030. .....

e) Dams store water for irrigation, factories and for human use. .....

(5 marks)

Paper total: 55

Task for the teacher:

Reflecting on assessment

1. What content area is this test set for?
2. What grade is this test for?
3. Discuss the range and type of questions asked. Is the range of question types varied enough?
4. Evaluate each question and what level of cognitive thinking was used
5. Complete the table below

	QUESTION NO.	LOW ORDER	MIDDLE ORDER	HIGH ORDER
	1			
	2			
	3			
	4			
	5			
	6			
	7			
	8			
55 marks (Total marks divided into percentages)				

6. Was this test set at the correct cognitive level percentages?
7. How can you improve this test?
8. Reword questions, so that this test becomes a test set at the correct cognitive levels.

2. Assessing higher order learning skills

Key to understanding climate change is being able to distinguish between climate change and climate variability, and understanding how the changing atmosphere is contributing to climate change. Learning activities relating to these topics that will enable you to assess higher order learning include assessing the collection and analysis of data, clear data presentation, and the ability to draw logical conclusions from data.

ACTIVITY 8

MEET THE SCEPTIC

Science is only one lens through which we view the world. There are other belief systems and ways of looking at the world that do not necessarily agree with the position taken in these units, that is that the global climate is changing.

Project:

Ask the learners to explain their positions on climate change, and to undertake a survey about climate change perception. Do their family members and friends think about climate change, does it worry them? If so, why? Encourage learners to explore their own views on climate change and its causes. Introduce learners to the notion of the 'climate change sceptic' – one who does not believe or denies that climate change is occurring.

Ask them to write up their survey methods and results, and to do a brief presentation to the class on their findings. Guiding questions could include:

- Does everyone share your teacher's concern about 'global warming'?
- If not, why not?
- What proportion of the people you surveyed believe that the global climate is changing, and what proportion could you describe as 'sceptics'?
- Is it OK to disagree with a textbook?

The assessment for this can be either for marks assigned for a written and or class presentation or marks given for a take home project.

Rating Scale:

CRITERIA
1. Accuracy of information
2. Clarity of ideas and arguments
3. Originality of ideas
4. Presentation of information
5. Relevance to climate change

Follow up their survey by providing the learners with a range of views on climate change, including typical northern and southern views; science knowledge and local or traditional knowledge; opposing opinions on the Green Economy, etc. Encourage learners to take on different roles and to debate the issue of whether or not climate change is happening, and the role of human activities in climate change. By becoming aware of and even exploring different views, learners can become more informed about climate change, and may feel more empowered to respond appropriately to this challenge.

ACTIVITY 9

DEEPER LEVEL ASSESSMENTS

Provide learners with a map outline of South Africa and two magazines each. On their maps ask learners to paste in various **current day activities** that may occur in the country (e.g. maize farming in the North West Province).

Once this has been completed, ask learners to describe and write down what the weather and climate may be like in 20 years time in these areas. Questions could include: Will the temperatures be higher or lower, will it be drier or wetter etc? What impacts may occur in these areas given climate changes? Learners to assign a symbol to illustrate the change e.g. a symbol showing fire, more rainfall etc. Learners may need to do some Internet searches on climate forecasts and scenarios for the future climate projections for South Africa.

Then ask learners to pretend that they are the mayors of ONE of these areas. They need to write their manifesto for the next election showing how they will help 'manage' climate change in their chosen area. This may be given as a take-home exercise.

An alternative option is to provide learners with extracts from the Government's 2011 White Paper on Climate Change and to ask each learner to present their critical views on aspects of the paper (e.g. the Flagship Programmes – see website for more information – Department of Environmental Affairs – call centre – 086 111- 24689 for further information and copies of the White Paper).

Example of suggested criteria for rating:

CRITERIA
1. Accuracy of information
2. Clarity of ideas and arguments
3. Originality of ideas
4. Presentation of information
5. Relevance to climate change

Conclusion

Climate change and climate variability have been presented using the theme of energy as it moves through the system, and as it is used, changed and added to the system. Impacts of how we as humans use and interact with this complex system have also been explored. Several key issues have been identified that should be remembered when teaching climate change:

- Climate change is an uncertain and contested science.
- Notwithstanding these issues, climate variability and change are key concerns facing the planet and humans.
- The climate system, driven in a large part by energy exchanges, is essential for human and ecosystem functioning as we know it.
- One of the causes of climate change and climate variability is the changing energy budget – that is energy is either added to the system in some areas or removed in others. Today we have evidence that humans are **adding** to the energy system through fossil fuel use and land use change. Such changes of the energy balance can result in changes in weather (e.g. storms and floods).
- What we **do** about climate change depends on our perceptions, belief systems, where we live, how we have grown up, in what socio-economic position we find ourselves etc. There is no **one** size fits all and as a result the **what to do about climate change** issue is one that is taking up much time and effort in both national and international debates and negotiations.

In this first unit, some examples of content knowledge, teaching practice and assessment have been provided essentially describing how energy as a theme is linked into climate change.

Unit 2

Energy resource use and change

This unit focuses on how energy is used and changed in the Earth System. The key questions addressed by this unit are:

How do various parts of the Earth System interact and use energy?
What impacts may occur?

This relates to some of the topics in the CAPS as shown in the table below. Teachers and teacher educators should consult CAPS documents and textbooks for specific curriculum content, as this unit is not a textbook, but rather a resource for teacher education.

Unit 2 related topics within the CAPS, showing relevant grades and terms

KEY CONCEPTS AND PROCESSES	GRADE	TERM
The role of people as actors in the climate system (population interactions; movement as a cause and consequence of climate change; climate change, population migration and greater pressure on resources)	10	2
Why some people use more of the global energy bundle than others; impacts of this	11	3
Hazards – droughts and floods; how the atmosphere responds to changes in energy flows	11	1
Resource and sustainability – energy use; conventional and non-conventional energy flows	11	3

The unit aims to show that humans AND natural interactions within the Earth System BOTH shape how we use energy. These interactions produce a range of outcomes. How we respond to climate change will therefore depend on our understanding of what is causing this change.

How do various parts of the 'system' interact and use energy and what impacts may occur?

We have used the following examples to explore these concepts:

Example:
The role of each one of us as an actor in the climate system (population interactions, movement both as a cause and consequence of climate change – impact of climate change could be population migration and greater pressure on resources) *(**GRADE 10**, term 3)*;

Example:
Why do some people and groups use more and others relatively less of the global energy bundle – impacts? *(**GRADE 10**, term 3, development geography)*;

Example:
Hazards – droughts and floods – how does the atmosphere respond to changes in energy flows (atmosphere's expression of imbalances)? *(**GRADE 11**, term 1)*;

Example:
Resource and sustainability – energy use – conventional and non-conventional energy flows *(**GRADE 11**, term 4)*.

Subject Conceptual and Content Knowledge

Understanding both the Earth System and the changes that are happening to (or the causal attributes) is complex and often difficult. We are only just beginning to discover and understand some of these causes. Unit 1 focused on natural causes of change within the Earth System. Unit 2 focuses on understanding the complex interactions between HUMANS and the Earth System. Specifically, we are going to be

> ***distinguishing between the role of human activity as a cause of change and the role of the natural system driving climate change, and the interactions between these sources of change.***

As we saw in Unit 1, climate change has been happening throughout the history of the Earth. So why do we have this renewed interest in greenhouse emissions? This is because we have begun to understand our relationship with the Earth System better with increasing amounts of research.

Exploring some of the human drivers of climate change

Climate is one of the vital parts of the Earth System regulating life on Earth. The changes to the planet, including the notable changes being made by humans, are now beginning to have a detectable impact on climate.

Humans influence the physical design and architecture of what happens on the surface of the Earth through simply trying to live on the planet (e.g. urban settlement, planning and design). We are also influencing the complex dynamics and processes of how the Earth as a system regulates its functioning (e.g. the atmosphere, hydrological system etc.).

In trying to understand the human relationship with the Earth System, it is also important to take a step back and examine who or what are some of the 'driving forces' BEHIND the big climate debates and meetings – who or what is shaping our view and our understandings of climate change:

- Who is making decisions that influence how we all try and live on the planet (e.g. how much energy we have; how much water we have etc.)?
- Are these decisions being made fairly – do some people win and some people lose in the decision making process of how resources are distributed?
- Who are the major players on the global stage, and what mechanisms are used? – e.g. policies and processes such as Kyoto, national Climate Change Strategies etc.
- How are these complex decisions influencing how we use our resources?

These questions fit closely with the human geography parts of the CAPS (e.g. development, economics, sustainable development etc.). The key question then remains: Can we teach and learn about climate change as being only a technological problem requiring a technological fix (e.g. green development)?

We need to remind ourselves that the Earth as a 'system' is the result of physical and human driving forces (we have shown the physical nature of the energy balance and how the climate system is driven by the natural processes operating in Unit 1).

But the climate story is also being influenced by a range of processes – for example, changes in the way we use the land (agriculture, energy and water use, changes in the ecosystem services and biodiversity) that are being driven by complex socio-economic arrangements, belief systems and ideologies that play themselves out in the way in which humans interact with nature.

In some cases the access to resources and use of resources enables some people to be winners and resilient (see section below) to climate change. In other cases interactions and arrangements (e.g. the role of past policies – history, institutional arrangements etc.) can make some groups more vulnerable to climate stresses. These issues are usually very well covered in the human geography sections of teaching and can be linked directly to climate change as is shown below.

Human geography can begin to be introduced here (please note it may be very interesting, however, to START here (with Unit 2) and only introduce the physical dimensions (Unit 1) later once these critical aspects have been understood).

Background

As was seen in the first unit, energy moves into and out of the atmosphere and is also transformed across time and space. By farming, changing landscapes, through industry and through urban and industrial centres, humans are influencing the ways in which the surface of the Earth and basic energy processes are changed and altered. These changes can then feedback into the atmosphere and cause enhanced changes (in some cases they can dampen or reduce the impact of the change).

This is a very large topic and so only a few examples are used to illustrate these changes here – namely food and water. The examples show how various factors, including human and biophysical aspects, impact together with climate on humans and the planet.

These sectors have been chosen because usually the focus is ONLY on energy and one needs to show the nexus and connections between energy and other sectors. These sectors provide good examples that show how energy is obtained, used and transformed by humans in various places (e.g. in urban areas – aspects of these sectors could be used in Grade 12, term 2 – urban settlements).

The interactions and feedbacks (involving BOTH human and natural processes) are also outlined in this section illustrating a holistic approach to this component of climate change. A great deal of work has been developed and written on this topic and a quick Google search will reveal several lessons and other rich source materials.

Although the various themes covered here are usually presented as separate sections of the Geography curriculum (e.g. population and resource use is coupled together with water use etc.), it is important to show the integration and interactions between these themes where possible because this gives us an enhanced understanding of impacts on the Earth System. To illustrate this, we have tried to show the integration here.

Other related themes that could be taught include natural resource use (e.g. biodiversity), oceans and land use and land cover change.

Resource use and change – sections on development – see Grade 11, term 3; term 4 – resources and sustainability.

A variety of approaches can be used to illustrate the use of resources and how this is as a result of and also a cause of climate change. The focus is not going to hinge only on the **resources as a product** that can be used but we will also raise some critical issues such as **access to resources** (who makes up the rules that enable some to get access to more whereas others only have access to little – e.g. livelihoods issues and developing capabilities to better utilise such resources).

See Amaryta Sen's extensive work on developing capabilities.

Some groups may be more **vulnerable** to gaining access to energy, food and water (key themes of research in international and local climate science), not only because of a climate stress but also because of changing food prices, difficulty to access fertilisers and other inputs; difficulty in accessing resources to grow food, etc. This latter issue becomes even more critical when one looks at international climate change negotiations where some arguably may be influencing global outcomes in such ways that may mean the poor could be made more vulnerable to climate change. The field of study in food and fibre and climate change is now moving strongly into an inter-disciplinary and cross- and trans-disciplinary science (Dietz, 2011).

Resilience and vulnerability

Two concepts are very useful particularly when exploring issues of access, use of resources and how these actions can influence climate and climate change. **Vulnerability and resilience** are increasingly being used as concepts to help explain the drivers, impacts and outcomes of climate change.

Vulnerability is a concept that is usually used when exploring notions of how robust or 'weak' a community or ecosystem may be in the face of a climate stress or shock (e.g. flood or a drought). The term or concept is also used in the disaster risk reduction community and is also used in the wider adaptation to climate change field.

See for example Fussel, 2006

Some good local examples of urban and rural vulnerability and resilience include case studies related to the Limpopo Province for example.

Many of these can be found in the Second National Climate Change Communication on the Department of Environment web site – see for example papers by Ziervogel, Archer and Vogel.

In the climate change field the practice has therefore been both to include climate as biophysical DRIVER of change that can produce a range of impacts and to examine the CONTEXT in which climate change occurs.

It is important, for example, not only to understand the role of climate impacting on a receiving community (e.g. to understand how strong the rains are or how devastating a drought may be in terms of reduced rainfall and higher temperatures) but also to understand what factors are making the receiving community STRONG or WEAK in the face of the threat or challenge. Such factors could include changing agricultural support (e.g. farm subsidies); poor urban planning design and infrastructure management – potholes in roads etc.; housing developments in poor land areas (e.g. wetlands or coastal zones) etc.

Coupled with the investigation of vulnerability is the concept of **resilience**. Here the concept is linked to the ability to bounce back after a threat or shock. Can a community easily bounce back after a long drought or what is that may make them stronger to periods of rain shortages or floods?

Read more about resilience internationally and within Africa in these useful websites:
Resilience Alliance – www.realiance.org
Africa Climate Change Resilience Alliance – http://community.eldis.org

Resilience is described as:

> *"… the capacity of a system to absorb disturbance and reorganize while undergoing change so as to still retain essentially the same function, structure, identity, and feedbacks."*
>
> (Walker et al., 2004 cited in Folke et al., 2010, p.20)

These Fundisa for Change units on climate change aim to facilitate understanding of climate change at various scales in order to draw out lessons and ways to better manage change through enhanced and more resilient adaptive capacity.

For additional sources on this very interesting topic as linked to education, training and teaching see also Cundill et al., 2005 and Fazey, 2010.

Folke et al. (2010) note that "deliberative transformation requires resilience thinking, first in assessing the merits of the current versus alternative, potentially more favourable stability domains, and second in fostering resilience of the new development trajectory".

So teachers should be aiming to inform each other and our learners about the complexity of climate change. We should also ensure that our learners do not view climate change as a static domain. Rather they need to know that even though the science is uncertain, the 'system' is changing rapidly and is also being impacted by complex financial and social change (e.g. global financial crisis and social uprisings). We need to, as a matter of urgency, find a pathway through this complex set of issues so that future generations can live with the changes and yet be resilient (able to bounce back from such change and hopefully also bounce forward).

What one ultimately **DOES** about climate change therefore usually depends on your **PERCEPTION** of the issue. If trained as a physical scientist, one invariably is given a very thorough training in science but often through a positivist or factual lens. If one is trained more in the social sciences then the lenses (ways of seeing) used may be more of the critical theory type of approaches (interpretative and ideographic) (Pohl, 2009, p.29).

See Cundill et al. (2005) for a very interesting paper that shows how different perspectives in natural resources management can influence how we understand, communicate and intervene on climate change and resource use. See also the introductory section to all three of these units where knowledge construction and approaches (e.g. epistemology and ontological views and notions) are addressed.

In the sections on teaching practice and assessment, examples of how to work with these rather difficult concepts of vulnerability and resilience to climate change will be provided. In order to teach resilience and vulnerability one must always remember that one is vulnerable TO something. CONTEXT therefore matters. The context in which you find yourself in turn is made up of a number of intersecting factors and processes (e.g. history, economics, etc.).

How do various parts of the 'system' interact and use energy and what impacts may occur?

The example of food access and food production

Africa's weather and climate; Grade 11, term 4, environmental geography – soils, ecosystems; Grade 12, term 3, economic geography; Grade 11, term 2, development geography.

As early as the 1700s, Malthus wrote about the dilemma that may face the planet if population expanded without a similar expansion in resource provision (e.g. food and water). Climate and weather have a very strong influence over resources such as food and water. The links between resource provision and ecosystem services that the planet provides needs to be understood for the future sustainability of these resources.

Food and fibre are strongly linked to climate (see box below). Population change (Grade 10 term 2) is also strongly linked to food provisioning.

It has been estimated in recent science that:

25 million more children will be malnourished in 2050 due to climate change without serious mitigation efforts or adaptation expenditures

Climate change will increase prices in 2050 by 90% for wheat, 12% for rice and 35% for maize, on top of already higher prices

Irrigated wheat yields in 2050 will be reduced by around 30% and irrigated rice yields by 15% in developing countries.

Source: Alliance between the CGIAR centres and written by Moorhead, A., 2009: *Climate and agriculture and food security: A strategy for change*.

Other good cross-references to the links between resources and population can be found in Platinum Learner's Book, Grade 10, 2011, pages 225-230.

It is important to note that the amount of food PRODUCED is not the only important aspect to understand in the climate change story. Even without climate change, many agricultural systems are already reaching a crisis point (Alliance of the CGIAR and Moorhead, 2009). Food also needs to be ACCESSED and USED. How food is accessed is dependent on complex, regulated rules, on supply and demand and on 'who is making the rules of the game' – e.g. trade.

So in the food arena, climate change may enhance areas and situations where food production may either become an advantage or a challenge (e.g. too much or too little rain can impact on crop production and also on where and when plants are grown). Climate change may also bring opportunities, enhancing periods of growth that are currently limited. In some places, changes brought with climate change, could be very beneficial to crops, so not all changes are, or are expected, to be negative (Dietz, 2011).

In terms of energy, any changes in land farmed or crops grown may also mean that exchanges of carbon are made into the Earth System, acting as a feedback into the system in complex ways. For example, the burning of biomass to clear areas for farming may release carbon into the atmosphere. Certain crops and trees may also grow differently if the climate changes and may therefore feedback into the Earth System in various different ways. The idea here, however, is not to only focus on food as a product that it is produced in a simple way. The types of crops grown, the range and amounts of food grown are all linked NOT ONLY to climate and agricultural factors but also to SOCIO-ECONOMIC and SOCIO-POLITICAL factors.

Climate change also offers the chance for humans to think seriously about how food is regulated, traded, prices assigned to products as well as about designing new seed types (where safe and ethical). So climate change is not just about drought=no food=starvation.

One of the key issues to share with learners is that prices, for example, also play a major role in how 'vulnerable' a place or population is to climate stress. Prices here can include prices for food, prices for fertilisers to grow food, subsidies for fertilisers and other equipment to grow food, etc. Climate change (including climate variability – periods of floods and droughts) may then aggravate and make an existing situation worse (e.g. farmers may go out of farming if a drought is added to their struggle to produce food because of high input costs). Development in the food arena, under climate change, can thus be positive and/or negative with many downstream impacts on livelihoods.

See, for example, the chapter related to food and fibre in the Fourth IPCC Assessment Report.

See for example paper by Dietz, 2011.

This section could be linked to topics taught in technology.

Growing food is also linked to how a farmer prepares for production. Climate seasons are therefore very important. If a farmer can know a little ahead of time what the rainfall and temperature MAY be he/she can then manage his/her inputs costs and farm or plan accordingly. Climate messages (e.g. climate outlooks/forecasts), when and how they are communicated are also important. Communities also have years of coping mechanisms and have valuable local knowledge to share in those areas that may be stressed by climate change and variability in the future.

See the section on GIS, Platinum Learner's Book, Grade 10, 2011, pages 23-43.

Communicating risk effectively (by using data in the form of maps, GIS, etc.) and building on local knowledge can therefore be very useful in helping people prepare for climate stress.

Related themes to climate change and food

Interesting websites:

Eldis Food Security and Gender Resource Guide http://www.eldis.org

FAO Focus on Gender – www.fao.org/gender/gender-home.en

Global Food Security Initiative www.globalfoofsec.net/modules/gfs/knowledge_resource/gender_and_food.

IFPT Focus in gender

IDS (Institute of Development Studies).

As seen above, a number of additional themes can be related to food and climate change.

- The role of women in food production. In Africa and also in parts of South Africa the issue of gender and climate change also provides an interesting lens to view the issue of climate change.
- The issue of **food sovereignty** is also becoming a consideration that may shape the resilience of a group of people to the challenges that climate change may bring. Here the issue of people's rights to produce and define their own food when compared to the role of market forces is becoming an area of interest.
- The role of **culture** in issues linked to food security. Issues of who eats first can impact on women and children's' food security etc.

Another theme that can be used to explore climate change and energy is the theme of WATER.

Water quantity and quality: links to climate change

See for example, sections in Platinum Leaner Book and Focus Geography Leaner Book.

Water, like food, is a very large topic to cover in a few paragraphs so a few ideas are given here on how human factors linked to water are also closely linked to climate change. Water is a critical renewable resource, if managed effectively. The hydrological cycle ensures that water is always circulating through the system (evaporation, condensation, precipitation and groundwater through flow). Water, like food, is also not just an isolated, stand-alone resource only linked to the physical dimensions of climate (e.g. rainfall). Water is also a very regulated resource (both locally and internationally).

www.IPCC.ch

See for example several local Water Research Commission reports, www.wrc.org.za.

See for example the series edited by Zietsman (2011) entitled "Observations on environmental change in South Africa"; and "Climate change – Global risks, challenges and decisions", by Richardson et al., 2011.

Floods and droughts are key sections taught in the Geography curriculum in Grades 10-12.

The state of water, as linked to climate change, has been covered in a special IPCC report on water and is a topic of major research locally.

The resources listed in the side bar, for example, all show water as being very closely linked to climate – too much water usually results in floods and too little water usually results in droughts. The outcomes of these processes generally become **additional** challenges for ecosystems and humans.

The ecosystem and settlements may already be challenged by a range of factors. Flooding or a drought period merely 'unveils' these underlying issues bringing them to the fore

(making them more obvious). For example, flooding may expose poor storm-water drain management in urban centres. Droughts may expose poor farming practices etc.

The National Climate Change Response Papers, Green and White Papers and the Second National Climate Communication for the UNFCCC all also contain some good extracts on water use and management and links to climate change. This exercise was conducted by several scientists to report on the 'state' of climate change science in South Africa.

As with the section on food, water is not only about supply but is also strongly impacted by the way in which the resource is managed, including regulation. Water quality can deteriorate if it is poorly managed.

One excellent resource that usually addresses these issues from both a human and physical dimension is the journal entitled *Environment, Science and Policy for Sustainable Development*.

The rate of change and magnitude of the problem (that it is ultimately everyone's problem – a global 'tragedy of the commons') is, however, of concern and hence part of the reason for an international response effort (Kyoto Protocol).

There are several sources on this topic and these are taught in Grade 11, term 1; Grade 12, terms 1 and 2 – urban and rural settlements and fluvial systems. The management of water as a resource is covered in Grade 10 and Grade 11.

See Platinum Learner's Book, 2011, pages 284-293.

Water quality and management: see for example publications of the Institute of Development Studies, the World Bank and OXFAM; and local newspaper articles (e.g. acid mine water drainage; the Lesotho Highlands Scheme) and several video resources available.

See for example issue 52, number 6, 2010 of the journal, which deals with the case of the Caribbean that is at risk because of pressures on its water resources, coastal zone resources and socio-economic stability. For information on issues on the environment and people in water and energy see also the journal *Environment*, Volume 54, 1, 2012, on "Our water and environmental security challenges".

Teaching Practice

In this section of unit 2 we present some examples of HOW you can teach learners about climate change. The aim is not to provide a pre-determined set of activities that you can use in your classroom. Instead, we will be working with you to help you integrate different methods of learning into your teaching practice, depending on your educational intent.

This unit takes a different approach to the teaching practice in unit 1. In unit 1 we explored a range of activities using different learning methods and resources. In this unit, we have selected a limited number of resources, and explore the different ways in which we can use these resources for teaching about climate vulnerability and resilience, and about the effects of natural and human actions on the Earth System.

We have purposefully referred to activities that engage learners in active meaning-making – in other words, there are no clear facts, or right or wrong answers. Learners need to engage with the information and make sense of it by research, debate and exploration. These activities open up spaces for integrated learner activity that provide opportunities for both 'deeper' (e.g. values issues) learning, and more 'surface' or factual types of learning.

Useful starting points

It is often useful to look through a few newspapers or do an online search on current news stories involving climate change – this will provide you with a range of pictures and mini stories to work with for a variety of activities. There are also a number of useful YouTube videos and podcasts sharing climate change stories that you can download. Alternatively, you can use a selection of case studies from some of the international reports.

Such resources can illustrate the relationship between the biophysical and socio-economic drivers of climate change. They can give you starting points for your classroom work, and create a link to the real world for your learners.

The way in which these case studies or stories are presented is very important. One must be very careful in assigning climate change as the ONLY causal factor (see unit 1, Figure. 3). The changes being observed in this case may be more closely linked to climate variability and not longer-term climate change e.g. drought. Other compounding or contributing factors such as human-induced change e.g. need for water for irrigation and basic water supply, may also be aggravating the situation.

These examples can then be expanded and linked into a group discussion on the role of population movement and migration as responses to change (Grade 10, term 3), and other themes for example.

In this unit, we will look at how a set of case studies and stories of resilience can be used in a number of different activities. The case studies and personal stories can be found in the appendices at the end of this resource.

Using topical examples

Another way to find useful resources is to identify a specific topic that is relevant. For example, Lake Chad is often discussed as a showcase for climate change.

Lake Chad is an interesting example for it is the largest inland drainage system on the continent. It is also a shallow lake system only about 1.2 metres deep. The lake is shrinking, however, through both the huge human demands being placed on it and also by biophysical changes, namely periodic droughts.

See earthobservatory.nasa.gov, *Africa's disappearing Lake Chad* and other similar web based sources.

This case study (that could be supported with interesting satellite pictures of change over time – often images that can be downloaded if one has access to the Internet) illustrate that water has both a 'driving' and 'response function' in the story of climate change.

Other interesting cases can include examining the 'case of drought' from both a biophysical and social perspective. There are several images of starvation and drought impacts (Somalia, Kenya) that are easily accessed on Google and there are also various YouTube case studies. These can be set as an exercise that once again shows the interaction between the biophysical and socio-economic drivers of climate change.

Scenario-planning and learning by doing

See pages 27 and 35 in the *Methods and Processes* booklet.

Using the article "Arid Areas are Becoming Drier Still!" in the appendices design a scenario-planning activity. Think about the following when designing your activity:

- You may want to include activities for reading and summarising the 'story of climate change' told by the two case studies. Asking the learners to identify the impacts of climate change described in the article will help them to make links between their existing knowledge of climate change and climate vulnerability.
- Asking the learners whether any of the impacts described in the case studies are relevant to them will assist them in making connections to their own lives and potential vulnerability in their lives.
- Asking learners to reflect on whether they have heard about similar issues within their communities will also help them to reflect on whether or not climate change is already affecting their lives.
- Remember that scenario-planning involves making predictions about how things could occur, based on the data available.

Next, design a 'learning by doing' activity. Use the examples of climate heroes and heroines included in the appendices. After reading these stories, ask the learners to design a plan to improve their resilience to climate change. Think about the following when designing your activity:

- Remember that you will need to assist learners to make a link between their vulnerabilities to climate change (that they identified as part of the scenario-planning activity), and how they can improve their resilience. Their plans should clearly reflect which

vulnerabilities they are responding to and how their proposed project will make them or their community more resilient.

- It is useful to remind learners to focus on practical things they can do (for example, practical activities that can improve their food security or water conservation).
- It would be ideal to then work with learners to implement some of their projects within their communities.
- Remember that both of these activities can be designed as both individual and group tasks.

Fieldwork and collaborative research

See page 24 in the *Methods and Processes* booklet.

Case studies can be used as starting points for a research project. Ideas for fieldwork include mapping the condition of learners' natural environments (Are there already signs of drought or flooding? Are there things that would make them more vulnerable to weather extremes, like erosion or poor water conservation techniques? etc.) Things to remember:

- Fieldwork needs to be focused and have a specific aim – what is the information the learners need to gather, and why is this information useful and relevant? What will it tell them about resilience or vulnerability?
- How will learners' use the information they have gathered to make sense of climate change and its impacts on their communities?

Role play and debating

See page 20 in the *Methods and Processes* booklet.

The same case studies (or articles and videos) can be used as a basis for role play. You could ask learners to pretend that they are reporters telling the story of what has happened. Ask learners to review the information within the case study, and develop a news report – either the case study or the stories of heroes and heroines can be used, because good news is as important as being aware of the negative impacts of climate change.

Role play allows learners to explore and put themselves in the shoes of other people from a variety of perspectives.

Things to remember when designing role play activities:

- Asking learners to adapt the stories for their own communities, using the information they have collected in one of the previous activities will allow them to present their findings in a new way.
- You will need to give learners a time limit for their plays.
- Role play is often more successful as a group activity.
- Remember to ask yourself what the purpose of the role play is – What do you want learners to learn about climate vulnerability and resilience? Will role play help you to teach this?

Examples of role play around vulnerability and resilience

A learner can take on the role of a TV newsreader commenting on the issue of desertification, for example. In this case the newsreader may not be directly engaged with the details of the issue and is rather 'communicating the issue'. Another learner could take on the role of a local member of the community living in a desertified area who then relates a day or week of the life a community member to the class.

Through this exercise differences in views and perspectives should emerge that can be expanded on for debate. The role of desertification as a 'feedback' into the Earth System can also be probed (for example, by examining the role of the albedo and the role of 'changing of the surface of the Earth' particularly over large spatial scales).

In the example above, a range of key issues in relation to climate change are being explored:

a) How land use management practices can alter the surface of the Earth which can then have feedback into the climate system.

b) Perspectives on what is driving or causing change – is it simple pressure on resources or are there other factors at play?

c) What interventions can be planned to make positive changes in this situation?

Another useful way of unpacking vulnerability and resilience issues is to design a debating activity. Learners would then argue for two sides of a story – for example, someone defending the development of a new factory, and another person claiming that it would make the community vulnerable to climate change. Things to remember:

- Learners will need to do enough research so that they are debating based on facts, and not simply based on their feelings or opinions. This research can be done as a group task.
- It is useful not to have too many people debating at once – small teams supporting each side of the debate are more practical than big teams or individuals. You will need to open up the discussion to the rest of the class after the initial debate so that they can contribute any views that were not represented.
- A debate usually needs to be followed up with an activity that supports learners to makes sense of and record their learning during the debate – this could be asking them to write a mini news report on the debate and the two sides of the argument.
- You will need to prepare some prompting questions to keep the debate moving – these should be provocative – something that opens up the debate and discussion, and should move between the two (or more) sides of the conversation.

Key questions for all of the activities above would include:

- What caused the changes e.g. desertification?
- What would it be like to live in such areas?
- What interventions can be undertaken (e.g. development and mal-development, water, food provision etc.) (Grade 11, term 1 and term 3) to improve the situation and how could this be done?

- Who or what is **vulnerable** to climate change in the picture you have (e.g. a scene in Africa showing the rural or urban context)?
- Why are these groups vulnerable to climate change? What **factors could be contributing** to their vulnerability?
- In what ways and through what activities are changes being made to the ecosystem that may then impact directly/or indirectly on the climate system? etc.
- Are there any solutions to these problems? Give an example of a few for each possible scale of intervention e.g. local scale, national scale and international scale.
- What social and economic factors are leading to environmental changes e.g. degradation in the urban environment?
- What are some of the biophysical factors that could also be shaping change?
- What would it be like to live in such areas? What interventions can be undertaken (e.g. effective development, water, food provision etc. – give some specific examples to improve the situation and how could this be done – what will it take to get the action on to the ground, to the people and places where it will count?

For example, see Grade 11, term 1 and term 3.

Assessment Practice

In this final section of unit 2, a few assessment approaches are provided. The focus is on testing knowledge, understanding and possible individual transformation around notions of climate change in terms of complex interactions, how energy is used and transformed by humans and other processes.

It is good to begin to assess if learners can also begin to make links between major climate patterns, weather and impacts. Some core climate knowledge may be required before one can begin to expand into other related areas of climate change science. A variety of cases can be given. Try to keep cases up to date and relevant to learners' contexts.

See examples in the Focus Series, 2006, Grade 12, pages 74-75

Basic – factual recall, remembering type assessments

The climate system responds to energy input into the atmosphere. If there is a build-up of energy it is either moved by winds or changes occur in the composition of the atmosphere to release energy e.g. through rainfall etc. Understanding how the climate and weather systems play a role is therefore key in understanding HOW energy is re-distributed across time and space.

- Learners need not only work with examples of tropical cyclones; mid-latitude cyclones and high pressure systems may cause prolonged periods of dry weather and drought.
- For example hurricanes release vast amounts of energy through latent heat release e.g. Katrina (but again such hurricanes should not be interpreted as being because of climate change).
- Drought cases.
- Hot days and heat waves in Europe.

In these tasks learners would be asked to draw and construct diagrams showing where and how these atmospheric pressure are located on the globe and what they produce e.g. high pressure usually produces or is associated with dry, sinking air.

> **NOTE:** *The key will be to assess if learners can get the subtle difference that these events are not clearly linked to climate change and may be part of normal weather and climate.*

Another key element in the exercises and subsequent assessment is to ensure that learners can show why such phenomena occur, where they occur and what can be done about their impacts. The various systems can then be expanded by examining HOW they may change in future given climate change.

To test such knowledge one can ask learners to answer factual recall questions on climate systems; one can also give them graphics of a low pressure and high pressure system and ask them to label and explain how they move and distribute energy or one can give them a specific situation e.g. a 'drought' case and ask them what pressure system is usually associated with such weather or climate.

The marks assigned for these assessments will vary but again marks should be given for the accurate understanding shown of how the phenomenon develops, together with where and what can be done to best live with or adapt to the event/outcomes of the phenomena.

Here the knowledge gained is that knowledge about how various parts of the Earth System interact and make use of energy and what impacts may occur if this energy use is uneven or over-used, etc. Here the biophysical and human parts and actors of the Earth System have to be examined, for example:

- the role of people as actors in the climate system (population interactions, movement both as a cause and consequence of climate change – the impact of climate change could be population migration and greater pressure on resources) (GRADE 10, term 3);
- why do some people and groups use more and others relatively less of the global energy bundle? And the resultant impacts of this unbalanced energy use (GRADE 10, term 3, development geography);
- hazards – droughts and floods (GRADE 11, term 1) – how does the atmosphere respond to changes in energy flows? (atmosphere's expression of imbalances).
- resource and sustainability – energy use – conventional and non-conventional energy flows (GRADE 11, term 4).

In this section the skills required include more interpretative skills, being able to read, understand and make the links between climate change and variability on the one hand to a range of human drivers on the other. The ways in which energy moves in the system and is used and/or abused needs to be foregrounded and understood.

Moving to some of the technical responses to energy movements in the systems the following assessments can be used.

Simple – factual recall, remembering type of assessments

Sections from the Platinum Series, 2011 (pages 92-93) are good to use here for assessment, e.g. examining the causes of global warming and interpreting geographic data from pie charts to examine which sectors produce the most greenhouse gases.

Shallow assessments in this section would be assessing some of the basic factual knowledge of different energy uses and how these energy systems operate in the world. Various energy types e.g. renewable and non-renewable could be assessed as well as examining which countries produce the most greenhouse gases. Here the assessment would be examining recall and remembering, important skills, but not the only skills required.

Examples of some of the types of tests and exam assessment can be obtained from the relevant Department of Education. These assessments examine some basic remembering and analysis but one notes the assessment is lighter on the higher order skills e.g. creating.

Deeper / higher order types of assessments – analysis, evaluating and creating

Assessment in this section can be very interesting both for the learner and the teacher. One is trying in the assessment of resource use (e.g. energy) to probe values, issues such as ethics and other deeper dimensions of the issue of energy resource use.

A number of assessments can be presented starting from a more basic probing of values. For example, a picture of a power station belching out gases can be given to learners as an assessment exercise. Learners can be asked, either in a test situation or in a take-home essay reflection, to comment on the picture.

Examples of probing questions:

- Who benefits from the emissions coming from this power station?
- What are the emissions from this power station?
- How do these emissions and the energy they produce contribute to the local and national economy?
- Who makes up the rules of the energy game in South Africa, e.g. who decides how much energy we have, what we pay for energy etc.?

The role of big business and the role of the small users and the role of larger energy providers, such as Eskom, can be explored here. This could be assessed using a range of criteria depending on the task (e.g. marks would be provided for showing new evidence and a good literature review; marks would be assigned for a good understanding of some of the 'politics' and 'ethics' that underpin energy use in South Africa; and marks awarded for being able to write clearly about such issues etc.).

Learners may also work on a small project. Here the work of Riedy from Australia is interesting to follow.

The work of Chris Riedy from the Institute for Sustainable Futures in Australia (www.isf.uts.edu) profiles some deep learning approaches and there are documents and inputs on water, energy and about the home and how to make energy usage sustainable.

Conclusion

In this unit, energy resource and change have been profiled. The links between social factors and the actions of humans as well as biophysical changes have been articulated. Knowledge content, teaching practice and assessments have been provided.

Concepts of vulnerability and resilience and how they have become central to the climate discourse have also been profiled. Such concepts enable a more comprehensive examination of how social and biophysical factors interact to produce situations in which climate stresses may either enhance of reduce the 'status' of an ecosystem or landscape.

Unit 3

Responses to energy exchange and climate change

This unit focuses on our responses to the changes in the overall Earth System, as described and worked with in the first two units. The key questions addressed in this unit are:

What can we do to make positive improvements to the energy system?

How does the system, including humans, respond to changes in the system?

The unit also attempts to bring attention to measuring the learner's progress in promoting a healthier self and planet.

This relates to some of the topics in the CAPS as shown in the table below. Teachers and teacher educators should consult CAPS documents and textbooks for specific curriculum content, as this unit is not a textbook, but rather a resource for teacher education.

Unit 3 related topics within the CAPS, showing relevant grades and terms

KEY CONCEPTS AND PROCESSES	GRADE	TERM
A narrative of change; Geomorphology: change through time	10	3
How do people respond to climate changes? Droughts and floods	10 11	4 1
How do humans interact with climate change? Responses and interventions; population movements, settlements; governance, climate policy	10	2

Actions for climate change can be based on scientific content and information as well as on beliefs, values and perspectives and issues that emerge from 'the gut' or from the heart.

We have come to understand that climate change is made up of both CONTENT and TRANSFORMATIVE knowledge domains:

In Units 1 and 2, Climate Change and Climate Variability were introduced. Content knowledge and knowledge for energy changes as well as the interactions between humans and the environment were explored. In this unit these themes are expanded, by focusing on how the Earth System (including humans), respond to changes in the system. We also consider how we can enable effective response to climate change and variability.

This unit aims to help teachers to understand the various types of interventions that are possible, including both internal (personal) and external (by some other agency) possibilities.

We consider this through the following examples:

Example:
Past changes – a narrative of change – geomorphology change through time *(**GRADE 10**, term 2)*;

Example:
How do people respond to climate changes? – droughts and floods *(**GRADE 10**, term 4; **GRADE 11**, term 1)*;

Example:
How do humans interact with climate change – e.g. climate change responses and interventions - population movements, settlements, governance – climate policy and international climate change legal/policy regimes COP etc? *(**GRADE 10**, HIV and AIDS, term 3; development themes, **GRADE 11**, term 3)*.

To make understanding the responses to climate change (including adaption and mitigation) easier, we have chosen to use a scaled approach. This means that the unit covers a range of responses, including:

- International level – major negotiations and agreements
- National and regional level – regional and national policies
- Local level – local policies and ACTION for change.

These activities link very well to the sections on **sustainable development and development geography** (Grade 11, term 2) at various levels, and will be briefly examined.

As with the other units, this unit is divided into core knowledge, teaching practice and assessment practice.

Subject Content Knowledge

In the Fundisa for Change programme, we have been aiming to enhance specific knowledge and skills. Learners should, for example, be able to distinguish between weather and climate and be able to understand the large energy complex that is the climate system.

Key content knowledge questions include:

- What is climate?
- What is weather?
- What 'drives' climate and weather?
- How does climate change over time – under the influence of the driving role of both human and physical factors?

At the same time, learners should also be asking some deeper questions that enable them to DO more about climate change – or make use of transformative knowledge. This knowledge draws on deliberation and potentially leads to change in our beliefs, values and actions.

> **So for you as a teacher and facilitator, this unit is NOT ONLY about communicating and sharing knowledge and information on climate change. It is ALSO about enabling your learners and yourself to journey on a path of deep introspection and reflection. The learner and the teacher are thus going on a journey together to learn about climate change. Issues such as: "How does my daily lifestyle impact on those around me"? "Who and what is shaping and influencing my daily choices of how I eat, work and move around?" "Am I becoming a greedy consumer or am I conscious of what impacts my actions have on my neighbours and on myself?" These are not trivial questions. These issues cut to the heart of the matter about climate change and sustainability, including critical ethical and value dimensions of climate change, the human security concerns and other aspects that continually frustrate a smooth set of international negotiations on climate change (e.g. Conference of the Parties meetings in Durban, COP 17).**

Transformative learning includes developing indicators of, in this case, knowledge for and about climate change, including:

- Experiencing an enhanced level of awareness of the context of one's belief and feelings (in this case about climate change)
- Critiquing one's own assumptions and particular premises (again about climate change)
- Performing an assessment of alternative perspectives (on climate change if required)
- Taking action based on a new perspective, and
- Cultivating a desire to fit the new perspective into the broader context of one's life. (Shambhala Institute, 2004)

This unit focuses on growing learners' knowledge, values and actions about and for climate change in two ways: by developing knowledge **about** climate change, and developing

transformative learning and knowledge that enables learners **TO DO** something about climate change.

International response to climate change

Climate change is a very useful frame that one can use to teach a number of critical life-long learning attributes (e.g. values etc.). The 'climate space' that is critical for life on Earth is being threatened by an interaction of physical and human-driven activities (as shown in Units 1 and 2). This is a **global problem** (tragedy of the commons) and requires a **global response**, that is made up of various actions, for example, international regulation and various protocol processes (for example, COPs), but will also require **personal change** to solve.

The tragedy of the commons refers to the depletion of shared resources by individuals or nations driven by self-interest, despite their understanding that this depletion is contrary to the long-term interests of all.

COPs – the Conference of the Parties.

The climate change response has up to now been contextualised and framed using two approaches, namely: through adapting and mitigating to climate change, and through climate variability. These two terms have become common in the climate change discussions and wider discourse over the last ten years or so. They are linked to our efforts to try and understand ways of ameliorating climate change including the impacts of climate change.

Reminders of key terms – Adaptation and Mitigation

Adaptation usually is used in association with 'living' with climate stress and change. Adaptation is often used at a more national and local scale. Mitigation is usually focused at a national, regional and global scale.

Species and people can, in some cases, manage their climate risks by either moving to a better habitat area, by enhancing their overall robustness (resilience) in the face of change or they can try and survive the stress by developing 'coping' mechanisms (e.g. planting more drought tolerant varieties of maize; by including various water harvesting practices into farming practice; by ensuring that storm water drains in large urban areas are well maintained).

The official definition for adaptation from the IPCC reads as follows:

> *"Initiatives and measures to reduce vulnerability of natural and human systems against actual or expected climate change effects."* (IPCC, 2007, p.76)

Mitigation usually refers to those activities that can be used to reduce the overall activities that are aiding in causing or driving climate change. Here activities usually are coupled to those that reduce your 'carbon footprint' or impact and are activities at a global and or regional and local scale (e.g. Kyoto Protocol; South African White Paper on Climate Change) to reduce greenhouse gas emissions and actions required to enhance greenhouse sinks (e.g. sustainable development of forests and sustainable land use management etc).

The IPCC definition states that:

> *Mitigation is the "technological change and substitution that reduce resource inputs and emissions per unit of output."* (IPCC, 2007, p.84)

The big debate in climate change, taking up much of the international climate agenda at COPs, is trying to find appropriate and sustainable ways to effectively address mitigation

and adaptation, and the benefits of adaptation/mitigation to climate change and climate variability.

The international response to climate change can be found in the Grade 11, term 2, Development Geography. Here issues of disparities of power, 'North' and 'South', the roles of development aid and financial support as well as the links between gender and development can be taught using climate change as a lens through which to view these issues. Resources on such themes can be found in, for example,WWF's *The New Climate Deal – A pocket guide* (Pearce, 2008); IIED, OXFAM and Greenpeace publications; and Dubash in the *World Development Report, 2010*.

Bearing in mind that these units provide insight into only a few of the key causes and effects of changes in the Earth System and their impact on climate change, it is useful to remember that the responses described in this unit are only key examples of work that is being done – it is not an exhaustive list by any means of the mitigation and adaptation efforts outlined in various policy arenas.

Climate change negotiations – struggles between North and South

As Dubash (2009, pp.1-2) noted the climate negotiations are aligned (usually along North-South lines) and unfortunately dead-locked by **'two competing ways of thinking about the problem – environment and equity'**. Dubash notes that for many years the climate change problem has been framed as a biophysical issue with a focus on greenhouse gases and stocks, with a key intervention being greenhouse gas emission reductions. In addition Dubash notes not only the 'tragedy of the commons' but also that the issue of equity is central to the discussions.

See also Bond, 2012 for some good South African examples.

One cannot talk about greenhouse gas reductions without a reflection on how the commons or how the 'ecological space' is apportioned and shared (e.g. what share do countries of the North have relative to those of those South. Such issues are part of the Framework Convention in the "common but differentiated responsibility" and "burden sharing" principles. The costs of 'going green' and developing in more 'climate friendly and sustainable' ways will be high, particularly for developing economies and those in transition.

Here issues of regulation can be addressed not only by presenting the costs and 'threats' and 'challenges' but also by discussing the climate change challenge as an opportunity.

See a critique of neo-liberal and capitalist paradigms on pathways of development and climate change in Bond, 2012.

There are therefore both 'winners and losers' in the climate change game. Moving to a 'low carbon economy' will be challenging and will require serious choices – for example about development pathways.

See for example India's submission to the UNFCCC and the role of civil society in such debates (Third World Network, 2009 cited in Dubash, 2009).

It is important to give learners multiple perspectives on climate change so that they can make informed critiques and choices about what is happening.

For collective solutions, see Dubash, 2009 and ASSAf (*Towards a low carbon City, focus on Durban*, 2011). See also several co-benefits between mitigation and adaptation in this volume) (Grade 11, urban and rural settlement).

An example often cited in various sources on how this can be taught and linked to CAPS curriculum content is to illustrate how work and residence/living spaces can be better planned and designed so as to co-locate the two sets of activities for reduced transport, better urban design including buildings etc., better public transport. In this way, we can reduce our carbon footprint and at the same time try and ensure that we can cope with and adapt to changes that may come about because of climate change.

See Wycoff and Roop (2010) on embodied carbon.

Another good example of how the international negotiations can be incorporated into the curriculum (including decision making, trade, climate change and development, all Grade 11 themes) is to focus on globalisation themes e.g. virtual water and carbon trade concerns. Carbon movements around the world are very interesting. Carbon emissions when mapped across the globe, including those sent to and exported and imported into various countries via traded products, raises interesting concerns when drawing up carbon baselines. Should carbon amounts (emissions) only be measured within a country? What about emissions that are brought into and exported out of a country?

Regional and national response to climate change and links to CAPS

At the regional and more local level, attention is increasingly focusing on CDM (Clean Development Mechanisms), a system under Kyoto that enables industrialists or others to obtain 'carbon credits' for investing in projects in developing countries to reduce greenhouse gas emissions (Pearce, 2008) and carbon budgeting (where countries and sectors are required to budget for their carbon emissions).

The Kyoto Protocol of 1997 is an international treaty on the reduction of emissions of greenhouse gases.

See the South African White Paper on Climate Change for more discussion on this with reference to South Africa.

While these issues are important it is also key that learners debate and critique these efforts, rather than seeing only one approach as right without considering whether there are better solutions, or whether these solutions favour some to the disadvantage of others. Learners should be supported to make informed decisions and draw informed conclusions from the wide discourse in this area of an even wider climate change discourse. Here the voices of civil society, the tensions between business and civic society and the green environmentalist position also need to be explored. It is also important to remember that we can hold several views at once, and that no singular view may be correct. The issues of ethics, environmental justice and other critical themes can and should be introduced to learners.

See Bond (2012).

About the CDM (Clean Development Mechanism) – cdm.unfccc.int; www.cdmcapacity.org; *The CDM: Rip-offsets or real reductions?*, thinkprogress.org; *Reforming the CDM for sustainable development: lessons learned*, www.environment.arizona.edu.

Useful resources for global and local response themes:

- UNEP: Global Environmental Outlook 5 – A Summary for Policy Makers
- UN Climate Information Kit – Information on climate change from the UN, World Meteorological Organisation
- Resource reduction: Meeting the World's Energy, Materials, Food and Water Needs – McKinsey Global Institute, 2012
- The Changing Wealth of Nations – Measuring Sustainable Development in the New Millennium – World Bank, Environment and Development

Ensuring '**change for climate change**' is therefore not easy. As a teacher and facilitator, you should be mindful of various conceptual framings of the climate problem as briefly illustrated in all the units. To facilitate personal change in this field, a range of self-exploration and other self-sensing activities will be required.

See several texts on this in the *Integral Journal of Education*.

Local and personal response to climate change

This section is really for the teacher that wants to explore some new IDEAS around climate change and behaviour and values etc.

Many people acknowledge, knowingly or unknowingly, that science though critical and valuable, including several Ten Year Science (e.g. DST) plans and policies, may not be enough to see us through the future challenges we face:

> *"in order to 'create the world anew' we will all be called to participate in changes that are 'both deeply personal and inherently systemic.'"*
>
> (Senge et al., 2004, p.1)

We need to find appropriate ways to reflect more on our own behaviour, at the very local level, including reflections on different cultural and other knowledge constructions of the climate change issue. Such reflection should also be aware of issues such as social engineering, avoiding trying to design change **via** legislation that may not be transformative. This type of an 'integral and reflective' approach could be used at the start of the teaching years in Grade 10-12 and then picked up throughout the curriculum. Using four quadrants, known individually as subjective, intersubjective, objective and interobjective (also referred to as "I", "We", "It", and "Its" or the terrains of "experience", "behaviour", "culture" and "systems") Integral Theory provides a way of making sense of diverse perspectives, (see Figures 3.1 and 3.2).

See for example Vogel, 2011.

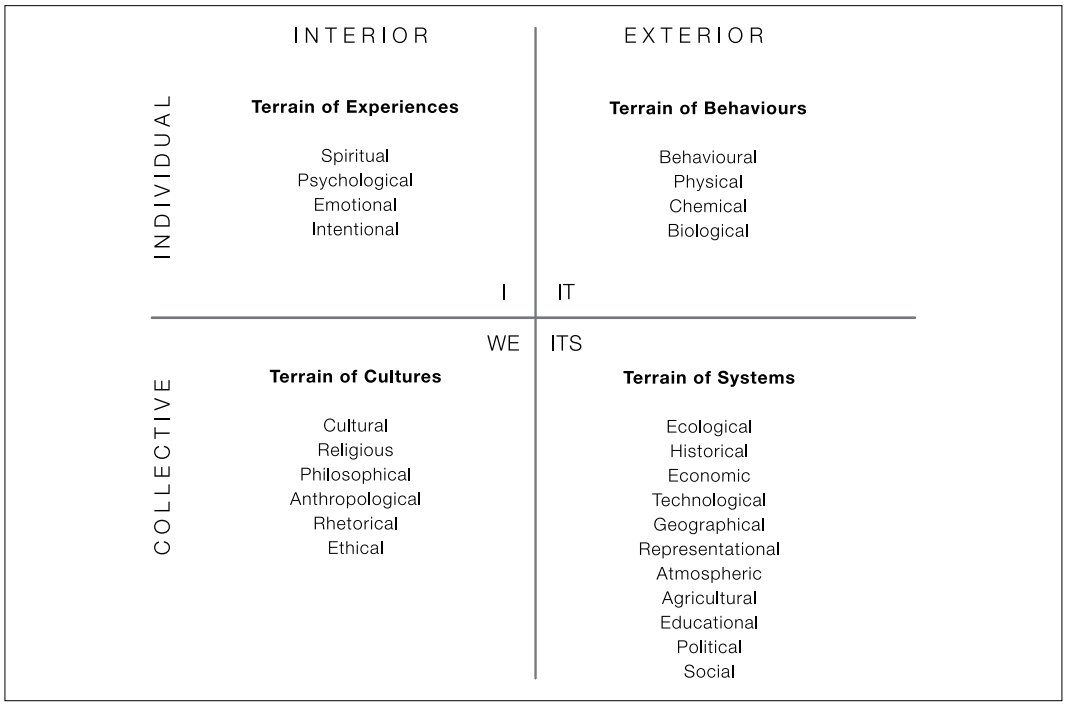
See Figures 3.1 and 3.2, and Esbörn-Hargens, 2010.

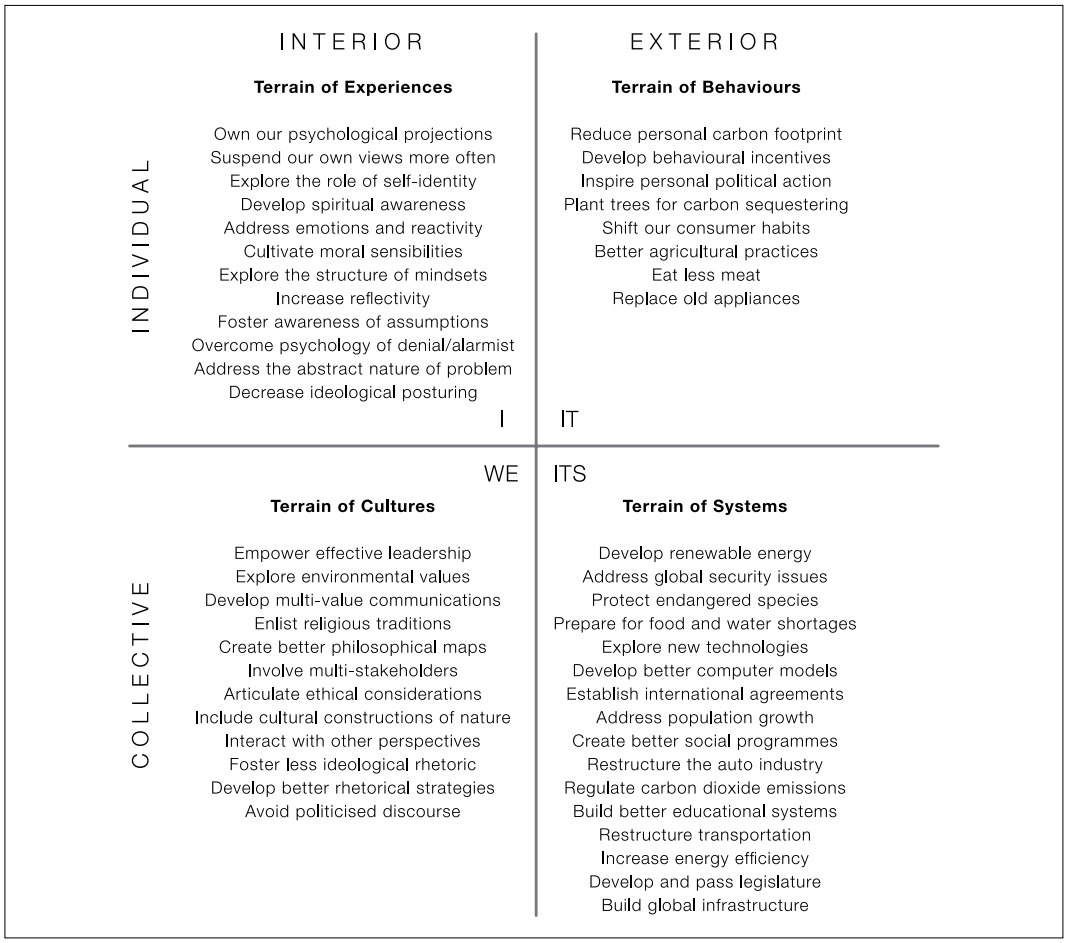
Some are beginning to explore the types of education (here interpreted in its wider sense) that may be required for an integrated understanding of what it may take to, for example, adapt to climate change (Inglis, 2009). The field is rich. Here some examples of reflections from Esbjörn-Hargen's recent work (2010) are explored. The ontological status of climate change and notions of ontological pluralism are investigated using integral theory (Figures 3.1 and 3.2). Such an approach clearly provides useful entry points for deeper debates about what may be required and what may be of relevance for a climate change adaptation curriculum.

See for example the *Journal of Integral Theory and Practice* and the *Integral Leadership Review*.

Climate change can therefore be divided into two components – interior elements and exterior elements. Much of the content provided in this unit, and as usually found in key climate change texts, is all about the system (the bottom right quadrant of the figure) and is rooted in the systemic and external understanding of the system. But of equal importance are also the 'interior' of left hand quadrants that are often not clearly articulated or explored (Figures 3.1 and 3.2).

Figures 3.1 & 3.2: Twenty-five major dimensions of climate change (after Esbjörn-Hargens, 2010b, p. 5).





In his thought-provoking paper, Esbjörn-Hargens (2010) presents a sample of methods, building from an integral perspective, of what may be considered for addressing climate change (Figures 3.1 and 3.2). Such framings begin to call for a much deeper reflection on what may begin to be considered for effective discussion on curriculum design. He also provides reasons why it is advantageous to both philosophically and pragmatically relate climate change as an ontological plurality (e.g. including, empowering effective leadership to enable people to work with many variables and scales associated with climate change; leadership also needs to be able to talk with and involve many stakeholders; we need to be able to engage and include various faith dimensions and cultural constructions of nature).

Of interest here and a criticism of the CAPS, is that even in the CAPS we still have a science-led, 'exterior view' approach (biophysically focused curriculum – see focus on the atmosphere in ALL grades), that should, if we are really serious about issues such as education for and about climate change, be led and introduced by a more integrated approach that includes both physical and human dimensions to an issue and a focus on the 'interior' dimensions. Values, views and people's beliefs also need to be probed when teaching climate change.

As Senge et al. (2004) observe, we should avoid 'reactive' learning that continues us seeing the world as we are comfortable with, 'downloading habitual ways of thinking' where we try to defend our comfortable, safe interests. If we can penetrate more deeply, and enable our learners to reach more deeply to see the larger wholes that generate 'what is' and our connection to that wholeness, then we can begin to better understand what may need to change both in ourselves and in our world.

Teaching Practice

As we have seen in Units 1 and 2, there are various ways one can share the types of knowledge for change. Remember that these are examples of possible activities, and should be replaced, adapted and changed depending on your specific teaching and learning needs.

When designing learning activities linked to the core knowledge above, it is important to keep asking the following:

- Do the learning methods and activities being planned help learners to think about and evaluate the assumptions about climate change, society and knowledge?
- Do the methods and activities open up spaces for deeper deliberative learning processes?
- What knowledge and skills are learners being exposed to during these activities?

As with Unit 2, the activities in this unit are provided in an integrated sequence, making use of more than one method or learning approach at a time to help create a depth of understanding.

See pages 23, 27 and 30 in the *Methods and Processes* booklet.

Combining Investigative, Deliberative learning and Learning by doing learning approaches

ACTIVITY

EXPLORING ENERGY USE WITHIN OUR COMMUNITY

Speaking to community members about traditional practices, norms and views can provide a valuable insight into the story of learners' own communities. Learners can be given a task to interview a variety of people in their communities about energy use, and how this has changed over the years.

Things to remember:

- Learners will need assistance in developing an interview questionnaire – this does not have to be strictly structured, and can allow space for flexibility so that learners can follow up on interesting information. It should give them a general outline for their interviews and should help them to identify which sources of information are important (i.e. what is the purpose of their interviews).
- Interviews should not have too many questions – many people do not have a lot of time to spare.
- This activity can easily (and perhaps more safely) be done as a group activity.
- What has changed about energy use is just as important as what has stayed the same. Help learners to find out why things have changed or why they have stayed the same.

Many households, for example, in both rural and urban settings do not use electricity solely in a house (e.g. for heating) for a number of practical and socio-cultural reasons.

Residents still prefer and use fires and coal fired stoves. These cultural elements and those linked to behaviour are becoming critically important to understand as we seek 'low carbon pathways' for sustainability. Human behaviour, usually driven by a complex set of 'drivers' (cultural; socio-economic, etc.), has a lot to do with how we may be enhancing climate change and may therefore be an area where we can begin to make some inroads into understanding why people use energy in the ways they do.

This activity can be extended by considering different views about energy at a national level. Here a good reference resource is some of the work by Professor Patrick Bond of UKZN who introduces and contests some of the current energy dialogue (see for example his latest book, Bond, 2012). Extracts from this book can be used in juxtaposition (in contrast) to what is presented by ESKOM so that students begin to understand that what you do about climate change depends on your 'belief system' or 'paradigm' and way of understanding the different ways in which how energy is provided, how it is distributed; how it is used and for what purpose, and who is 'setting up the rules of the game'.

The activity above could lead into another method – for example, '***learning by doing***'.

ACTIVITY

EXPLORING OUR PERSONAL IMPACTS

Using carbon footprint tools to identify personal contributions to climate change can be an effective way to help learners to understand how they contribute to the transfer of energy within the Earth System, and by extension, to climate change locally and globally. This activity can be extended into a group activity as part of a term-long project by designing an energy use monitoring task, where learners are asked to monitor various energy uses over a period of time (a week, month, etc.). They could even work together to monitor the school's carbon footprint.

This activity can also be used as part of the learner's assessment portfolio (e.g. in Grade 12).

A range of related activities, including case studies, fact sheets can be used to help learners to identify which appliances (e.g. stove; fridge etc) are more or less energy-efficient than others.

See for example *EnviroTeach* Vol. 15., Energy Use and Management; Energy Dialogues (Shell South Africa Marketing and Delta Environmental Centre); and *Counting the Cost of Energy* (ESKOM and WESSA).

Things to remember:

It is important to design your activity so that it helps learners to probe deeper than a surface exploration of the energy discourse or debate. Key questions to begin to stimulate learners here are:

- Why are some users more intensive with their energy use and some less intense?
- Why do some businesses and forms of energy set our economic activities on a pathway of intensive usage when other approaches for energy use may be used?

See for example, Grade 11 term 4, conventional and non-conventional uses of energy.

- Learners need to be able to report their findings in a clear and useful way – this means that the data sheets need to be carefully planned before they begin monitoring and collecting data?
- Learners will need an activity to help them relate what they have found and concluded about their energy use to the key concepts presented in this unit.

Getting to the DOING for climate change part

The two activities described above help learners to gather different forms of data about energy use in their personal lives and communities. They also open up spaces for different views about energy use. Often the most challenging step for any of us is to take our understandings and findings about energy use and translate them into meaningful action to address the challenges and issues we have begun to understand.

Asking learners to work in groups to find practical ways to address the poor energy use habits they have identified as part of their carbon footprint or a monitoring task gives them the space to do so. This can be extended to a community project if this is practical and possible.

By engaging and sharing with the local community, students begin to develop a sense of stewardship, citizenship and agency (Rosenberg et al., 2008). The learner is no longer a passive victim absorbing 'negative' images of the climate catastrophe that may be occurring, but is rather empowered to become an active agent in the wider climate change discourse. Students could, together with members of the community, establish small 'communities of practice' who can then record their various energy use practices and activities over time.

Here the learners can begin to do some 'citizenship science'. In such an exercise, the critical ethical dimension of learning and knowledge 'collection' is also made very clear. Learners need to be made aware that knowledge comes in a variety of forms. Knowledge is not only that produced and accepted by experts. Other sources of knowledge, both social and experiential, can and do count. Knowledge is often held sacred, and built up over time, and therefore cannot be merely extracted from a group – rather, it has to be carefully negotiated and shared.

Learners will also begin to identify and understand that as a result of a number of 'driving factors', various users use energy in a variety of ways and that often energy is viewed and used in very different ways to the way the learner may be using the resource.

See pages 30-35 in the *Methods and Processes* booklet.

Critical deliberation

This section focuses on exploring the role of environmental justice, governance and climate change linked strongly to Grade 11 (Development Geography) and Grade 12 (sections on urban and rural issues and Economic Geography of SA, for example, the structure of the economy; strategies for industrial development).

The recent COP 17 meetings held in Durban in 2011 are an example of international and local climate change regimes and governance processes that provide a climate change governance lens through which to explore this aspect of climate change. At the COP a range of methods including dialogues, social media, factual presentations, lectures, community mobilisation and other methods of exploration and learning were evident.

Here a range of methods can be used possibly as a scaffolding of methods (proceeding from one type to the next) to explore the issue; for example, information transfer; experiential (role play; values clarification); deliberative learning (media analysis; scenario and backcasting methods). Examples in previous units apply here but an additional method that works well in the classroom is role play: here you can divide learners into groups representing small island states, USA, China, Europe and Africa.

Set learners a task to explain in their own words what is meant by 'common and differentiated principles' under the COP. Ask them to explore the meaning of this, show how it applies in their particular case and motivate why their case (e.g. developed world view) is relevant in the negotiations of a Kyoto-type regime arrangement (methods involved may include information transfer; media analysis; role play and some scenario analysis). This section can also be taught or reinforced in the section on development.

Grade 11, term 3.

The religious and historical/political factors / issues of climate change can also be explored with senior learners. Some useful questions to help learners begin to unpack the complexity of views and beliefs about climate change include:

- Who are the 'stewards' of the Earth?
- Are we all 'stewards of the Earth system?
- If not why not? Who determines and decides who are 'stewards'?
- Will our role as stewards change from the ways we interact NOW with nature to those that may be required for the FUTURE?
- Who gives some people the right to 'assign' energy while others cannot gain easy access?
- How do issues of poverty and access to energy work in South Africa?
- What has been the history of natural resources in South Africa? Have there been struggles of power over resource use? Why? etc. etc.

Values clarification

See page 21 in the *Methods and Processes* booklet.

Doing for climate change requires more than building knowledge or understanding complexity around climate and energy issues. It requires citizens who are able to make ethical choices for the restoration and protection of a healthy environment. Learners need to develop environmental values that they can carry into their lives and futures that will help them to make pro-environment choices in a wide variety of contexts.

Ken Wilber and Sean Esbjörn-Hargens are proponents of Integral Theory, which promotes learning approaches that take account of all aspects of human lives, both interior and exterior, individual and collective. Integral approaches can help learners to examine their own belief systems and 'blind spots' relating to climate change.

Learning that involves dialogue between various groups (e.g. experts and learners) is an example of a deeper learning method. Learners can express their views and values and, in dialogue with others, come to a new and more nuanced understanding of matters (Rosenberg et al., 2008).

In this activity, learners are encouraged to challenge the values they have about certain issues.

Learners can be given a worksheet with the following extract included for reflection for homework. The students will be asked to reflect on and jot down the first thoughts that come to their mind:

"It's easy for people in an air-conditioned room to continue with the policies of destruction of Mother Earth. We need instead to put ourselves in the shoes of families in Bolivia and worldwide that lack water and food and suffer misery and hunger. People here in Cancun have no idea what it is like to be a victim of climate change."

– Bolivian President Evo Morales (cited in Bond, 2010, p.7-8)

The worksheet could probe various things but some interesting areas that would link back to themes on sustainable development and equity would be to ask learners some probing questions and to ask some of the class to be representatives of the Bolivian homeless and some of the class to represent the USA at the COP.

Ask your learners to think about what the following may mean: What may/does climate change mean for a homeless person? What does climate change mean for a bureaucrat working in a well-resourced, developed country?

Learners could then be asked to 'cross the floor' and assume the role of the opposing side. One can then repeat the task, drawing and writing about how it feels to be part of the new identity.

To encourage learners to identify more closely with climate change and energy issues, ask them to express how they feel when they have no access to electricity, either due to rolling blackouts or if access to energy is prevented because of poverty. Many emotions can surface relating to issues of access and entitlement. This can make issues of energy and climate change feel more real to learners.

It is important to remind learners that addressing climate change is not simply a matter of better environmental management and coming up with technological 'green fixes'. Solving this issue is going to require serious examination of the ways in which we as humans acquire, use and share resources. Climate change has as much to do with environmental justice and inter-generational equity as it has to do with renewable energy technologies.

Values usually underpin beliefs and vice versa and shape actions, including influencing how ethical decisions are made. The aim of this activity is for learners to probe their values, challenge each other's values, and potentially reconsider the way they see the world and their values.

An alternative approach to this activity is to ask learners to wear a variety of professional caps:

In the context of climate change, ask learners to assume different roles, such as scientist, philosopher and artist. In these roles they can explore their views and understandings of climate, including aspects such as rainfall and seasons. Sharing diverse views will generate more than just 'scientific' explanations for these phenomena. In these roles they can also explain an aspect of climate change*. This will allow them to probe whether or not science is the only discourse and lens through which we can explore climate change. Becoming more flexible in our viewpoints may help us to find answers to the complex issue of climate change.

See for example Esbjörn-Hargens et al., 2010.

Another alternative or supplementary activity is to provide the class with a recent article from a popular blog or website and for learners to read the piece and then answer a range of questions that assist them to unpack and consider the values behind what is being said. Note that learners may have varying perspectives and these are good in that they may reveal the various values and beliefs that learners have about the 'story of climate change'.

Assessment Practice

The critical question when teaching about climate change and impacts on the Earth System is: How will a teacher or facilitator know that the learner has learnt about climate change? Assessing content knowledge is usually easier to than assessing transformational and deeper knowledge.

In this final section, we examine and assess some of the AND NOW issues. WHAT is being done and how can we improve on our actions? Our actions however are all embedded in OUR meta-perspectives and different paradigms of the ways of thinking and indeed approaching the problem of climate change must be encouraged (see Orientation).

When assessing some of the key areas explored in this unit, it is of course useful to assess content knowledge. BUT it is also important to create deliberate and carefully thought out approaches for assessing DEEPER knowledge because it is often this deeper knowledge that supports CHANGE and TRANSFORMATION in our ideas, values, beliefs and lives.

International response to climate change

Learners need to be able to navigate swiftly and easily through the complex landscape of international interventions into climate change. Here the historical summary provided by WWF in their publication "The New Climate Deal a pocket deal" is a very good overview of what has been going on in the international arena on climate change.

Resources for the New Climate Deal: www.preventionweb.net; www.wwf.org.uk; www.wwwf.se

Other very good and simple examples of major climate negotiations and outcomes can be found in a publication called *Tiempo* (available on www.cru.uea.ac.uk/tiempo). This very useful set of resources can be used in a variety of ways in the classroom, as will be shown below.

Shallow – factual recall, remembering type of assessments

A shallow, but necessary assessment, could be designed to promote learning and critical thinking on the interventions that we have been using for climate change. Here the timeline can be set but learners are challenged to begin to examine the major milestones and then to couple these milestones to ways of thinking and developments in the climate change history (e.g. Malthusian thinking; thinking on sustainable development etc., see the next section).

LEARNING ASSESSMENT TASK

As part of an assessment exercise learners can be asked to compare and contrast the Kyoto and Montreal Protocols, highlighting any similarities and differences. A table of key headings could be given to learners to help them focus e.g. countries involved, main sticking points, places where agreement is reached, outcomes etc.

Deeper assessments – analysis, evaluating and creating

Of interest however, here and particularly with older learners (e.g. Grade 12), is an assessment that begins to link the history of climate change intervention to some of the global economic changes that have been occurring and also to some of the paradigms that have

underpinned environmental thinking over time (e.g. a strong Malthusian focus in environmental thinking, to sustainable development etc. see again Unit 1).

Extra reading on such trends in environmental thinking can be obtained from the web. The idea would be to encourage an exercise (compiling a table) that could be assessed as part of the term mark (e.g. as part of Grade 12 revision) that has the history/time line of climate change interventions and major meetings (e.g. a column of events on the one hand) next to a column of the 'thinking' that seems to explain the intervention taken on the other. By doing such an exercise learners are not only able to 'sort' out a range of key events and actions at a global scale but will also begin to realise that such actions are not surprise events but that are the outcome of the social construction of knowledge (they begin to question values and the role of power and agency in knowledge creation and accumulation).

The references by Patrick Bond, read alongside those of the more 'traditional' climate scientists, would also be a good exercise in assessment. Learners could be given an extract from one of Bond's recent books and then asked to read and compare this alongside extracts from the IPCC assessments. In this way learners will begin to understand and form some formative ideas on the role of environmental governance and environmental justice issues that are a strongly emerging paradigm in environmental sciences.

Regional and national response to climate change

In a similar way the regional and national landscape of climate interventions can be explored looking at a range of cases (e.g. past responses to flood events; past responses to drought events; working up to South Africa's position in the international negotiations (e.g. at the Conference of the Parties). Simple and concise overviews of such vast dialogues and discussions are usually not available but the Second National Climate Change Communication contribution from South Africa is a very good source of a range of South African activities.

In such a broad section a number of activities could be set for assessment and evaluation in either *shallow* and/or *deeper assessments*:

1) Examining past national climate change and variability interventions using a theme as an entry point (e.g. focus on Africa and drought). Once this example has been used a number of others can be adapted for flooding, heat waves etc.

2) The learners can be encouraged to do various role plays and could be assigned the task of being an Environmental Impact Advisor who must write a report on the possible impact of sea level rise in Africa (using IPCC science assessments as inputs). These role plays must then be assessed.

3) The rubric for the report writing exercise, for example, can be provided with tips on how to write a report.

See for example Platinum Learner book, 2011, page 99.

4) For this assessment exercise, the learner could be asked in the report to include possible solutions and suggestions for action that may be taken at a national and local level to 'best manage' (adapt) or 'just manage' (cope with) the climate problem. A rubric for assessment could then be mapped out and also given to the learner e.g. percentage marks for good structure; good introduction and clear aims of the report; concise and clear academic writing; a good literature overview etc.

5) From the *Focus on Geography* learner book some assessments could include the learner receiving a figure of the combined and complex interactions of climate change on Africa's (see impact of climate change on Africa's people and environment Figure 2.38). Learners using such a flow diagram could be asked to come up with at least three (but more can be requested) 'practical' ways in which farmers could adapt to climate change as shown in the diagram. Once again a marking rubric and assessment scoring could be designed depending on whether this is set as a 'take home assessment' or a part of a class test. The excellent case study on page 114, entitled climate change and sub-Saharan Africa could also be set as part of an assessment exercise (either as a take-home longer assignment or as a part of a class assessment).

Personal responses to climate change

Consider what it is that each one of us can do about and for climate change. Here the work of Esbjörn-Hargens introduced in Unit 1 and 2 are useful references. Climate change is partly a result of our actions on the Earth. By producing and consuming we are making an impact on the planet both now and for future generations.

Most of the assessments in this category, that is those related to the personal, will require a more personalised assessment process. Several examples can be provided:

a) Learners are encouraged to keep a diary, that is personal, and are asked to assess themselves in their daily activities, how they use resources etc. This self-assessment should be done with mature learners. Marks here will not be assigned but learners will self-evaluate and note their actions and feelings and beliefs over time (Can they see a change in their behaviour over time? Do they care about the state of the Earth System? If not, why not? etc.).

b) Learners can undertake a futures scenario exercise where they develop a vision of what the world may be like. Learners can be asked to prepare a PowerPoint presentation (that is assessed – 30% for literature content; 30% for slides and information; 30% for future interventions; 10% for presentation) that outlines the world as they would like to see it in 2030. From this future picture they then have to recommend actions that can be undertaken NOW to ensure that we can reach the desired vision of a 'perfect' world in 2030.

By Kartha, *Tiempo*, Issue no 70, 2009. www.tiempocyberclimate.org

c) Each learner should be provided with a copy of the article "Greenhouse Development Rights". Learners should prepare answers to a series of provocative questions. These can range from very basic ethical and equity questions to more personal questions e.g. What will it mean for me to ensure that my rights to a sustainable planet are ensured? What does it mean for someone living in an informal settlement? What does it mean for someone living in a developed country context (e.g. England) versus someone living in an informal settlement in Johannesburg? Is there a difference and if so why?

d) A range of stimulating examples prompting novel assessments can be used e.g. through the use of art, music and video.

Conclusion

In this unit, we have focused attention on what interventions we can make to ensure that we can play a role in assisting and moving the Earth system forward in a positive and sustainable way. This was probed in this final unit by investigating actions at three levels: global, regional/national and local and personal.

The activities for change are not universally accepted. This is a VERY contested DOMAIN.

In some cases technological changes are promoted such as carbon credits, the clean development mechanism and other mechanisms linked to various agreements including the Kyoto Protocol. For others, some of these mechanisms are challenged. The notion that issues can be contested is a necessary part of all good science and politics. Learners should be assisted with being able to identify such contestations and should also be shown how to 'manage' and interpret such challenges.

References

This list includes both references cited in these units as well as extra useful resources.

Alliance between the CGIAR centres and written by Moorhead, A., 2009: *Climate and agriculture and food security: A strategy for change*.

ASSAf, 2011. *Towards a low carbon City, focus on Durban*. Academy of Science of South Africa, Pretoria.

Biggs, R. et al., 2010. Preparing for the future: Teaching scenario planning at the graduate level. *Front. Ecol. Env.* 8(5). 267-273.

Bond, P., 2010: *Politics of climate justice: Paralysis above, movement below.* University of KwaZulu-Natal Press, Scottsville, South Africa.

Bornman, M., Cohen, S., Ranby, P., Sookdeo, N. and Saunders, J., 2011. Platinum Geography, Learner's Book 10, Maskew Miller Longman, Cape Town.

Brunner, W., 1996. *The Mission.* Solbergaskolan, Visby, Sweden.

Burns, M. and Weaver, A., 2008. *Exploring sustainability science: A southern African perspective.* Sun Press, CSIR.

CLACC, December 2007. Capacity strengthening of civil society in the Least Developed Countries for adaptation to climate change. *CLACC Newsletter*, Special issues for COP 13/MOP3.

Cundill et al., 2010. Foghorns to the future: Using knowledge and transdisciplinarity to navigate complex systems. *Ecology and Society.* 10(2). http://www.ecologyandsociety.org/vol10/iss2/art8

Dea, W., 2011. *Igniting brilliance: Integral education for the 21st Century.* Integral Publishers, Tucson, Arizona.

Demeritt, D., 2006. Science studies, climate change and the prospects for constructivist critique, *Economy and Society*, 35, 3, 453-479.

Department of Science and Technology, Republic of South Africa, no date. *Ten-year global change research plan for South Africa*.

Dietz, T., 2011. Silverlining Africa, from images of doom and gloom to glimmers of hope, from places to avoid to places to enjoy. Inaugural address, Leiden University and African Studies Centre, 14 January, 2011.

Dilley, L., Earle, J., Keats, G., Ravenscroft, G. and Nxele, A., 2011. FOCUS, Geography Learner's Book, Maskew Miller Longman, Cape Town.

Dow, K., R.E. Kasperson, and M. Bohn, 2006. Exploring the social justice implications of adaptation and vulnerability. In N. Adger, J. Paavola, S. Huq and M.J. Mace (eds), *Fairness in Adaptation to Climate Change*. MIT Press, Cambridge, Massachusetts, London, 79-97.

Dubash, N.K., 2009 for the World Bank Development Report, 2010: Climate change through a development lens. *World Development Report*. World Bank.

Esbjörn-Hargens, S., 2010a. An ontology of climate change: Integral pluralism and the enactment of multiple objects. *Journal of Integral Theory and Practice*. 5(10). 143-174.

Esbjörn-Hargens, S., 2010b. An integral overview of climate change – Why truth is not enough, *Journal of Integral Theory and Practice*, 5 (1), 1-42.

Fazey et al., 2007. Adaptive capacity and learning to learn as leverage for social-ecological resilience. *Fron. Ecol. Environ*, 5(7), 375-380.

Fazey, I., 2010. Resilience and higher order thinking. *Ecology and Society*, 15(3) 9., Online: http://www.ecologyandsociety.org/vol5/iss3/art9

Ferrer, J.N., Romero, M.T. and Albareda, R.V., 2005. Integral transformative education: A participatory proposal. *Journal of Transformative Education*, 3, 4, 306-330.

Folke et al., 2002. Resilience and sustainable development: Building adaptive capacity in a world of transformation. Scientific background paper for the process of the World Summit on Sustainable Development on behalf of the Environmental Advisory Council to the Swedish Government.

Folke, C., Carpenter, S.R., Walker, B., Scheffer, M., Chapin, T., and Rockstrom, J., 2010. Resilience thinking: Integrating resilience, adaptability and transformability. *Ecology and Society*,15 (4):20. [online] URL: http: www.ecologyandsustainability.org/vol15/iss4/art20.

Fussel, H-M., 2006. Vulnerability: A generally applicable conceptual framework for climate change research. *Global Environmental Change*, 17, 155-167.

Guba, E.H. and Lincoln, Y.S., 1994. Competing paradigms in qualitative research. In: Denzin, N.K. and Lincoln, Y.S. (Eds), *Handbook on Qualitative Research*. Thousand Oaks, CA: Sage, 105-117.

Guba, E.G. and Lincoln, Y.S., 2005. Paradigmatic controversies, contradictions and merging confluences. In N.K. Denzin and Y.S. Lincoln (eds), *Handbook of qualitative research.* Revised edition. 2nd edition. Sage Publications, London.

Gujt, I., 2007. Assessing and learning for social change: A discussion paper. Learning by Design and Institute of Development Studies (IDS). Brighton, UK.

Inglis, J., 2009. Publicly created systemic responses to climate change: An integral approach to civic engagement. *Journal of Integral Theory and Practice*, 4(4), 67-87.

International Alliance of Leading Educational Institutes, 2009. *Climate change and sustainable development: The response from education*.

IPCC, 2007. *Climate change 2007: Impacts, adaptation and vulnerability*. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. ML Parry, OF Canziani, JP Palutikof, PJ van der Linden, & CE Hanson, (Eds.) Cambridge,UK: Cambridge University Press, 976pp.

IPCC, 2012. *Managing the risks of extreme events and disasters to advance climate change adaptation*. A Special Report of Working Groups I and II of the Intergovernmental Panel on Climate Change [Field, CB, V Barros, TF Stokker, D Qin, DJ Dokken, KL Ebi, MD Mastranda, KJ Mach, G-K Plattner, SK Allen, M Tignor and P Midegley (eds.)] Cambridge UK and New York, USA: Cambridge University Press, 582 pp.

Jasanoff, S., 2010. A new climate for society. *Theory, Culture and Society*, 27, 2-3, 233-253.

Kartha, S., 2009. Greenhouse development rights. In *TIEMPO* (www.tiempocyberclimate.org).

Manuel-Navrette, D., 2010. *Power, realism and the ideal of human emancipation in a climate of change*. WIRES, Wiley.com/climate change, Opinion piece, 781-785.

Marina et al., 2010. Integral transformative education: A participatory proposal. In Esbjörn-Hargens, S., Reams, J. and Gunnlaugson, O. (eds), 2010. *Integral Education: New directions for higher education learning.* Suny Press, New York.

Murray, T., 2008. Exploring epistemic wisdom: Ethical and practical implications of integral theory and methodological pluralism for collaborative knowledge building. Paper presented at Biannual Integral Theory Conference, John F. Kennedy University, Pleasant Hill, CA.

National Science Foundation, 2003. *Complex environmental systems: Synthesis for earth, life and society in the 21st century.* Report summarizing a ten-year outlook in environmental research and education for the National Science Foundation, 68 pp.

O'Brien, K., 2009. *Responding to climate change: The need for an integral approach*. Integral Institute, Resource Paper No 4, 1-12.

O'Brien, K., 2010. Responding to climate change: The need for an integral approach. In S. Esbjörn-Hargens (ed.). *Integral Theory in Action: Applied, Theoretical, and Critical Perspectives on the AQAL Model*. New York: SUNY Press, 65-78.

O'Brien, K. and Hochachka, G., 2010. Integral adaptation to climate change. *Journal of Integral Theory and Practice* 5(1): 89-102.

Oliver, J.E. and Hidore, J.H., 1984. *Climatology: An introduction.* Charles E. Merrill, Ohio.

Pearce, F., 2008. *The New Climate Deal: A pocket guide.* WWF for a living planet, Banson Production, The Lavenham Press, UK.

Pohl, C., 2009. Collaboration of Natural and Social Sciences in research for sustainable development. In *The future of knowledge: Mapping interfaces*. European Science Foundation. www.esf.org.

Richardson, K., Steffen, W. and Liverman, D., 2011. *Climate change, global risks, challenges and decisions.* Cambridge University Press.

Scharmer, O., 2007. *Theory U: Leading from the future as it emerges – The social technology of presencing*. Cambridge, Massachusetts: Society for Organizational Learning

Senge, P.M., Scharmer, O., Jaworski, J. and Flowers, B.S., 2004. Awakening faith in an alternative future: A consideration of presence: Human purpose in the field of the future. *The SoL Journal on Knowledge, Learning and Change*, 5(7). 1-16.

Shambhala Institute, 2004. Fieldnotes. Waking up and getting engaged. *Transformative learning in the University classroom*. Issue 4. 1-5.

South Africa, Government of the Republic of South Africa, 2011. *National Climate Change Response White Paper*.

Spencer et al. (Sustainability Institute Stellenbosch), 2010. A strategy for a developmental green economy for Gauteng – Preliminary report, Draft, January 2010.

Taylor, P., Deak, A., Pettit, J. and Vogel, I., 2006. *Learning for social change – Exploring concepts, methods and practice*. IDS.

Van Wilgen, B., 2009: Global Change Grand Challenge, National Research Plan, South Africa.

Vogel, C.H., 2011. Climate change curriculum: In search of creative design. In *Climate change, adaptation and higher education: Securing our future.* SARUA (South African Regional Universities Association), Leadership Dialogue Series. 2(4). 117-131.

Walker et al., 2004. Resilience, adaptability, and transformability in social-ecological systems. *Ecology and Society*. 9(2):5. http://www.ecologyandsociety.org/vol9/iss2/art5

Wilber, K., 2000. *Integral psychology: Consciousness, spirit, psychology therapy*. Boston, MA: Shamabhala.

Wycoff, A. and Roop, J., 1994. The embodiment of carbon in imports of manufactured products: Implications for international agreements on greenhouse gas emissions. *Energy Policy*. 22(3). 187-194.

Zietsman, L. (ed.), 2011. *Observations on environmental change in South Africa*. Sun Press.

Appendices

"ARID AREAS ARE BECOMING DRIER STILL"

Case Study: **Africa**

Scorched landscapes, withered crops, dried-up rivers and lakes; or the opposite – devastating floods; dying livestock, hungry people. This could be the picture we face in Africa in a decade unless we manage climate risks better.

New research suggests that the vulnerability to the climate-change threat is in Africa greater than in many parts of the world. And the changes won't be limited to a rising average temperature and changing rainfall patterns. Droughts and floods are happening with increasing severity and frequency, accompanied by diseases such as diarrhoea. Malaria is also making an appearance at altitudes that previously had no mosquitoes, such as in the mid-highlands in Ethiopia. Rift Valley Fever has reappeared.

Changing weather patterns in recent years are having a detrimental impact on food security; farmers are finding they can no longer plant or harvest their crops as they used to for centuries as rainfall is late or erratic.

Communities are vulnerable to unfamiliar hazards and cannot cope with even minor shocks – leading to a constant rise in the numbers of people needing humanitarian assistance. The average number of food emergencies in Africa per year has almost tripled since the mid-1980s, and in the last year alone 25 million people faced a food crisis.

Africa, with its resources already overstretched, has little capacity to deal with further disasters from climate change. Around 90% of people depend on agriculture for their livelihoods – many are subsistence farmers who only grow enough food to feed themselves and their families. Any decrease or change in rainfall patterns could mean crop failure and consequently serious food shortages or even famine.

Agricultural production will be severely impacted by climate change – the area suitable for agriculture, growing seasons and yield are all expected to decrease. This would further adversely affect food security and exacerbate malnutrition in some countries.

The yield from rain-fed agriculture could be reduced by up to 50% by 2020, according to scientists on the Intergovernmental Panel on Climate Change (IPCC). Many parts of Africa are already considered "water stressed" – something that will be exacerbated by climate change.

Any significant rise in temperature could also seriously affect cash crops such as tea or coffee. Arid and semi-arid areas all over Africa are becoming yet drier. On average the continent is 0.5 °C warmer than it was 100 years ago, in some parts even more.

Migration is another outcome of climate change as people move away from drought-prone areas and work as labourers on other farms to earn money to buy food, increasing pressure on particular parts of the continent.

Ethiopia

Divided by the East African Rift Valley into highlands and lowlands, Ethiopia has an extraordinarily diverse climate, from the cool and rainy Dega highlands to the Danakil depression – one of the hottest, driest places on Earth.

The economy is based on agriculture, which accounts for half GDP, 60 per cent of exports and 80 per cent of total employment. But only 1 per cent of farmed land is irrigated and drought can throw the whole country into crisis and food shortage.

According to Abebe Tadege, head of research at the national meteorological office in Addis Ababa: "There have been signs of climate change in Ethiopia since 2000, and even before. Tropical Africa is a hotspot for precipitation changes. I am very worried. What is the impact on crops, on *tef* [the traditional staple], tea, coffee, livestock?"

With five major droughts in two decades, many families have not had time to recover and hundreds of thousands of people live on the brink of survival every year.

In 2000–3, 46% of the population were malnourished, according to the Food and Agriculture Organization.

Meanwhile 2006 saw some of the worst floods in Ethiopia's history, displacing people all over the country. Flash floods in Dire Dawa, the second largest city after Addis Ababa, killed nearly 250 people and displaced thousands.

More than 400 people died during outbreaks of acute watery diarrhoea in 2006. Fadis, in the east, has been badly hit by drought. Many farmers have suffered from poor harvests year after year due to erratic rainfall. In recent years the rains have failed completely.

Yusuf Idris, a village elder, has lived in the area for 40 years and his family and community are regularly dependent on relief food. The rains have failed consistently for the last few years and he cannot plant his crops. "When there is a little rain, we can plant sorghum and maize but we don't produce much," he says.

The nearby River Boco, which used to be one of the main sources for irrigation in the area dried up several years ago, partly because of the lack of rainfall. Yusuf remembers orange and lemon groves beside the river. He reports that many people in his community migrate every year because of drought, and scarcity of food and water.

Malaria

A few kilometres away near the town of Harar, Lake Halamaya also dried up several years ago, partly because of the scarcity of rainfall in the region. Lake Halamaya, about five kilometres long, was the main source of water for Harar and the surrounding communities and provided income for fishermen.

Fatiya Abatish Jacob is a local trader who lived near the lake for 14 years: "I used to get my drinking water from the lake, now I have to walk eight kilometres to get it. Also there were many vegetables farmers round here using the water for irrigation and we used to get fish. Now there are no fish around here and vegetables are more expensive."

And while there was drought in Harar area to the south there were bad floods in 2006 in west Shoa, where 3,000 people were displaced. "Such heavy flooding hasn't happened for 40 years," says Tiringo Engdawork, Ethiopian Red Cross Society (ERCS) branch secretary. "It destroyed houses, crops and cattle." Local malaria rates have shot up.

ERCS disaster preparedness emphasizes clean water and tree planting for wood, fruit and terracing. Gabriel Aebachew, head of organizational development, believes that they have to now "create awareness of climate change, collect data and train volunteers" at branch level.

According to relief officer Geude Beyenne: "We have volunteers trained in disaster preparedness activities in every part of Ethiopia. We started two years ago because we realise we are affected by natural calamities more frequently. We are trying to prepare relief materials such as blankets and jerrycans and store them in various regions. The policy now is that 10% of branch income will go to supplies for preparedness activities."

The ERCS has also placed considerable importance on the need to conserve water. Rain "harvesting" is an efficient way of collecting clean water during the rainy period and it can last several weeks or months.

"In Moyale, for example, in the south, there is no river and so rainwater harvesting is important," Geude Beyenne explains. "Water is key, especially in disaster preparedness. Some people in the south might only use a litre a week." More than 50 rainwater harvesting tanks, on roofs and underground, have been built in the last two or three years.

The ERCS also has a programme of community-based health care for awareness-raising and education, but this will have to be scaled up in the light of climate change. Malaria, typhoid, cholera and diarrhoea are all diseases that spread more rapidly during times of hardship.

Diseases that were considered to have been eradicated are also making a reappearance. In 2006 Acute Watery Diarrhoea cases were recorded for the first time in ten years. And there is clearly interaction between malnutrition, malaria and HIV/AIDS.

Rwanda

Despite a decade of rapid economic growth, poverty remains widespread in Rwanda. Known as the "land of a thousand hills", Rwanda is a small landlocked country surrounded by Burundi, Tanzania, Uganda and the Democratic Republic of the Congo. But despite its size, it has very diverse ecosystems.

Rwanda forms part of the Great East African Plateau, which rises from the lowlands in the west that are characterized by swamps and lakes to the highlands of the east. This divides the country between the Nile basin and the Congo basin. The climate is moderate and tropical, with a short dry season from January to February and a long dry season from June to September.

Parts of Rwanda have been hit by persistent drought over the last few years, rainfall patterns have been erratic with the result that, again, farmers are confused as to when to plant and harvest. Musoni Didace, director of the country's meteorological service says climate change is "clearly visible" from the rise in minimum temperatures in the last 30 years of up to two degrees.

Indeed 2005, was the hottest year for many years in Rwanda. Temperatures in the capital, Kigali, soared to 35 °C. Higher temperatures also mean the spread of diseases such as malaria, already the principal cause of morbidity and mortality in every province.

The interaction between diseases is also of concern: someone with malaria, for example, will be more prone to catching HIV, and vice versa. Malnutrition also means diseases spread more rapidly. It is a vicious circle. And diseases thought to have died out, like cholera, are reappearing. New cholera cases were recorded for the first time in Kigali in 2006 and in the north-east in 2007.

The agricultural sector is central to Rwandan environment. It dominates the economy in terms of contribution to the GDP and it also accounts for over 90% of employment. Agricultural exports represent over 70% of the total; coffee and tea are the two main export crops. Climate change could have serious consequences for agricultural production.

In 2006, there were a number of deaths as a result of heavy rain and floods, and crops and livestock were destroyed. Patricia Hajabakiga, the environment minister, said this affected the national budget as money intended for economic development was used for emergency measures such as buying food relief.

At the same time water levels have gone down and hydroelectric stations, particularly in Ntaruka and Mukungwa, have been affected. Electricity generation has declined and there has been an energy crisis in the last few years; to produce electricity the government has had to buy generators costing millions of dollars. This had an impact on the population – with the price of electricity tripling.

Migration

Bugusera, in southern Rwanda, is an area that has persistently been hit by drought and here around 40% of people lack secure sources of food. Many farmers in this area have suffered from bad harvests due to late or erratic rainfall.

Mary Jane Nzabamwita is a farmer in Gashora with five children to feed. Since 1998 rain has become unpredictable. "We think it will rain, then it doesn't rain and then we lose our harvest," she explains. Mary Jane grows sorghum, beans, sweet potatoes and vegetables, some of which are sold at the market but last year her harvest was down by half.

She just managed to save enough money to send her children to school (the children get food from the World Food Programme at school), but she cannot afford to pay for health insurance fees for the whole family. The family now has to drink water from the nearby swamps and continually suffer from diarrhoea and malaria.

"I feel like I am going backwards," she says. "The children are not doing so well. When you see a child of ten, you think he is five."

A Rwandan Red Cross Society (RRCS) volunteer in Bugusera explains that you can now see more erratic climate patterns and drought is making people migrate to other areas of Rwanda where they can work. People might also go to a nearby town, earn some cash there by petty trade and buy some food to sell in their own villages.

Many families are separated. Mimi and Josephine are looking after their children and their farms while their husbands have gone elsewhere to earn some cash. This year their maize crops have failed due to lack of rainfall and they are still hoping for rain for their bean harvest. If they fail or come late, they do not know how they are going to get their food.

Migration became such as serious problem that almost 80% of the people in the area left their farms to look for work in other regions between 2003–5. However, the local government has tried to stockpile maize, sorghum and beans and migration has now decreased, according to Viateur Ndavisabye, executive secretary of the Gashora regional government.

"Climate change is a big problem," says Apollinaire Karamaga, RRCS secretary general. "We need to train volunteers with basic skills, like being able to advise farmers when to sow seeds, dig the swamp, and so on. We need to help them think, 'What can I do according to my realities to cope?'"

According to Marie-Antoinette Uwimana, RRCS head of programmes: "The government has started talking about climate change this year, and as we are a member of the disaster management task force, we discussed this with them." There is now a realisation that disaster response is no longer enough and that risk reduction is important and has to be scaled up.

"The impacts from climate change are there and have been problems in the last years," according to Eric Njibwami, head of volunteers. "The eastern and southern regions suffer from lack of food because

of the long season without rain." The result is that communities can no longer plan harvests or planting because of erratic rains.

The RRCS tries to address this by informing people when they are going to have a drought, getting weather information and warning people to keep a stock of food. But in the long term, says Eric Njibwami, people have to "diversify through business activities or generating other incomes".

A major problem is that farmers are very traditional and hesitant to change, says Karamaga. "We may need to change our crops or diets in the future, but people change only very slowly." He believes it's important to train volunteers to train farmers to move away from their traditional methods of producing crops, which may not be the most efficient in today's circumstances.

Clearly water management and environmental protection of land is going to be key. Due to population pressure much of Rwanda has been deforested – with resulting soil degradation and erosion which worsens the impact of drought. Almost 90% of the population use wood as cooking fuel. Mobilising the community to plant trees is, therefore, an important objective for the Rwanda Red Cross. The eventual aim is for every district to have a nursery with 10,000 seedlings.

Swamps

Rwanda not only has numerous hills but also numerous swamps at the bottom of the hills. In the past many of these were not cultivated because of the expense of drainage and managing the swamp. However, given the pressure on land and more erratic climactic conditions that affect crops traditionally grown on the hillsides, developing swamps would provide new arable space, for beans, rice or cassava.

Underground water also means that agricultural production is less dependent on rainfall and can survive periods of drought.

The RRCS has one such project which began several years ago – some 10 hectares of the Agatenga swamp are now successfully cultivated, providing beans, cassava and rice to nearby communities. This part of Rwanda has been hit by drought in the last few years and up to 30% of the people are food-insecure. Developing projects such as this is part of the RRCS strategy to promote the capacity of local communities to cope.

Emmanuel Munyentwari is one farmer who works there. He has his own plot of land on the hillside but there he is more dependent on rain. "Last year rain was expected in September but it came only in November," he says, "so we couldn't plant until November and people had little to eat – there were food shortages." But the extra crops that he grows in the swamp project are useful. His own harvest is low and he is really not growing enough food to eat. His dream, he says, is that one day he will be able to afford school fees to send his wife back to school. "The Red Cross did a good job here," he adds, "and I hope it can expand."

Training volunteers and mobilising the community is key to dealing with climate-change impacts. Yvonne Kabagire is a communications officer at the RRCS and is also a radio presenter with her own 15-minute programme, Rwanda Red Cross Humanitarian Action. Every week she covers subjects such as HIV/AIDS, the environment, drought, floods and disasters, and commands an audience of no less than 70% of the entire population of Rwanda.

Kabagire sees radio as an important tool in disseminating information on climate change. "People need to know about it because our country is not an island," she explains. "They need to understand the phenomenon and how they can have a role in building coping strategies."

After a long drought which killed livestock in Kenya, floods took what was left. This man lost most of his goats and sheep.
Photo: International Federation of Red Cross and Red Crescent Societies

Climate heroine

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Char Bangla, Bangladesh: Lamia's story

ActionAid

Lamia was seven years old when cyclone Sidr hit her village, Char Bangla, in November 2007. It was the worst storm to hit Bangladesh for 16 years.

"When the teacher announced in class that there would be a cyclone, and released us at two o'clock, my five friends and I went back to our village and moved from door to door spreading the message that people should store their valuables and go to the cyclone shelter.

Where other villagers listened to us, mine refused, saying that we had been warned of a tsunami earlier on in May and nothing had happened. I was so worried that I grabbed my father's hand and crying, pulled him to go to the cyclone shelter. He reluctantly agreed."

Lamia and her friends' actions saved not only the lives of her family but also those of her fellow villagers.

ActionAid

Lamia's father (right) admits,
"I don't want to imagine what would have happened had I completely refused to go to the shelter."

ActionAid built the school that doubled up as the cyclone shelter for Lamia and her family. As part of its Disaster Risk Reduction through School project, ActionAid had trained the school's staff to teach the pupils what to do in event of a cyclone.

Lamia's determination to follow her teachers' advice to act on early warnings and get to the safety of the shelter made sure her family and other members of her village were safe during the worst of the cyclone.

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Lamia and community members standing outside the cyclone shelter.

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Climate heroine

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Charkhali, Golachipa, Patuakhali near the Bay of Bengal, Bangladesh: Salma's story

When 14-year-old Salma heard the loudspeakers at nearby mosques alerting people to the impending cyclone Sidr in southern Bangladesh, she immediately knew what to do: head for the emergency shelter.

But trying to persuade her family was another matter. Her mother, Amena Begum, didn't want to leave her home. She had three cattle, five goats and 100kg of rice, as well as all their possessions to protect.

Salma said she pleaded with her mother. She had learned in school that if people stayed in their homes until the last minute, when the storms came it might be too late to get to the shelter.

Salma was determined this was not going to happen to her family. At school, she had learnt what she needed to do before, during and after a disaster. Her teachers had been working with ActionAid and South Asia Partnership to help children understand how to keep themselves safe during a cyclone.

Salma had learned that families should bury their legal papers and precious crockery in a hole dug at their home, marked with a bamboo cane. They should also move their livestock to higher ground and go to the emergency shelter. After a disaster they learned that communities need to stick together and help one another rebuild their homes to get back to normal.

Salma refused to give up. She repeated her pleas to her mother and eventually persuaded the whole family to pack some possessions and move to the safety of the shelter at nearby Charkhali primary school. The family moved the cattle and goats to higher ground so they were safe too.

Salma saved 11 members of her family (including herself) that night: her grandmother, mother and father, brother and sister, uncle and aunt and her three cousins.

"When the storm hit it was terrible – we could hear banging and crashing outside and the walls shook… it seemed to last forever although it was all over in 15 minutes.

There were a thousand people in the shelter and we all had to stand because there was no room to sit. We were there for three hours from nine o'clock in the evening till midnight."

After midnight, Salma and her family returned home, but there was nothing left. They went to a relative's house and stayed there. The next day it became apparent that many people had not made it to the shelter and had died trying to reach to safety.

ActionAid

Salma near her home in Charkhali.

Learning to live a normal life again

Cyclone Sidr had destroyed Salma's house and valuable assets. Immediately after the cyclone, Salma's family received assistance from the government as well as ActionAid's local partners.

In December 2007, Salma took her school exams and passed successfully.

To repair their damaged house her parents took a loan of Tk30,000 (about £240) from a local non-governmental organisation and started repair work.

Six months after the cyclone, most of the work on their house had been completed and they were living there again. Salma and her family are slowly rebuilding their lives, getting back to normal and looking to the future.

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Climate hero

My name is Mohir Uddin Hariapa.

I am 99 years old. I live near the Brahmaputra River in the North East of India.

The river has always flooded. When I was a boy the floods made us happy. The waters entered the villages slowly. They brought fish and helped things to grow.

Now the floods are changing. They are much worse than in my childhood. Then the rain was slow and drizzly. Now it's huge downpours.

I have seen children and old people swept away by floods and houses destroyed. The flood water has silt (mud) in it and it takes out the nutrition from the land. These are times of starvation for us.

Huge snakes come out during the floods. They can be up to 12 feet long. They come into our houses while we are sleeping. Their bite can be deadly.

I teach the children about the warning signs of floods. You can tell if a flood is coming by looking at the sky. Colours or cloud patterns might look different from usual.

Animals and birds give lots of clues too. "Dub! Dub!" is the emergency call of the Kora bird. When you hear this call at sunset it means floods are on their way.

Then the children prepare by climbing onto the bamboo platforms in their houses. These are raised high above the ground and keep them safe from the raging waters.

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5

My climate story

My name is Bobita

I'm 12 years old. After our home was destroyed by a flood we searched and searched for somewhere good to live. Now we are living close to a dam in Titma village. At first we had no shelter but some people helped us build a small shed, made of bamboo and tin. It's not very strong and it can't protect us from the heat and strong wind.

When my father got ill and had to become a beggar, my mother became a maidservant but she didn't earn enough to even feed us two meals a day. So I'm a maidservant as well now; I work all day washing their clothes, cleaning pots and pans and looking after the children.

Before the floods, I was in Class 4 at school and my oldest brother also went to school, the others were too small. My father's dream had been for us to be educated, but now this dream has gone.

My grandfather says the floods are getting worse day by day. The river is becoming shallow and overflows when the rains come. Forty years ago, life for families like ours was different; there was plenty of good land to cultivate, and we could eat fish, vegetables and meat. People felt they had enough to live on and relationships were good.

If I could only go back to school I would study to become a doctor. I would provide medical facilities for people in need and try to get rid of different health problems.

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Climate heroine

My name is Imrana

and I'm from Assam. I'm eleven and I help teach younger children how to be safe during a flood.

I am teaching my five little sisters and one little brother to swim. The other children from my village join in too, so I'm teaching them all!

I say to them, 'climb on my back and I will swim along with you'.

We practise in the still waters of the beels (lakes). The Brahmaputra River is too strong so we stay away from there. Sometimes dolphins come into the beels. We always try to swim with one. They are so beautiful to see.

When they are getting good we go on a raft to the deep waters. I put them there and row for a while. Then I call, 'swim to me' and they come.

The water can rise quickly. It turns black and moves in fierce circles. I tell the children to get onto the raised platforms immediately.

When the water gets too high we go to the shelters in rafts. These are made from banana stalks and tarpaulin and rock from side to side. It is very important to know how to swim and to hold on for safety.

If there are no rafts we swim to the shelters. We stay away from strong currents. These come from west to east and they break over the land with anger.

I teach the children to take the help of the water hyacinths. We hold on to them in the fierce waters.

These are some of the things I do to prepare children for floods. It makes me feel proud to help my community in this way.

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7

Climate hero

My name is Marahaj Chandra.

I am the headteacher of Karchua Bori Primary School in Assam.

The people in this area know how to live in floods. We are like amphibians!

But in 2000, 2004 and 2007 we have had terrible floods and many people lost their lives. We were surrounded by deep waters. Disease came and many suffered with fever.

In 2004 we lost everything. Desks, benches and books were washed away. The children had to sit on sacks.

The floods destroy things that take a long time to build. But I continue to teach. The children learn about flooding and how to survive in the waters. We don't need books for that.

We learn about climate change. We have heard that the glaciers are cooling down in the mountains and the water is coming here. The fast mountain rivers are angry. They are bringing all of this dead silt (mud) to us. It kills our crops.

We made flood maps to look at where the floods were worst and how we could prepare for next time. We decided to plant trees between our school and the Brahmaputra River. These will stop the force of the water and protect our school building.

We also learn how to cope in the middle of a disaster situation. We teach the younger children how to swim and not to go to the flood waters without an adult.

We also learn how to make canoes from banana plants, bamboo and tarpaulin or how to make life jackets from bottles and jerry cans. We learn how to get above the water level on to a raised platform. If the water keeps rising we know that we must run or swim to the shelters.

The children go to their homes and tell their families what they learn in school. This is great because they are educating a whole community!

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My climate story

I'm Jorina

and I'm 14. My sister and I live with our grandmother and uncle in Char Harikesh village, because my mother is so sick. To help her I started working as a maidservant but that was poorly paid. Now my sister and I have been given the chance to bind cigarettes. This pays really well and I'm now going to school in the mornings. In the afternoon we collect vegetable leaves and cow dung from the nearby field and bind the cigarette sticks in our yard. In the evening we help our mother prepare food.

I will never forget how our lives were devastated by the floods. The riverbanks of the Dhorola River got eroded and the water worked its way across our land. My family left there and looked for a secure place to live... we moved many times. For a while my father worked as a rickshaw driver, life was hard and he still couldn't provide for us. In the end he left my mother to care for us four children alone. She had no way to feed us and so became a maidservant, but even this wasn't enough to buy three meals day for everyone, so she worked as a labourer as well. Gradually she became sick due to the hard work.

Our house is still not strong enough to protect us from the weather. It's made of tin, the walls are bamboo fence and the floor is made of mud.

My aim is to complete my education and become self-sufficient.

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A partnership programme for environmental learning and teacher education

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