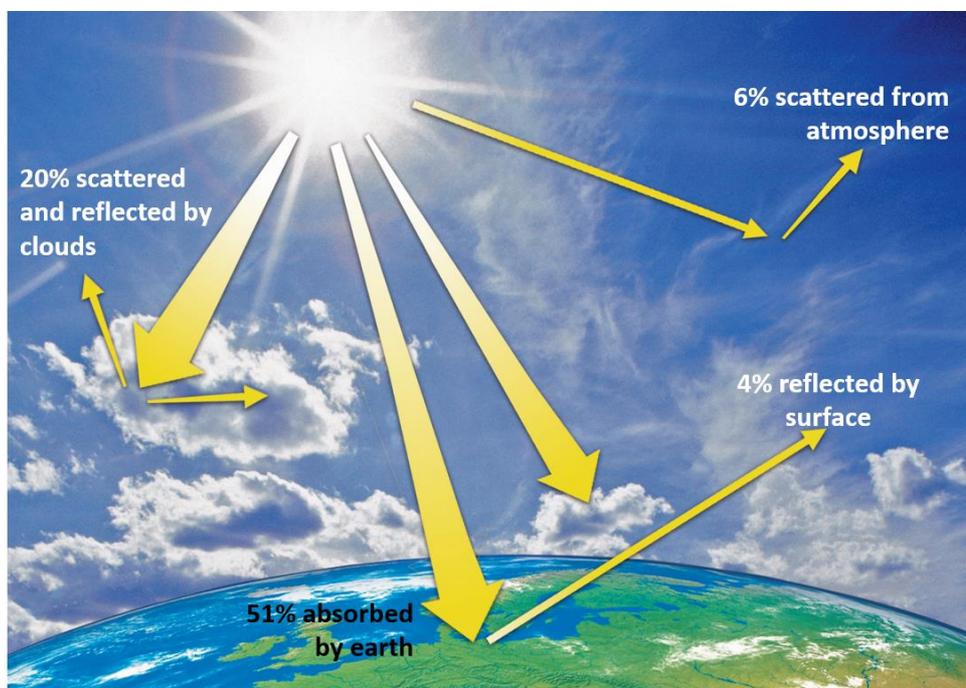


Exemplar: Climate Change

A question of balance

Over the last 50 years, human actions have increased carbon dioxide and other greenhouse gases to affect the global climate. Climate change is the biggest challenge that faces the world today and it is also a threat to sustainable development. Climate change is disrupting national economies and affecting lives in every country. We see around us changing weather patterns, rising sea levels, extreme weather conditions. These changes pose a huge risk to health, from death to extreme conditions to changing patterns of infectious diseases. In addition to this, changing weather patterns affect food systems and quality of water. Climate change not only affects humans but it greatly affects biodiversity. In the midst of this, saving lives, livelihoods require actions to address climate change.



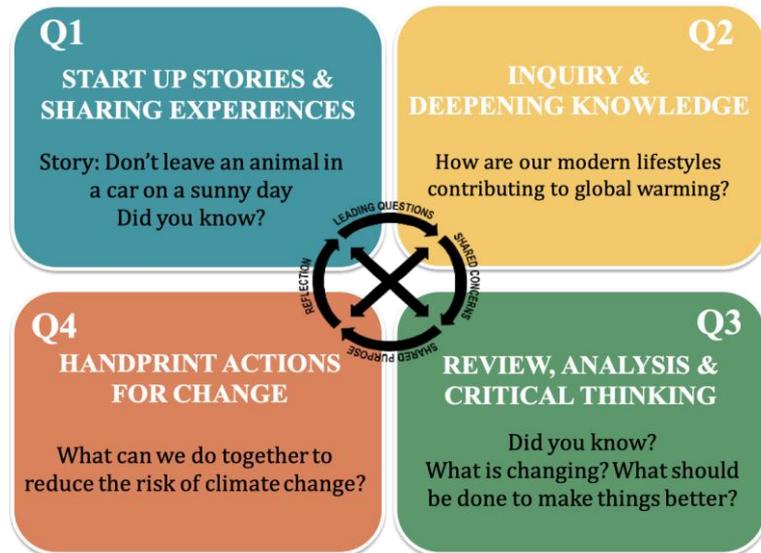
Linkages to the SDGs

While all 17 goals have strong links to climate change, **Goal 13 Climate action** calls for urgent actions against the climate crisis in order to save lives and livelihoods. In this exemplar, we consider SDGs through which we can work with learners to understand key climate change concerns and impact on the planet, people and prosperity.



Handprint CARE Pedagogy

Teachers using the Handprint CARE pedagogy could facilitate learning among students by taking them through experience sharing to inquire about the issues to critically think about what can be done and then taking actions. The quadrant diagram guides teacher about how this exemplar could be used:

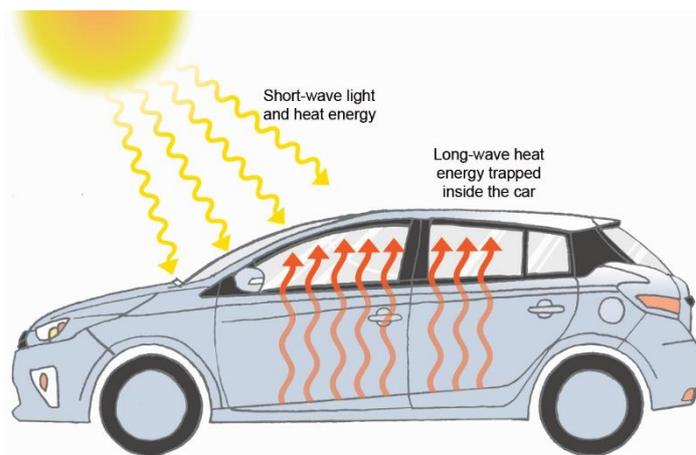


Quadrant 1

Start up Stories & Sharing Experiences

Story 1: Don't Leave an Animal in a Sunny Day *Too sunny for a birthday ice cream!*

Simon's granny bought him a puppy for his birthday. It fell asleep in its basket in the car and Simon wanted to stop for ice cream on the way home. He did not want to wake the sleeping puppy by moving the basket but his gran explained that they could not leave the pup in the car as the car was like a greenhouse with long wave light radiation coming in through the windows to be absorbed, reflected and dispersed as short-wave heat radiation that was reflected back inside by the windows.



The car is a solar collector like a greenhouse, and would get too hot for the puppy. It would become overheated within minutes and could die of heatstroke. They made a plan to have ice cream some other day.

NOTE: This is developed around a question of why is it cruel to leave an animal in a car on a sunny day and a simplified picture of the Earth as 'a solar powered greenhouse' with a 'balanced energy budget.' These concepts can help us explore some of the changes driving regional climate change and to understand

what we can do to 'keep it cool' together. The cards are designed to inform and to invite deliberative learning.

To know more refer to weblink <https://serc.carleton.edu/eslabs/weather/2b.html> and/or video on Earth's Heat Budget <https://www.youtube.com/watch?v=e17ygWztQqA&t=136s>



Puzzling Climate Change Together

How is energy-in, as mainly short-wave solar radiation - (light) balancing against this being reflected, dispersed and absorbed as long-wave radiation (heat)?

Did you know?

Climate System Extremes Come in Many Forms

Seasonal patterns of extreme weather events can take many forms:

1. Heat waves and droughts
2. Cyclones and heavy rain
3. Tornados
4. High tide flooding and beach erosion,

In many parts of the world, extreme events are increasing as greenhouse gasses have increased in the atmosphere to increase global warming.

Story 2: Sharing Heritage

PAST Climate Action: End of Season Galesha

For centuries, the Xhosa experienced cycles of drought in eastern southern Africa. The regional climate variation did not enable them to predict when and if the rains would come each year. They were cattle people who gathered wild foods and grew grains and vegetables in household gardens.

Each year as Orion's Belt became visible in the night sky, they would know that the summer season was coming to a close and that croplands had to be cleaned in preparation for the next season. The cattle would be put into the fields to eat the remaining stalks of the summer crops and to fertilise the lands for the next season.

The process of cattle cleaning the lands concluded with *galesha*, breaking ground so that any winter rains would sink into the soil for the crops of the next season.

Past Climate Action: Some Indigenous Knowledge Practices

In drought seasons the sweet veld pastures would not support the cattle so that Xhosa herders would migrate to the *Zuurveldt* to graze on the nutritious sour veld grasses that were high in nutrition over the short period of summer rainfall.

As the grazing declined the cattle were returned to the grassland areas north of the Kei River (Transkei) which would usually have recovered. Even in bad years the pastures were usually sustained into the new season by the lighter winter rains.

Galesha, late rain migration and other indigenous knowledge practices sustained village communities.

These practices helped maintain food security, ensuring nutrition and avoiding poverty. Today rain water harvesting and *Izala* composting are enabling food production in droughts; nutrition is improving with wild leafy vegetables like *Imifino* and fermented foods like *Amasi*, *amaRewu* and *Isonka*.

Story 3: Climate Action in Mexico

Tlacotalpan is a town located on the banks of the Cosamaloapan River, the most abundant in Mexico. Living by the river has allowed the inhabitants of this town to develop a very rich culture based on all the riches (food, ecosystems) that a river like this has. Unfortunately, the town is located below sea level, and with climate change and changes in the cycles of the rainy and dry seasons, there have been episodes in which, for example, when it rains a lot, the town floods, thereby causing many deaths during periods of flooding. On the other hand, the water that remains accumulated has no outlet and remains stagnant, thereby causing diseases associated with vectors such as those transmitted by mosquitoes. To adapt to these irreversible conditions, a group of young people and a group of academics from the Veracruzana University are participating in developing planning and action workshops with residents who live on the banks of the river, in order to design risk and contingency plans to be able to deal with more information and training when a flash flood event occurs. Likewise, this group of young people are training the inhabitants to understand the reproductive cycle of mosquitoes to prevent diseases such as dengue from spreading. People understand that there is no longer much to do in terms of river levels, but they can be prepared to better face the risks that living in these risk areas implies.

Story 4: 'Cooling Actions' by Students for Warming Earth in India

A team of students and teacher in-charge of the Love Green eco club of St. Anthony's Upper Primary School in Wayanad, Kerala (India) initiated a climate focused action project at Karlad lake situated near the school which is spread over a 7 acres area. To compare present status with the situation 50 years ago, students collected information through a questionnaire and interviewed older inhabitants around the lake. Students walked a 5km stretch along the lake and marked vegetation, houses, fields, other physical features and drew the map showing the present status. These maps were analysed to understand the impact of human interventions on climate change. From their analysis, students found that the microclimate has become warmer in 50 years. Deforestation for agriculture, urbanisation, overuse of fertilisers and synthetic pesticides contributed to warmer temperatures in this area.

Students then decided to find solutions for these issues. Students organised a seminar 'Snehathinte Thannel Marangal' (Loving trees that cool the climate) and the findings of their study were discussed with the community, local Panchayat and Kudambasree members. After the seminar, 30 saplings were planted around the Karlad Lake.

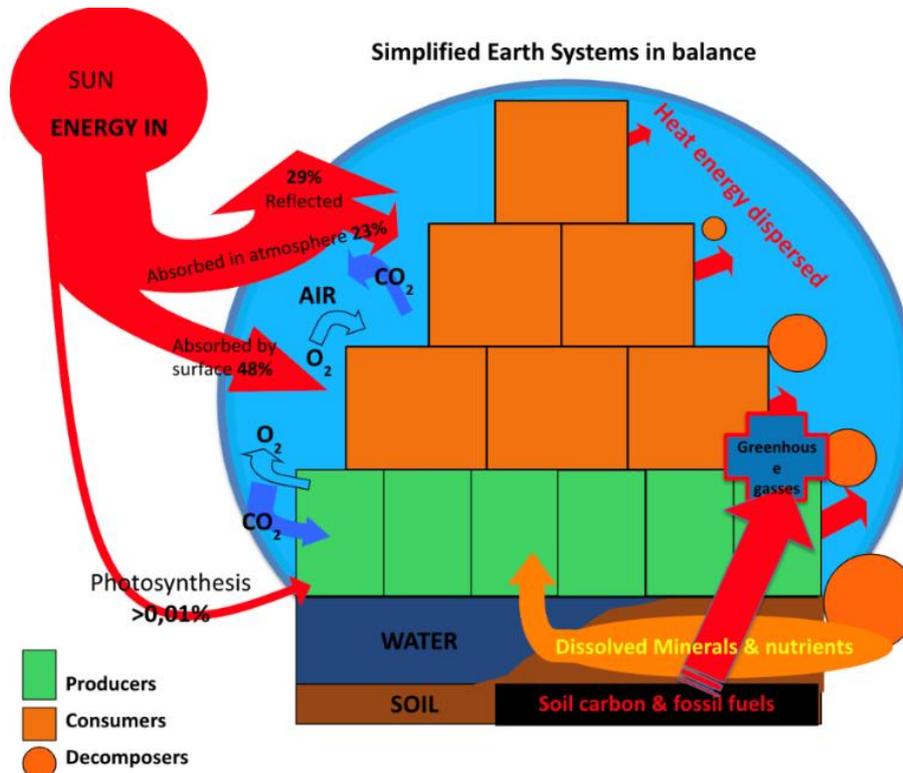
During the rainy season that year, students started a greening programme around the lake. Nearly 2000 saplings were planted around the 4 acres of land around the lake. Local community and Kudambasree members, officials from the local forest department, Sarva Shiksha Abhiyan wing and students from nearby schools - all participated in this programme. Nine species of plants, some of medicinal importance including gooseberry, Mango, and drooping Asoka, were planted. Students also planted 16 species of bamboos (Bambusa species) in a 1.5-kilometre stretch along Karlad Lake. Students also gave one sapling to the households in the village and each student of the school to plant. In addition, 1600 teak saplings were distributed to each household. Students and teachers monitored the plants every month to ensure better growth of these saplings. Two copies of the survey card were maintained - one by the household and other by the school. At the end of the year the trophy was awarded to the household and the student who protected and took good care of the sapling. The record showed a survival rate of about 85% which was highly encouraging.

Source: NGC ESD Case Study Handbook, CEE <https://paryavaranmitra.in/9-CLIMATE-CONCERNS.pdf>

Quadrant 2 Inquiry & Deepening Knowledge

Eco Puzzle Activity 1: Find out about the Earth Systems Balance

The diagram below shows a model of the earth systems when it is in balance and how it functions. Guide learners to further understand through discussion and debate related to the functioning of the earth systems.



Solar Energy

The Sun (Latin word Sol) is the star at the centre of our Solar System. The Earth and other matter (including planets, asteroids, meteoroids, comets, and dust) orbit the Sun, which makes up about 99.8% of the Solar System's mass. Energy from the Sun, in the form of sunlight and heat, supports almost all life on Earth through photosynthesis, and drives the Earth's climate and weather. Use below questions for discussion:

1. Where does our planet, Earth, get its light and warmth from?
2. What energy source heats our Earth and enables plants to grow?

Topics to debate

1. What would happen if the Sun burnt itself out and the Earth received no light?
2. South Africa's average number of sunshine hours each day is amongst the highest in the world – 8.5 hours. What are the advantages and disadvantages of using solar technology?



The Greenhouse Effect

The “greenhouse effect” describes the warming effect that certain gases have on the temperature of the Earth's atmosphere under normal conditions. Sunlight (shortwave radiation) passes easily through the Earth's atmosphere. Once it strikes and warms the Earth's surface, longwave radiation is given off and goes back into the atmosphere. Some is reflected back to Earth, absorbed or held by carbon dioxide and other gases that exist in the atmosphere. These greenhouse gases keep the Earth warmer and more habitable than it would have been if this effect did not occur. However, if the greenhouse gas layer gets too thick the Earth will become hotter and less habitable. Use below questions for discussion:

1. Can you find a picture representing the Earth's greenhouse effect?
2. Find a picture showing shortwave (or solar/incoming) radiation and outgoing longwave radiation.

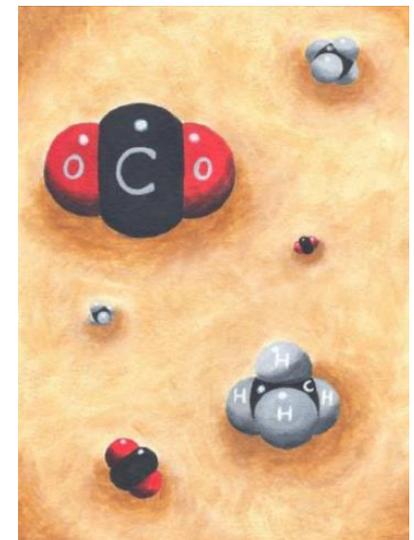
Topic for Debate: What would happen if there was no ‘greenhouse effect’ on our planet?



Greenhouse Gases

Greenhouse gases are gases in the atmosphere that absorb and emit radiation within the thermal infrared range. The main greenhouse gases in the Earth's atmosphere are water vapour, CO₂, methane, nitrous oxide, and ozone. Due to people's activities, the amount of CO₂ released into the atmosphere has been rising during the last 150 years. The opposite of CO₂ emission is “sequestration”, which means to capture carbon from the atmosphere and store it in biomass, oceans, and other “sinks”. Currently our emissions are exceeding carbon sequestration, thereby contributing to global warming. Use below questions for discussion:

1. Can you find a picture representing the molecule, carbon dioxide, CO₂?
2. What is generated as a by-product of the combustion of fossil fuels or the burning of vegetable matter?



Topic for Debate: Do you think people's everyday activities contribute to the greenhouse gas layer?

Global Warming

Global warming describes the gradual increase of the air temperature in the Earth's lower atmosphere. This is caused by an increase in greenhouse gas concentrations through natural and human activity. If current pollution trends continue, most scientists estimate that the Earth could become tangibly warmer in the coming decades. Use below questions for discussion:

1. Find a card showing the Earth getting hotter!
2. The gradual increase of the air temperature in the Earth's lower atmosphere is referred to as global warming – find a picture representing this.

Topics to Debate

1. What do you think the effects of global warming could be?
2. Do you think our everyday actions, like bathing, getting to school in a bus or car, have an effect on global warming? How?



Quadrant 3

Review, Analysis & Critical Thinking

Did you know?

Increases in atmospheric CO₂ have been measured since 1958

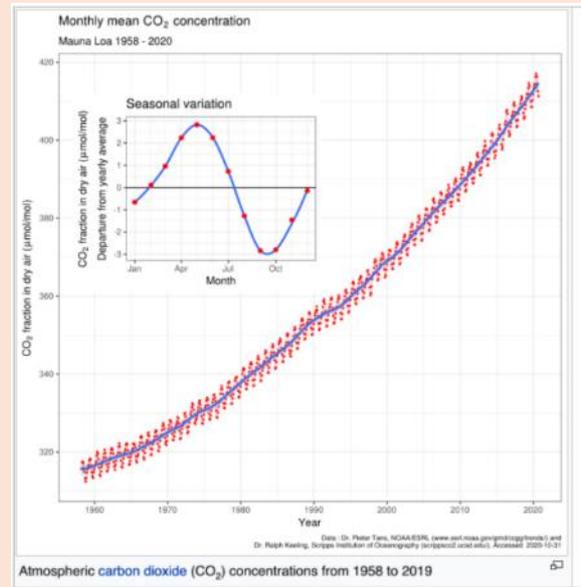
Wikipedia notes that the **Keeling Curve** is a graph of carbon dioxide accumulating in the Earth's atmosphere based on continuous measurements taken at the Mauna Loa Observatory on the island of Hawaii from 1958 to the present day.

The curve is named for the scientist Charles David Keeling, who started the monitoring program. His measurements showed the first significant evidence of rapidly increasing carbon dioxide (CO₂) levels in the atmosphere

How have our past activities produced present challenges?

Global climate is driven by complex weather patterns that scientists can usually predict in daily weather forecasting. Seasonal climate and climate change is far more difficult to accurately measure and predict.

Climate scientists are measuring long-term climate change with increasing levels of greenhouse gasses from the burning of fossil fuels. Increasing greenhouse gasses in the atmosphere mean that the earth is retaining more short-wave heat.



Today global warming is driving climate extremes in the annual seasonal cycles in many regions of the world. Learning to do something about this slowly growing problem can help us to take climate action so that humans can continue to thrive on the planet. Seasonal change has always been with us, so we can learn from how earlier cultural practices aligned with seasonal climate.

Eco Puzzle Activity 2: Let's review some of the changes

CHANGE: Pollution from vehicles

Today's settlements are strongly influenced by the motor car. Sprawling settlements in South Africa requires citizens to often travel far for work, schools, and shopping. People prefer transport by car above public transport, either because of comfort or because of poor transport services. This leads to an increase in our consumption of petrol and CO emissions. What can we do? Cycle or walk where you can; use lift clubs and public transport; cars should be serviced regularly as an inefficient, poorly maintained engine can reduce a car's fuel efficiency by 10% or more. Electric 'green' cars could be one solution

1. Find common forms of road transport that generate carbon monoxide.
2. Carbon monoxide (CO) is a weak greenhouse gas but has important indirect effects on global warming.

Topics for Debate

1. How can we reduce the number of vehicles on our roads?
2. Try to list carbon-free modes of transport.



CHANGE: Pollution by Aeroplanes

Air travel is one of the world's fastest growing sources of greenhouse gas emissions. The world's commercial jet aircraft currently generate more than 600 million tons of carbon dioxide (CO₂) per annum; this represents 3.5% of the entire world's emissions. According to the Intergovernmental Panel on Climate Change, 'by 2050 emissions from aircraft could be responsible for up to 15% of total global warming produced by human activities.

1. Find the mode of transport that is becoming the fastest growing transport sector.
2. Local holidays are better for the planet than overseas trips. Find the card that illustrates the reason why.



Topics for debate

1. Why do people feel that it is necessary to fly in aeroplanes? Are there other options which are not as damaging to the environment?
2. Do you think that 'paying' for your carbon emissions is an answer to flying?

CHANGE: Pollution from Factories

During the Industrial Revolution (about 150 years ago), people began altering the climate and environment through agricultural and industrial practices. We began using machines to make life easier. Before the Industrial Revolution, our activities released few gases into the atmosphere, but through population growth, fossil fuel burning, and deforestation, we are affecting the mix of gases in the atmosphere. The need for fossil fuel-based energy to run machines has steadily increased and is the biggest contributor of global emissions.

1. These places produce gases that contribute to global warming.
2. Find a place where the energy from fossil fuels is used to create consumer goods.



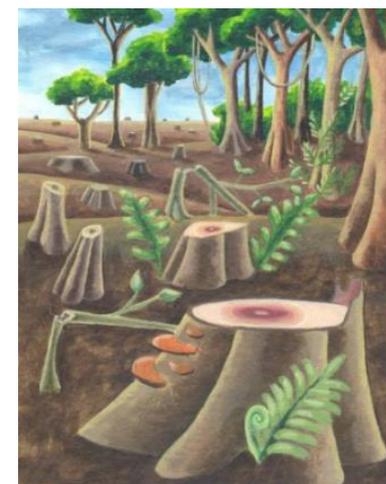
Topics for debate

1. What does 'sustainable development' mean?
2. How is it possible to meet the needs of South Africans through "development" and yet still live sustainably?

CHANGE: Deforestation

Tropical forests hold nearly half of the carbon present in vegetation around the world in their biomass. Furthermore, trees also absorb CO₂ and release oxygen. When they are burned to clear land, the trees, soils and undergrowth release the stored CO₂. Rainforests also cool the climate on a more local level, their canopy helps to trap moisture and allow it to slowly evaporate, providing a natural air-conditioning effect. The replacement of tropical forests with other land uses means that we lose one of our most important mechanisms to combat climate change.

1. What do people use to warm themselves and cook their food?
2. Forests are our planet's lungs – trees absorb CO₂, banking it away in their woody parts and roots. Can you find a picture showing deforestation?



Topics for debate

1. Why do people chop down trees?
2. What are the benefits of looking after our existing indigenous forests, rather than removing them for other purposes?

Eco Puzzle Activity 3: What are the outcomes of these changes?

Outcomes: Extreme weather events

Predicting seasonal rainfall with respect to climate change can be problematic, but most climatologists agree that certain parts of South Africa will see an increase in rain, while other areas may experience more regular drought conditions. The increase in flooding is also a real risk. We are already seeing some of the irregular weather patterns as a result of climate change.

1. In some places storms may become stronger due to climate change.
2. Find a card showing severe weather patterns predicted as a result of climate change.

Topics to debate

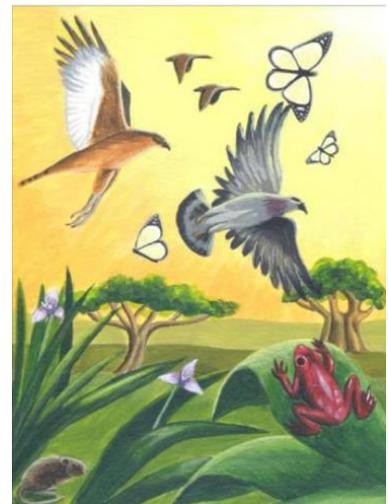
1. Will climate change cause the Earth to get hotter in all places?
2. What will be the effect of climate change on agriculture and other farming practices in South Africa?



Outcomes: Loss of Biodiversity

Changes in climatic conditions will alter the world's habitats and ecosystems. Many of these places depend on a delicate balance of rainfall, temperature, and soil type. When climate changes occur slowly, plants and animals may be able to adapt to the new environment or move somewhere else. However, if future climate changes occur as rapidly as some scientists predict, plants and animals may not be able to react quickly enough to survive. This also gives the opportunity to more robust invasive species to dominate ecosystems.

1. Rapid changes in climate endanger many plants and animals. Find a picture with birds and butterflies.
2. Some of South Africa's fauna and flora are threatened with extinction. Find a picture showing fauna and flora.



Topic to debate: Does it really matter if some plant and animal species become extinct? Why?

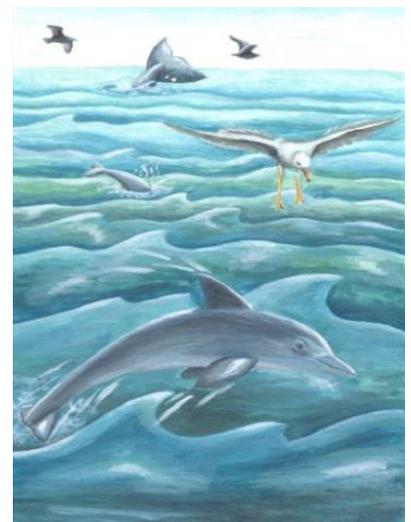
Outcomes: Rising Sea Levels

Oceans cover about 70% of the Earth's surface. Over the last 100 years, global sea levels have risen by a few millimetres every year. Sea level rise is mostly because of melting glaciers and land-based ice. Warmer temperatures also make water expand. When water expands, it takes up more space and the sea level rises. One effect we can expect of rising sea levels is an increase in coastal flooding around the world. Scientists believe that It is very likely that the rate of global mean sea level rise during the 21st century will exceed the rate observed during 1971– 2010.

1. If water levels rise, coastal cities will flood.
2. Phytoplankton form one of the most important "carbon sinks" on Earth.

Topics to debate

1. What will be the major impacts to people living in low lying or coastal areas if the sea levels rise?
2. What is a "carbon sink"?



Outcomes: Increased Disease Risk

Throughout the world, the prevalence of some diseases and other threats to human health depend largely on local climate. It is predicted that, as climate change occurs, some diseases such as malaria may spread to places where malaria did not occur in the past. Warmer conditions may allow the malaria-carrying mosquito to survive in places where it used to be too cold.

1. Find a card that shows an insect that could spread malaria.
2. It is predicted that diseases like malaria will spread with climate change.

Topics to debate

1. Diseases, such as malaria in humans and sleeping sickness in cattle, are restricted by temperatures. As temperatures increase, these diseases spread. Why do you think this happens?
2. What would be the consequences of malaria-carrying mosquitoes moving to cities such as Durban and Johannesburg?



Climate Extremes and the SDGs

Use SDG wheel to discuss following aspects referring to quadrant model:

Description of context

Q1: We live in a solar powered global greenhouse where greenhouse gasses are driving global warming.

Focus of inquiry

Q2: Exploring climate extremes and restoring natural biodiversity to reduce atmospheric change

Scoping the concerns

Q2-3: SDGs 13, 14 & 15, 7 and 3

Change challenges

Q3-4: How did people cope with seasonal cycles of drought in the past and what can we do today?



Creative commons tool of ELRC Rhodes University, South Africa

Quadrant 4 Handprint Actions for Change

RESTORE HABITATS - STABILIZE CLIMATE

‘Take the forest with the tree’

What did the mPondo do when moving plants home from a forest and how can this be used to restore valley thick as a carbon sink for sequestering carbon?

In the mid-20th century, the people of Grahamstown were excited about becoming ‘The Arbour City,’ a city of trees after so much of the indigenous forest habitat and key species like the Yellowwood tree had been lost along with the Rameron Pigeon that spreads its seed.

Nurseries began to produce indigenous trees for people to plant in their gardens to beautify the city and to bring back birds.

The trees initially grew well but then died during drought times. Something was missing that Xhosa naturalists knew you had to do when moving trees home from a forest, you had to ‘Take the forest with the tree.’

Scientists discovered why this was so when they started work on the forest soils of the Eastern Cape where there was a wide variety of mycorrhiza, small microscopic root fungi. These provide nutrients for plants whilst benefiting from the moisture from their roots and producing a hormone that promotes root growth.

PUZZLING CLIMATE CHANGE

What climate action can we take to make things better for the common good?

Increasing climate variability and extreme weather conditions are beginning to characterise the modern-day world in which we all live. Climate action can take many forms and there are many changes that challenge future sustainability.

Play Puzzling Climate Change to explore some of the science informing a concern about climate change and consider local climate actions to change modern lifestyles so as to reduce atmospheric carbon through:

- Transport (How we move around)
- Local foods (What we eat and where it is from)
- Self-help (How we can become more self-reliant)
- Small business (Local is lekker)

PRESENT-TO-FUTURE

Climate Actions to restore habitats and stabilize climate

- **Habitat Restoration** and carbon sequestration (Wetlands, woodland and forest restoration)
- Exploring **low-carbon lifestyle** change and energy generating technologies.
- Planning **disaster risk responses** to mitigate extreme events and support people to restore livelihoods.

Ride a bicycle instead of using a car

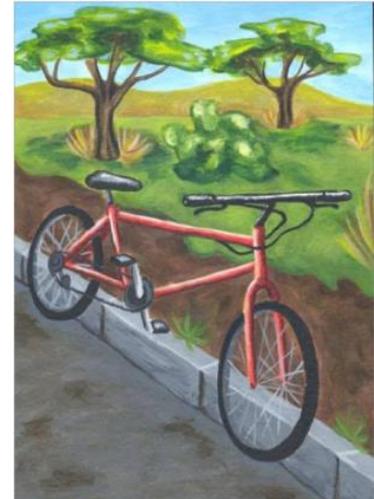
Did you know? Bicycles were introduced in the 19th century and now number about one billion worldwide, twice as many as motor cars. They are the main means of transportation in many countries.

The energy and resources needed to build one medium-sized car could produce 100 bicycles!

1. What type of transport can we use that is virtually carbon neutral?
2. Find an environmentally friendly form of transport.

Topics for debate

1. In South Africa, what problems can you foresee in using bicycles to get to and from work?
2. What can decision-makers do to increase the number of bicycles on the road?
3. What are other ideas for carbon-free transport?



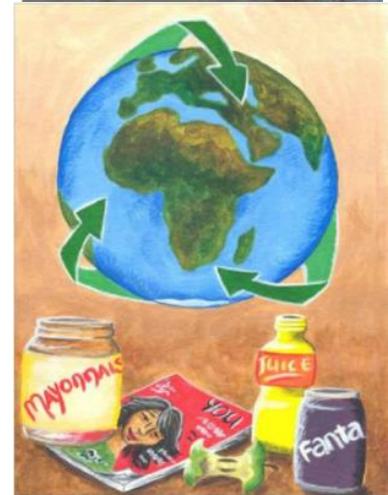
Reduce and Recycle Waste

Waste prevention and recycling can help reduce greenhouse gas emissions by: diverting organic waste from landfills, avoiding the production of methane which is released when organic matter decomposes anaerobically (without oxygen); and, reducing the amount of newly manufactured items, since the most CO₂ is produced in industrial processes to manufacture the items we throw away as waste. We therefore need to cut down on the amount we buy and then throw away.

1. What can we do with the waste that we produce?
2. Waste prevention and recycling can help reduce greenhouse gas emissions.

Topics for debate

1. Why is reusing and reducing better than recycling?
2. How does consumerism contribute to litter and waste?
3. Should manufacturing companies be responsible for the waste resulting from their packaging or is it the consumer's responsibility?



Save electricity

About 80% of the energy used to create light in incandescent (old type/standard) bulbs escapes in the form of heat. Compact Fluorescent Lamps (CFLs) or Light-Emitting Diodes (LEDs) use less energy thereby saving money and electricity. Energy saving light bulbs also last longer and do not have to be replaced as often as incandescent bulbs.

1. After the geyser, lighting is usually the largest consumer of our household electricity!
2. By using less electricity, you can reduce your carbon footprint and save money.

Topics for debate

1. CFLs still rely on electricity. What types of lighting are carbon neutral?
2. Find out how much carbon is emitted by an old type 100W light bulb in one hour and compare it with how much carbon is emitted by a CFL light bulb of 11W in one hour.



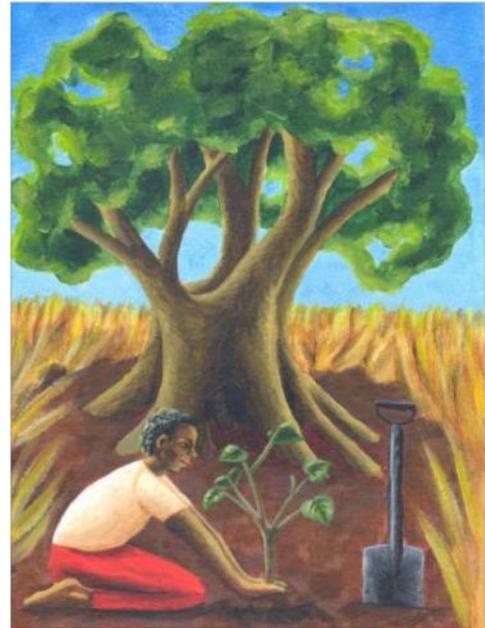
Plant a Tree

Trees act as a major carbon store or ‘sink’. They take up carbon dioxide (CO₂) from the atmosphere and use it to produce the carbohydrates that make up the tree.

1. Because of South Africa’s unique climatic, megafauna and anthropogenic history little of our surface area is covered with indigenous forest. Therefore, great care should be taken to conserve the little we have, what do many people do for National Arbor Week?
2. CO₂ is ‘banked’ in their woody parts and roots – what are they?

Topics for debate

1. Many countries get lots of money by harvesting trees and so are inclined to remove indigenous forests and grasslands to make way for exotic tree plantations that grow quickly. What are the dangers of this practice?
2. Debate the issue around planting trees to offset carbon emissions.



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