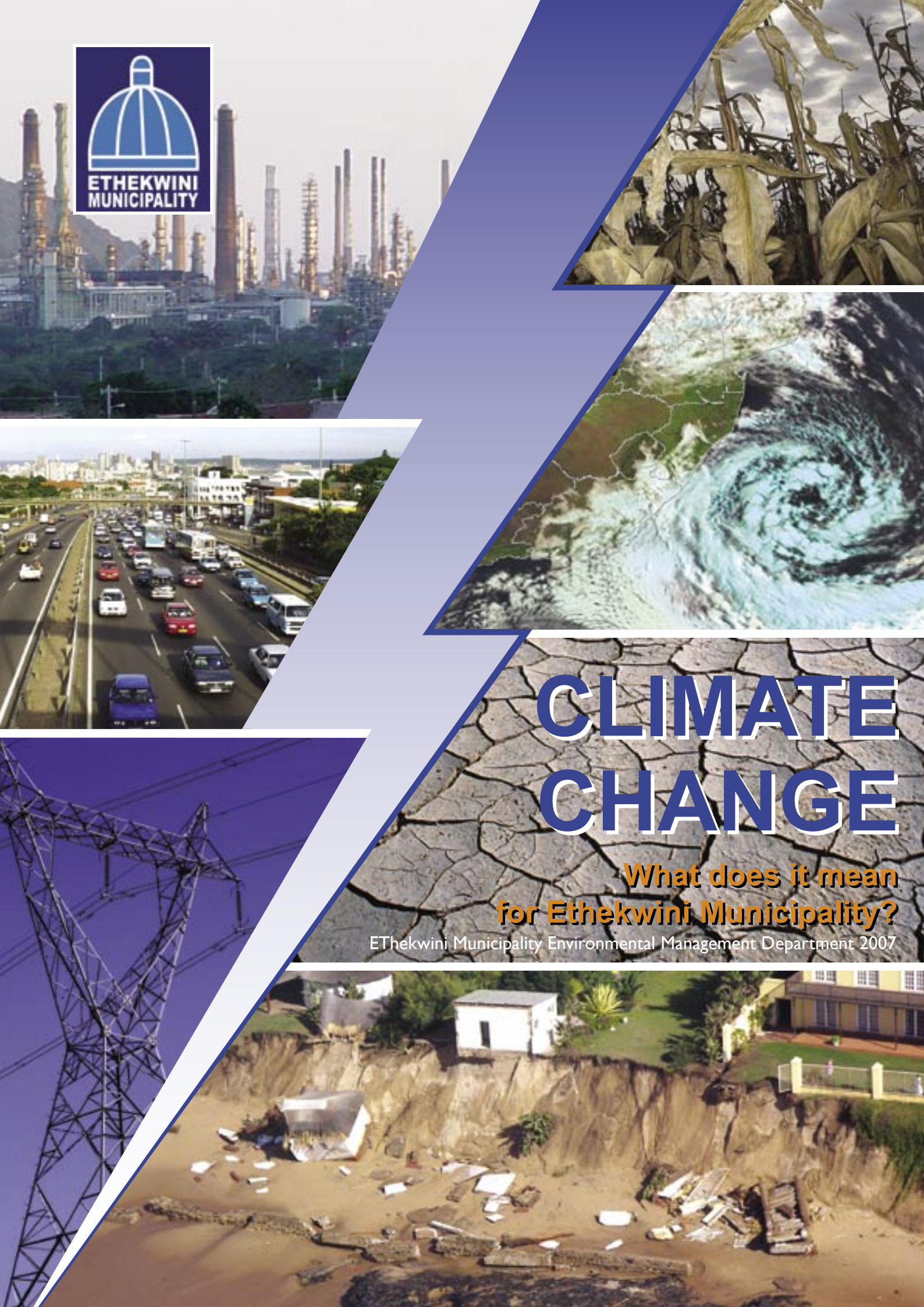

CLIMATE CHANGE

What does it mean for Ethekwini Municipality?

EThekwini Municipality Environmental Management Department 2007

EThekwini Municipality
Environmental Management Department

Climate Change: What does it mean for eThekwini Municipality?

Printed in June 2007 for the 2006/2007 Municipal Financial Year

This document is available in print and electronic format. This report and more information can be found online at the eThekwini Municipality Environmental Management Department's website:
http://www.durban.gov.za/durban/Municipality/environment

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Units of measurement

ha	hectare (100m x 100m)
kg	kilogram
km	kilometre
km^2	square kilometre (100 hectares)
kW	kilowatt (1,000 Watts)
kWh	kilowatt-hour (kilowatts per hour)
MWh	Megawatts per hour (1,000 kWh)
ppb	parts per billion
ppm	parts per million
t	ton (metric, 1000 kg)
t/yr	tons per year
W	Watt
W/m^2	Watts per square metre
W/m^2ppb	Watts per square metre per part per billion

Acronyms used

CCP	Cities for Climate Protection
CDM	Clean Development Mechanism
CER	Certified Emissions Reduction
CFC	Chlorofluorocarbon
CFL	Compact Fluorescent Light
CH_4	Methane
CO_2	Carbon dioxide
DAEA	Department of Agriculture and Environmental Affairs (Provincial)
DEAT	Department of Environmental Affairs and Tourism (National)
DME	Department of Minerals and Energy (National)
EESMP	eThekwini Environmental Services Management Plan
EMA	eThekwini Municipal Area
EMD	Environmental Management Department (Municipal)
EU	European Union
EWS	eThekwini Water and Sanitation (Municipal)
GHG	Greenhouse gas
GWP	Global Warming Potential
HCFC	Hydrochlorofluoride
ICLEI	Local Governments for Sustainability (previously: International Council for Local Environmental Initiatives)
IDP	Integrated Development Plan
IPCC	Intergovernmental Panel on Climate Change
N_2O	Nitrous oxide
NEES	National Energy Efficiency Standards
NEMA	National Environmental Management Act
NGO	Non-Governmental Organization
UNEP	United Nations Environmental Program
UNFCCC	United Nations Framework Convention on Climate Change
WMO	World Meteorological Organization
WRI	World Resources Institute

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Global climate change is predicted to increase the frequency of severe weather events and cause a rise in average sea levels. On 18-19th March 2007, Durban's coastline experienced an extreme cut-off low pressure system at the same time as higher than normal tides. This resulted in damage to and loss of homes, businesses, and infrastructure, as well as closure of the port, Durban's economic hub. Such events are likely to become more frequent in the future and the eThekwini Municipality and its inhabitants will need to be better prepared.

WHAT IS CLIMATE CHANGE?

Why do I need to know?

Climate change is a global problem that requires action on individual, local, national, and international levels to be effectively addressed. The eThekwini Municipality has recognized the serious challenges that climate change poses for sustainable development and biodiversity preservation in Durban. The municipality is making efforts to reduce greenhouse gas emissions and to adapt municipal planning and activities to address the predicted impacts of climate change. Activities that will reduce the impacts of climate change range from simple behaviours, like turning off lights when they aren't needed or using public transport rather than private cars, to the use of sustainable technologies, like producing electricity with solar panels rather than coal or developing vehicles that run on cleaner fuels. Governments can't tackle climate change alone; they need the support and action of their citizens to make a difference.

Global climate change is the increase in the average temperature of the Earth's atmosphere, which will cause **changes in local climate patterns** and **sea level rise** worldwide. The Earth's average temperature increased by about 0.74 °C in the last century. This century's rate of warming has been faster than any global temperature changes estimated for the past 10,000 years. A broad consensus of scientists has agreed with 'very high confidence' that the recent, rapid warming was caused by *human actions* and that its effects are already being seen (IPCC, 2007). Human activities, such as *fossil fuel burning* and *land cover change,* produce **greenhouse gases,** such as carbon dioxide, that trap heat in the Earth's atmosphere. It is predicted that the continuation of these activities will result in a 1.8-4°C average temperature increase over the next century (IPCC, 2007).

In South Africa, climate change will result in increased temperatures and rising sea levels, but it will also alter rainfall patterns and seasons across the country. These changes will threaten water availability, agricultural production, health, biodiversity, and infrastructure. Despite these threats, South Africa plays a significant role in causing climate change: the country is ranked number fourteen for national carbon dioxide emissions worldwide and produces more greenhouse gases than the rest of Sub-Saharan Africa combined (WRI, 2006).

Definitions of all blue words in the text of this document can be found in the ***Important Terms*** glossary starting on Page 44.

The Greenhouse Effect

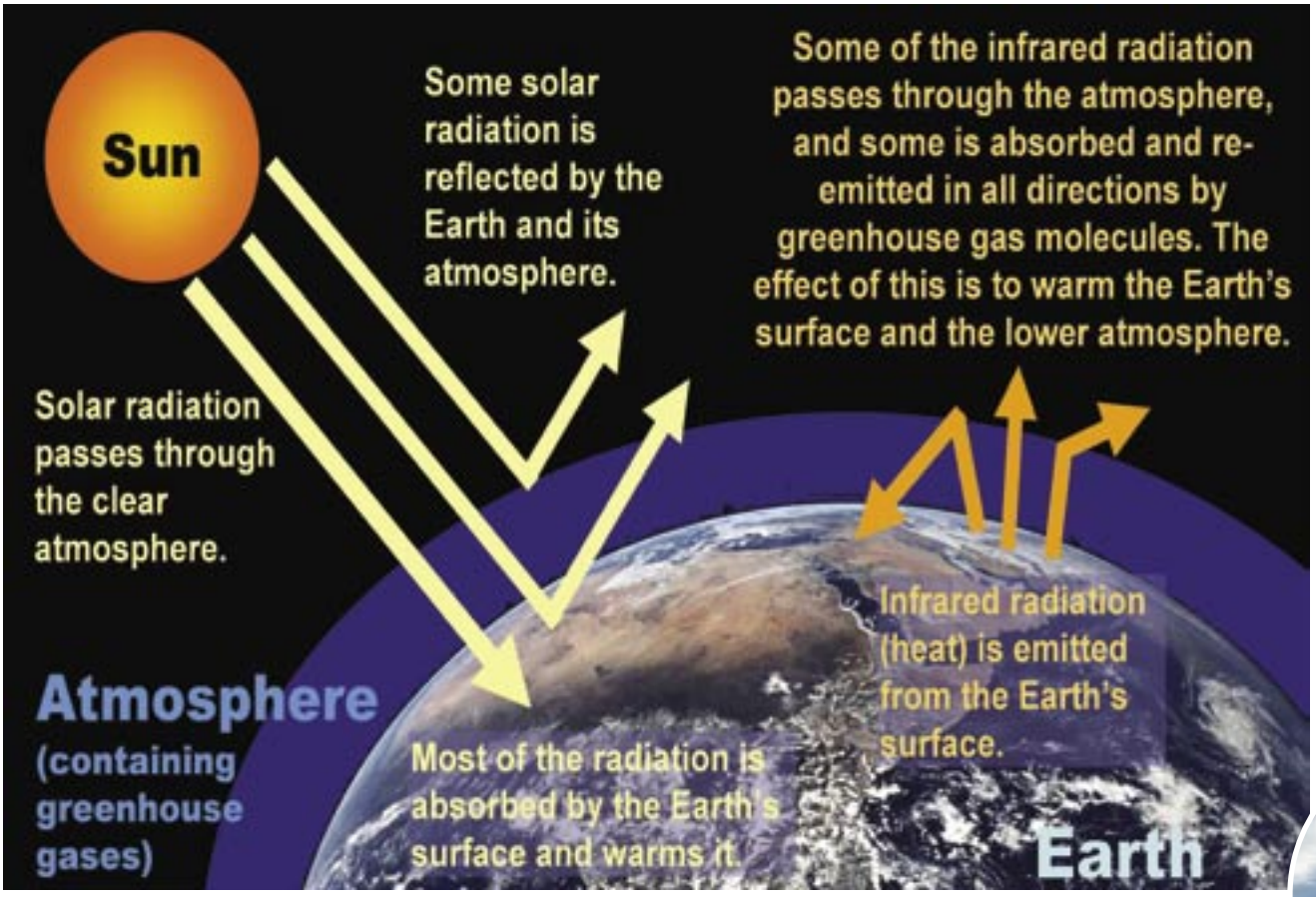
Climate change is caused by a process called the **greenhouse effect**. The sun's light (also called solar radiation) passes through the atmosphere and hits the Earth's surface. Energy from the sunlight is absorbed by the Earth's surface making it warmer. Some of this energy is released back into the atmosphere as heat (also called infrared radiation). Certain gases, called **greenhouse gases (GHG)**, form a layer in the Earth's upper atmosphere that prevents much of this heat from leaving the atmosphere and going out into space. These gases act like the glass of a greenhouse or a window: they let light in, but keep some of the heat from passing back out.

The most common GHGs are:

- **Carbon dioxide (CO_2)**
- **Methane (CH_4)**
- **Nitrous oxide (N_2O)**

Greenhouse gases are like a heat trapping blanket around the Earth. This greenhouse effect has kept the Earth at temperatures appropriate for life. Without it the Earth would be very cold, possibly 30°C colder than the current global average of 14°C! Our moon is roughly the same distance from the sun as Earth, but doesn't have a GHG atmosphere to trap heat. It has an average temperature of -18°C. Human activities that produce additional GHGs have thickened this blanket and have greatly enhanced the greenhouse effect over and above natural fluctuations.

The term **global warming** is often used interchangeably with climate change because the *average* temperature of the Earth is increasing. However, climate change will affect different parts of the world in different ways. Average *warming* of the whole planet could cause some places to actually become *colder!* This is because a warmer Earth will have different wind and ocean currents and weather patterns than we see today.
For example, the Gulf Stream current that carries warm water from the equator, keeps England warmer in the winter than other countries which are that far north. Ocean warming may decrease or stop this current and make England's winters colder.



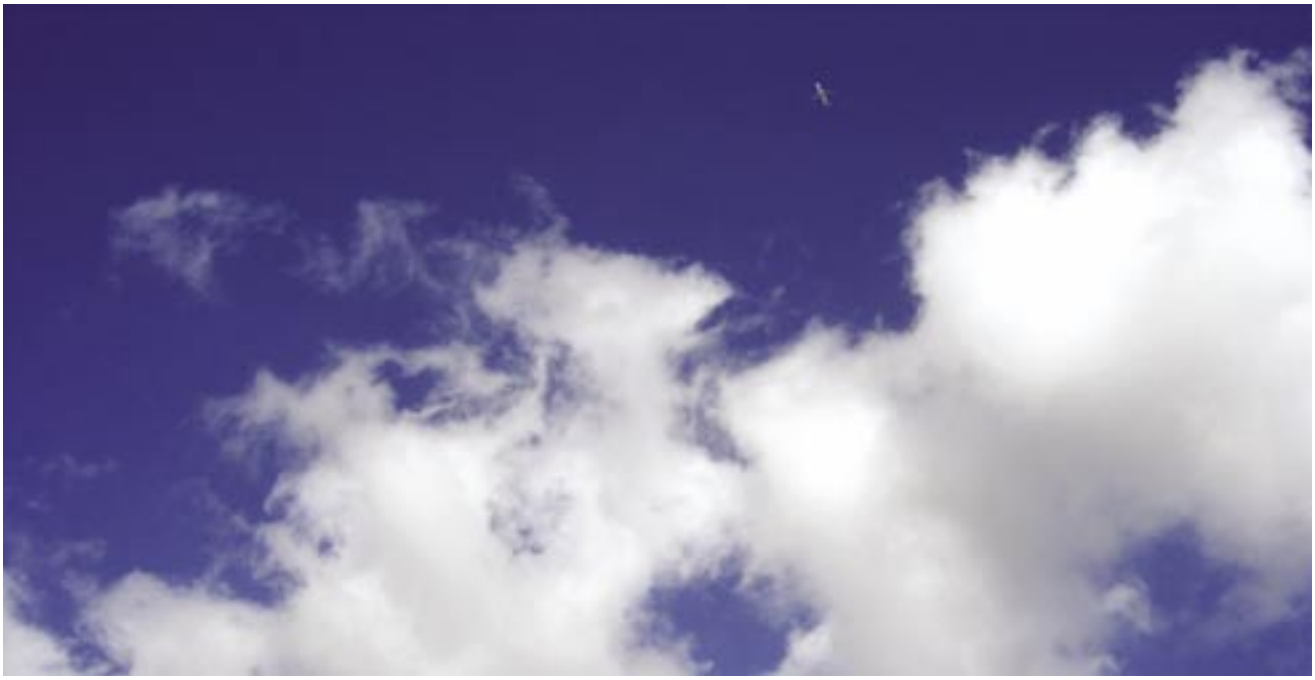
Greenhouse gases, their strengths, sources, and current effect on the climate

(Data from: IPCC, 2007)

Green-house gas	*Relative radiative forcing efficiency compared to CO_2*	*Lifetime in atmosphere (yrs)*	Global Warming Potential compared to CO_2	Primary human induced emissions sources	Atmos-pheric concen-tration 2005 (ppm) *Change since 1750 (%)*	Radiative forcing caused 2005 (W/m^2)
Carbon dioxide (CO_2)	*1*	*500-10,000*	1	Fossil fuel & biomass burning Land cover change	379 *(+36%)*	1.66
Methane (CH_4)	*26*	*9-15*	23	Decomposi-tion in landfills Livestock rearing	1.774 *(+153%)*	0.48
Nitrous oxide (N_2O)	*216*	*120*	310	Agricultural fertilizer Industrial processes Fossil fuel burning	0.319 *(+18%)*	0.16
Examples of less common GHGs *(not present in atmosphere in 1750)*						
Chlorofluoro-carbon (CFCs) *E.g. CFC12*	*22,857*	*100*	10,600	Production/ disposal of air conditioners, aerosol cans	0.000538	0.063
Hydrochloro-fluorocarbon (HCFCs) *E.g. 'Freon': HCFC22*	*14,286*	*12*	1,700	Production/ disposal of air conditioners, refrigerators, aerosol cans	0.000169	0.033
Tetrafluoro-methane 'Freon-14' (CF_4)	*7,143*	*50,000*	5,700	Production/ disposal of alumi-nium, cooling systems, circuit boards, insulation, semiconductors	0.000093	0.012
Sulphur hexa-fluoride (SF_6)	*37,143*	*3,200*	22,000	Production/ disposal of electrical equipment & semiconductors	0.0000056	0.0029

Different GHGs trap different amounts of heat (*radiative forcing efficiency*, measured as W/m^2 at a certain concentration, ppb) and remain in the atmosphere for different amounts of time before being chemically changed or broken down. **Global Warming Potential (GWP)** combines these factors to indicate how much warming an amount of a GHG would cause over a period of time. It is measured relative to the warming from one ton of CO_2 over a 100 year period.

(E.g. CH_4 has a GWP of 23, so 1t CH_4 causes 23 times the warming of 1t CO_2 over 100 years. While CO_2 is not the strongest GHG, it has the highest atmospheric concentration and longest life so has the greatest total radiative forcing.)



Radiative forcing: The Earth receives energy from the Sun in the form of solar radiation (or sunlight). The effect that this energy has on the temperature of the Earth depends on a few different factors. Some of the sunlight might be blocked from reaching the Earth's surface by clouds or smog or reflected back out to space by snow, ice, or other shiny surfaces. The rest is absorbed and turned into heat. Some of this heat escapes back into space but some is trapped by clouds and by the layer of greenhouse gases in the upper atmosphere.

Radiative forcing is the term used to describe the effect a factor has on the balance of energy coming into and leaving the Earth-atmosphere system (IPCC, 2007). It is measured in energy (heat) per unit surface area (W/m^2). Negative numbers indicate a cooling effect while positive numbers indicate a heating effect. The size of the number indicates how important a factor is as a climate change mechanism.
E.g. Snow has *negative* radiative forcing: it reflects sunlight and so has a *cooling* effect. GHGs have *positive* radiative forcing: they trap heat in the atmosphere and so have a *warming* effect.

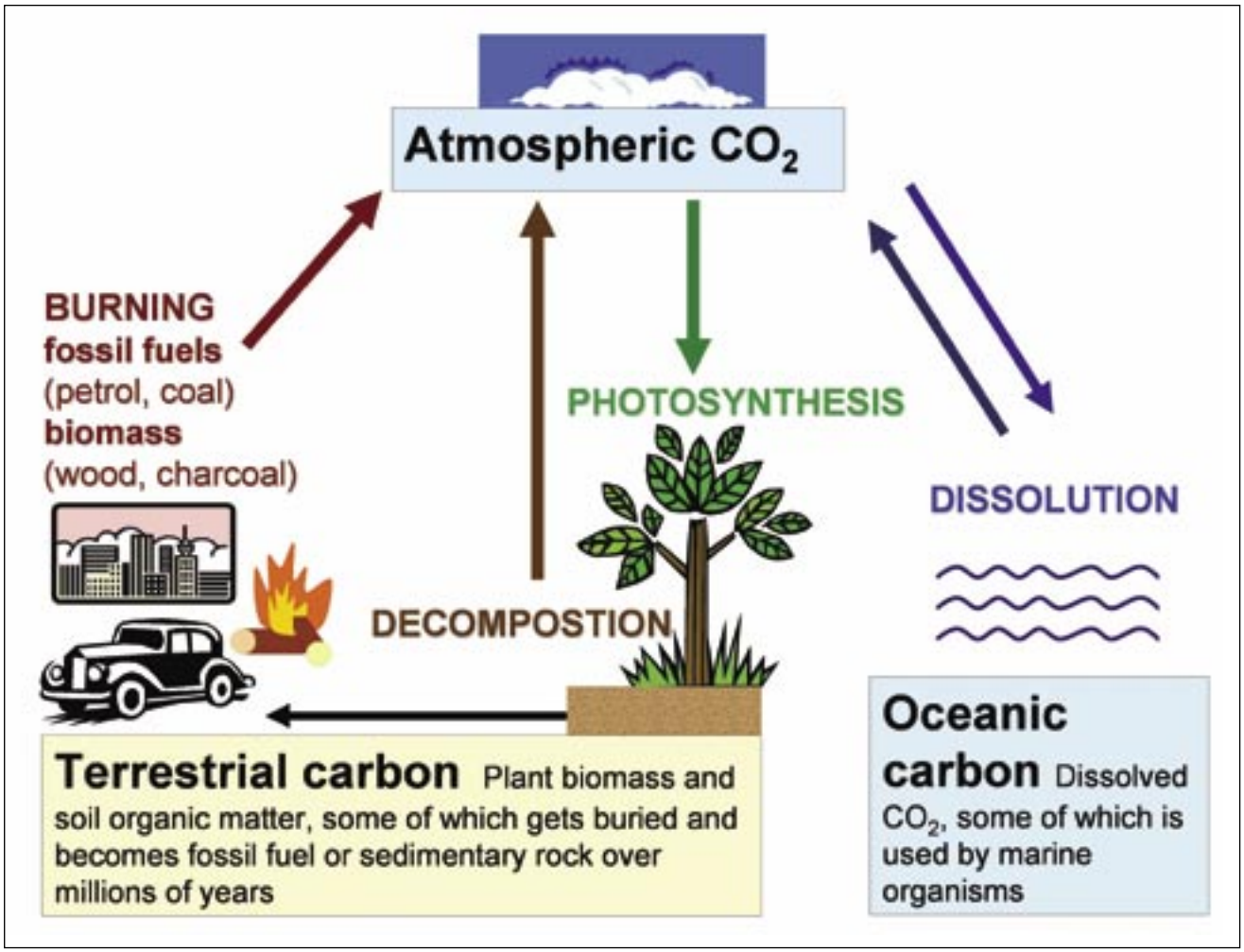
The Carbon Cycle

Carbon dioxide (CO_2) is considered the most important GHG because it is produced in large amounts by common human activities like driving cars, generating electricity, or burning wood, and once it is emitted, can persist in the atmosphere for 500 years or more. Methane (CH_4) and nitrous oxide (N_2O) are actually 'stronger' GHGs than CO_2, meaning that one ton of these gases will trap more heat in the atmosphere than one ton of CO_2; however, these gases are produced in much smaller amounts, so their total effect on the climate (radiative forcing) is currently less than CO_2.

Carbon pools (or **carbon stores**) are the places on the Earth where carbon is found. Carbon is stored in different pools in different forms such as CO_2 gas in the air, carbon based organic compounds that make up wood, carbon compounds in oil and coal, or carbonic acid naturally found in the ocean.

The major carbon pools are:

- The atmosphere
- The ocean
- Vegetation (& aquatic organisms like algae and plankton)
- Soil organic matter
- Fossil fuels (oil, gas, coal)
- Sedimentary rock



The Carbon Cycle: *a simplified diagram of the movement of carbon between atmospheric, terrestrial, and oceanic carbon pools.*

The amount of carbon in the *atmospheric pool* will determine the strength of the greenhouse effect and how much climate change we will experience. It is therefore important to look at how carbon moves in and out of the atmosphere:

- **Carbon emissions**, carbon released into the atmospheric pool, come from natural decomposition of organic material, but also from **human activities** such as:
  - **Fossil fuel burning** (e.g. petrol use in cars, coal use in electricity production)
  - **Biomass burning** (e.g. fuelwood use)
  - **Land cover change** (e.g. deforestation)

- **Carbon sequestration** is the process of removing CO_2 from the atmosphere and storing it in another carbon pool. Plants and algae naturally absorb CO_2 from the atmosphere as they grow, using the carbon to build their body structures *(photosynthesis)*. The carbon is then trapped in organic compounds, in living or dead plant matter, soil organic matter from dead plants, or fossil fuels (partially decomposed organic matter that gets buried deep in the ground). This carbon will be stored on land or in the ocean until it decomposes or it burns, emitting CO_2 and some CH_4 to the atmosphere.

Most carbon pools are constantly undergoing *both* processes that take in carbon and processes that release carbon:

- **Carbon sinks** are carbon pools that are taking in CO_2 faster than they release it, so the amount of carbon in the pool is *increasing* with time.

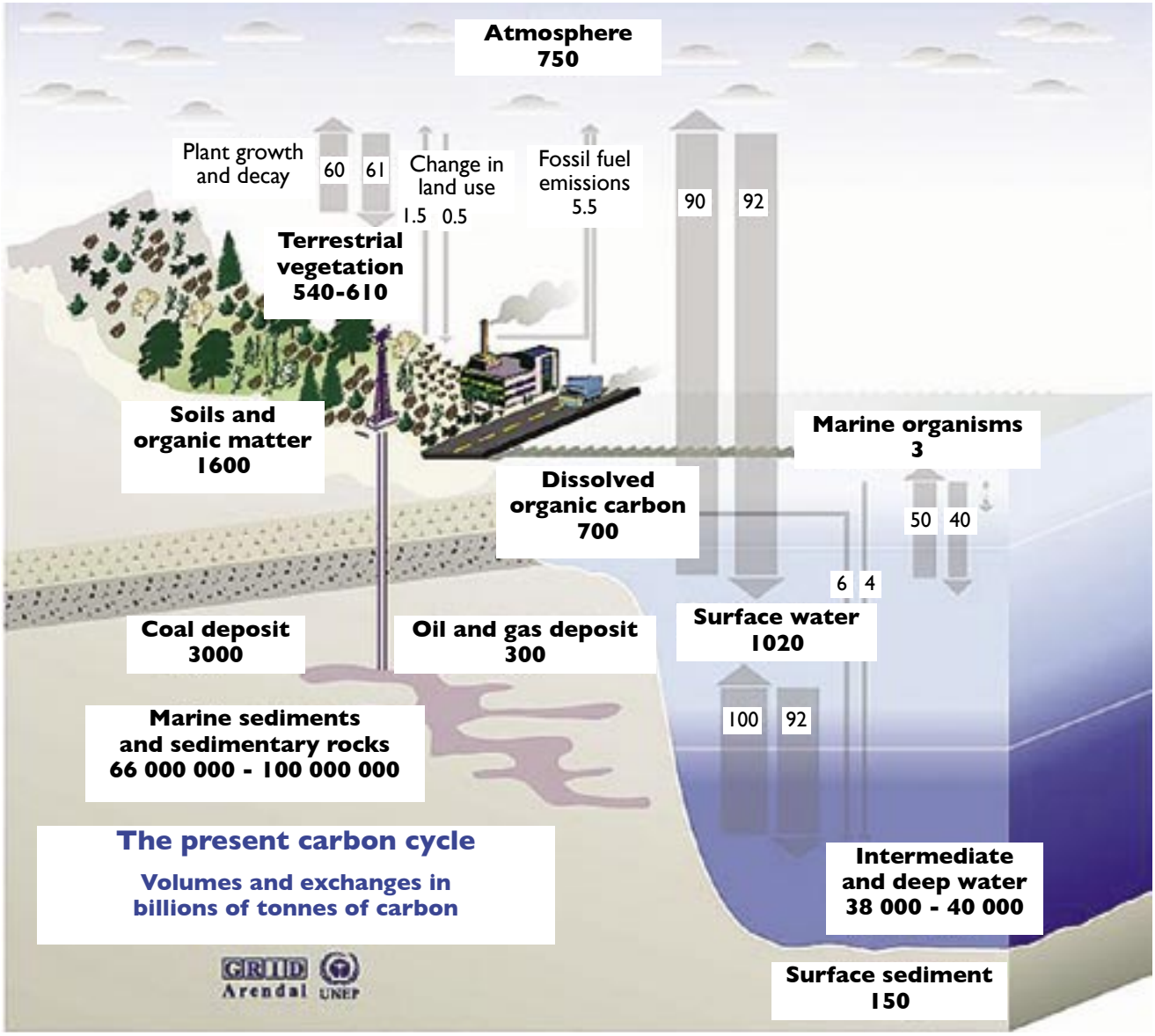
Carbon sequestration > Carbon emissions

> ***Example***: In a forest, this means that photosynthesis (plant growth) is occurring faster than decomposition (of dead plant material). All ecosystems *store* some carbon, but they are not all sinks! Young or regenerating ecosystems can be assumed to be sinks, but some more mature ecosystems may have reached a point at which new plants are growing at the same rate that old plant matter is decaying. In this case the total amount of carbon in the ecosystem is *not* changing

- **Carbon sources** are carbon pools that are releasing CO_2 faster than they take it in, so the amount of carbon in the pool is *decreasing* with time.

Carbon sequestration < Carbon emissions

> ***Example***: In a *disturbed* swamp wetland, the rate of decomposition of dead plant material could become faster than plant growth. Wetlands store large amounts of carbon in their soils because the wet conditions make decomposition very slow due to a lack of oxygen and cooler temperatures. If water sources for a wetland are cut off, the soils could dry and warm up so that decomposition speeds up and becomes faster than plant growth. In total, the area would then be releasing carbon to the atmosphere.



The Global Carbon Cycle:
Numbers in black represent the amount of carbon stored in a carbon pool, given in billions of tons. Numbers in the grey arrows represent the amount of carbon moving from one pool to another each year, given in billions of tons per year. For example global plant growth within stable ecosystems takes 61,000,000 tons carbon/yr out of the atmosphere pool and stores it in the terrestrial vegetation pool.

The total amount of CO_2 in the atmosphere is determined by the balance of emissions and sequestration from all the other carbon pools worldwide:

Atmospheric CO_2 = carbon emissions – carbon sequestration

All over the world, increasing rates of activities like fuel burning all have significantly increased emissions, while activities like deforestation have decreased sequestration, so the amount of CO_2 in the atmosphere (the *atmospheric concentration*) has increased.

Human influence in the carbon cycle

Humans have been directly measuring the concentrations of GHGs in the atmosphere regularly since 1957 when Charles David Keeling set up a monitoring station in Mauna Loa, Hawaii. High on a mountain on a Pacific Ocean island, away from the direct emissions of cars and factories, this monitoring station gives a good estimate of the global average GHG concentration in the atmosphere. The data are now confirmed from stations across the world. Researchers have also been able to estimate historic and pre-historic concentrations using air bubbles trapped deep in the ice of the Earth's poles and by looking at the chemical make-up of organisms that have been trapped and preserved in ice or rock.

The amount of CO_2 in the atmosphere has increased rapidly since the Industrial Revolution that began in the late 1700s, the period when humankind started burning large quantities of fossil fuels:

- In the last 100 years, emissions from fossil fuel burning have increased 1200%.
- The pre-industrial atmospheric concentration of CO_2 was about 280 parts per million (ppm), but by 2005 it had increased to 379 ppm.
- This rate of change in CO_2 concentrations is much greater than the natural range of concentration changes seen over the past 650,000 years, if not longer (IPCC, 2007).

Global carbon balance for 1980-1990 (data from: IPCC, 2007 & Houghton, 2005)

Process	**Carbon emission (+) or uptake (-)** (billion tons carbon /yr)
Fossil fuel burning (& cement production)	+ 6.4 ± 0.4
Net land use & land cover change	- 1.0 ± 0.6
Land cover change emissions (tropical deforestation)	*+ 2.2 ± 0.8*
Land cover change sequestration (temperate reforestation)	*- 0.03 ± 0.05*
*Residual ecosystem sequestration **	*-2 to -3*
Ocean uptake (dissolved CO_2)	- 2.2 ± 0.4
Change in atmospheric pool	**+ 3.2 ± 0.1**

***** The measured increase in the amount of carbon in the atmosphere has not been as large as predicted from the estimated emissions (from fossil fuel use data and land use change monitored by satellite images) and uptake (from reforestation monitored by satellite images and measured ocean carbon concentrations). This indicates that there is a carbon sink that hasn't been measured. This *'missing sink'* is likely to be growth of vegetation within established ecosystems, such as young/damaged forests maturing/regrowing within Northern Hemisphere temperate forests. Net plant growth within established forests can't be easily detected with remote sensing is difficult to monitor globally.

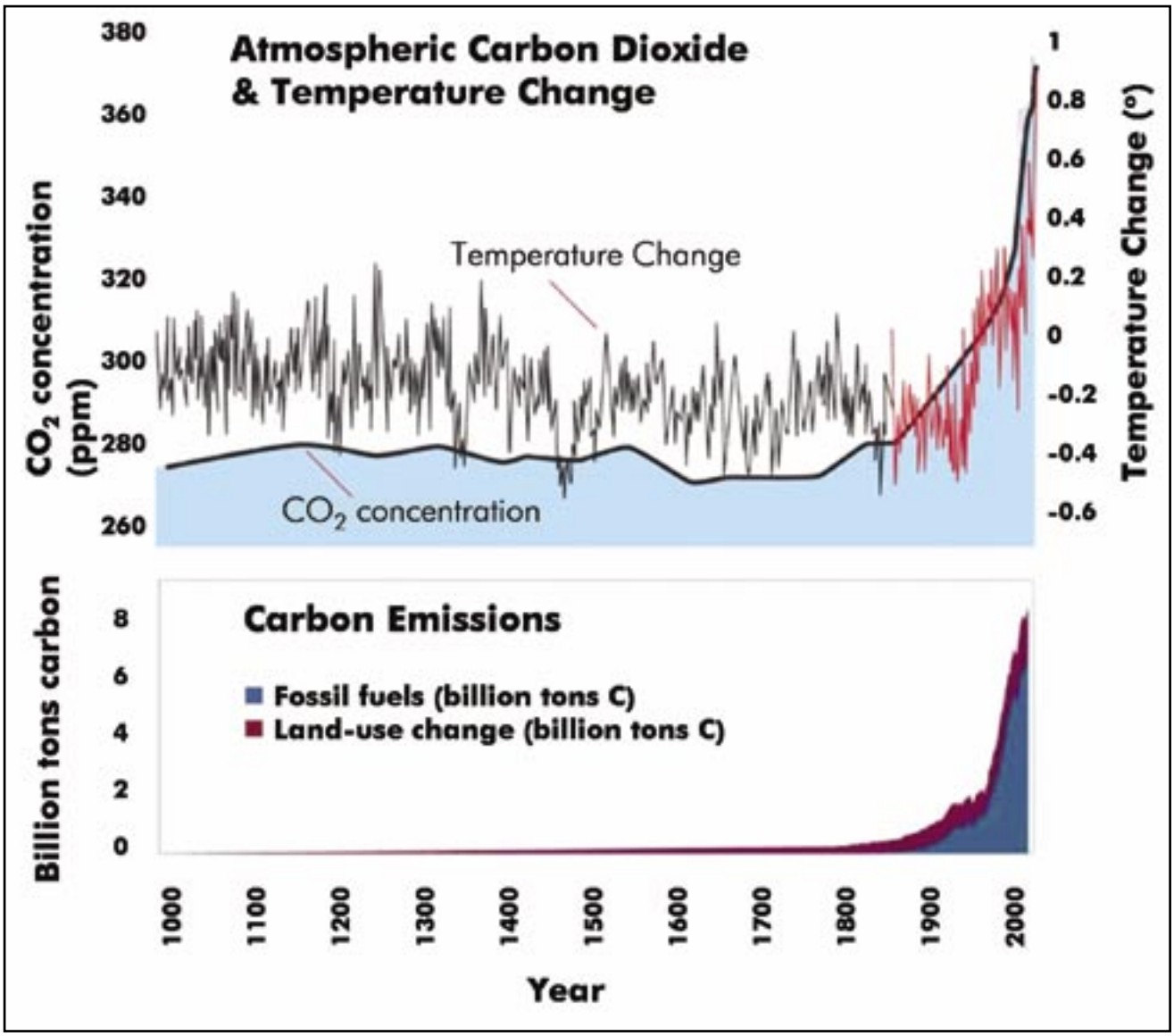
Concentrations of methane and nitrous oxide are also increasing, related to increasing agricultural and industrial activities which produce them (IPCC, 2007). The atmospheric concentration of methane, produced in activities like livestock production, flooded rice cultivation, and decomposition in landfills, has increased by over 150% since 1750! It is a strong GHG with a rapidly increasing concentration and so may become a problem of similar magnitude to carbon dioxide in the future.

The individual's role in the carbon cycle: *The average South African emits about 7.8 tons of CO_2 each year* (WRI, 2006).
One would need to plant about **38 trees** every year to take in all this carbon! (In Durban, the average indigenous tree stores 203 kg of CO_2 in its lifetime.) In other words, you'd have to burn completely burn 38 trees to emit this amount of CO_2.
It is important to remember that trees can take 30-50 years to grow to maturity and take in all that carbon, which you can emit in a single year or less. To permanently offset emissions one would also have to ensure that planted trees are replaced when they die. Tree planting will help reduce GHGs in the atmosphere, but significant emissions reductions are still necessary to reduce future climate change.

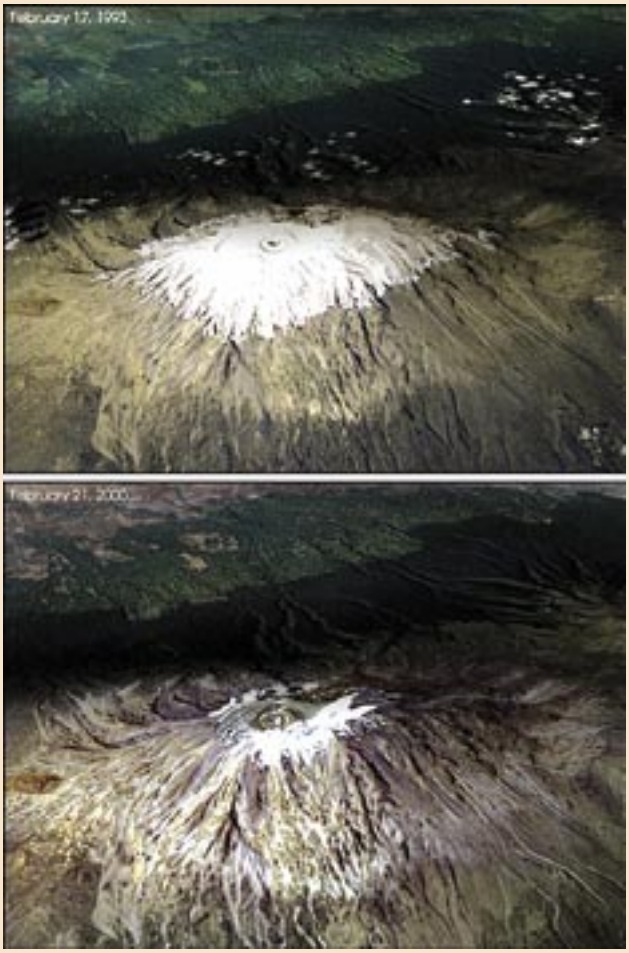
Evidence that we are causing changes in the climate

Global average temperatures have been rising with a direct relationship to increasing GHG production by humans. This is over and above natural temperature fluctuations. In the last 100 years the global average temperature has risen by 0.74°C and the rate of temperature rise is increasing. It is predicted that the global average temperature will increase by 1.8-4°C in the next century depending on how much the world relies on burning fossil fuels in the future (IPCC, 2007).

Many of the other effects scientists have predicted as a result of the enhanced greenhouse effect are already being seen. For example, over the last century there has been a net drying in southern Africa and southern Asia, an increase in severe precipitation events and heat waves over much of the world, and a decrease in size of glaciers, snow cover, and Arctic ice sheets (IPCC, 2007). Global average sea levels have also risen by about 1.8 mm per year in the last 40 years and it appears that the rate has increased to about 3.1 mm per year in the last 10 years (IPCC, 2007).

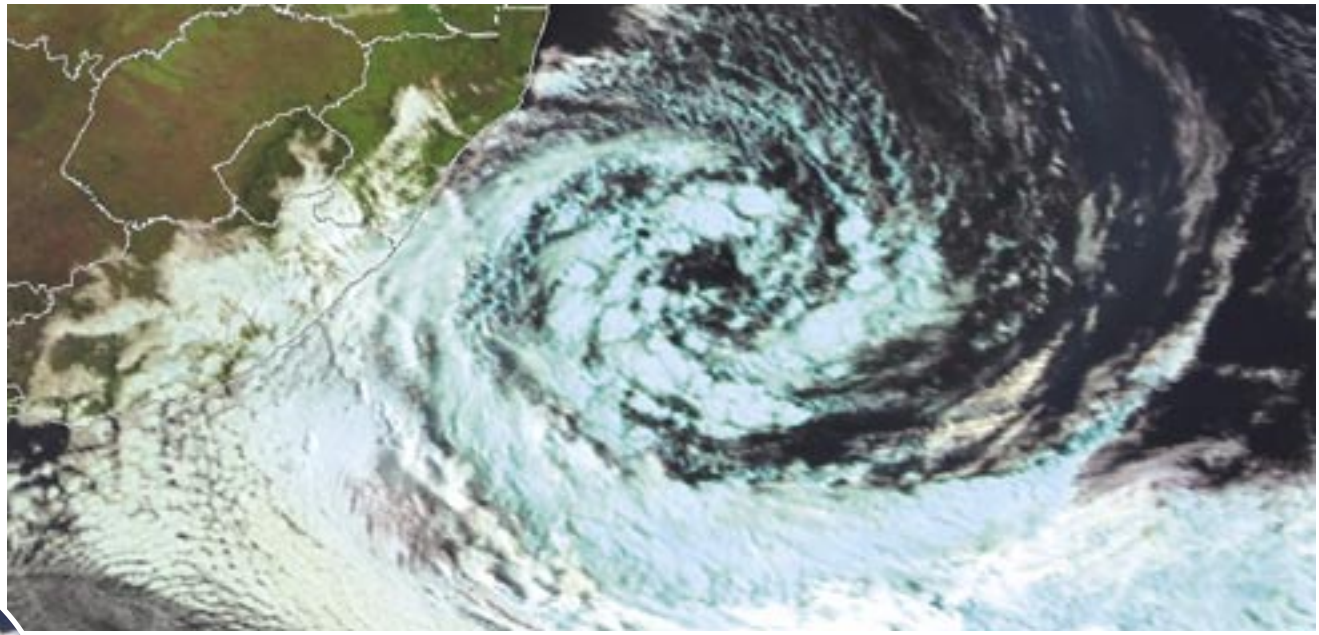


Carbon emissions, carbon concentration, and temperature change: Over the last century, the concentration of carbon dioxide in the atmosphere and the Earth's surface temperature have followed corresponding patterns. Both have risen sharply as human carbon emissions increased drastically since the Industrial Revolution.
(Source: www.usgcrp.gov)



NASA satellite images of Mt. Kilimanjaro, Tanzania *show the loss of its glaciers from 1993 to 2000 (both pictures taken in February) due to decreased snowfall and increased temperatures. During the annual dry seasons, precipitation in mountain regions and the partial melting of this glacier supplies many rivers. Much of East Africa is semiarid and these rivers supply the region with freshwater. If the glacier disappears, the region will suffer severe water shortages.*
(Source: www.earthobservatory.nasa.gov)

The Quiver Tree (Aloe dichotoma), *grows in the Succulent Karroo region of the Northern Cape, an area predicted to become drier and hotter as the climate changes. Monitoring by the South African National Biodiversity Institute (SANBI) has shown that the quiver tree is now dying out in the hottest and driest parts of its range, in response to climactic changes that are already occurring. This and many other species may have to shift their ranges southwards, towards the pole, and to higher altitudes or face extinction as the climate becomes inhospitable to their requirements for life. (Foden et al, 2007)*



Cyclone Gumede, March 2007: *Durban was hit by several extreme weather events and high seas in early 2007 due to cut-off low pressure systems and influenced by three tropical cyclones in the Indian Ocean.*

Climate Change Impacts for eThekwini Municipality

The warming of the Earth's atmosphere will have a range of global effects that will come from increased average temperatures, including:

- Changed local rainfall and temperature patterns
- Increased numbers of extreme weather events (like cyclones, hurricanes, floods, and droughts)
- Melting of glaciers and polar ice caps
- Global sea level rise (from water expanding with increased temperatures and ice caps melting)

Changes in climate patterns, such as seasonal temperature and rainfall cycles, will vary from place to place. Scientists worldwide use climate models to predict how increased global temperatures will change local climates. In 2004, the eThekwini Municipality commissioned a study of localized climate change impacts for the city of Durban (CSIR, 2006 a).

This study and subsequent research indicate that the eThekwini Municipal Area (EMA) is likely to experience the following changes:

- **Temperature:** Daily maximum temperatures are likely to increase by 2-3°C and daily minimum temperatures by 3-4°C in all seasons. Heat waves with temperatures over 30°C will increase in the period of October to March.
- **Rain:** Rainfall patterns will become more concentrated into heavy falls or floods and longer dry periods.
- **Sea Levels**: Average sea levels are likely to rise by roughly 2.5 cm every 10 years.

These changes will have negative impacts such as:

- **Increased health problems** due to heat stress, a serious problem for the very young, very old, and those who work outdoors, and an increase in the area that will be susceptible to vector-borne diseases like malaria and waterborne diseases like cholera.
- **Decreased water availability** due to decreased recharge of dams that supply the city, like Inanda and Midmar, due to irregular rainfall and increased evaporation from increased temperatures
- **Decreased agricultural productivity** due to increased temperature and evaporation coupled with decreased water availability and increased erosion of topsoil
- **Increased problems of erosion and flooding** due to more intense rainfall
- **Loss of biodiversity and ecosystems** due to loss of climate sensitive indigenous species, erosion, floods, sea level rise, and increased growth of invasive alien species
- **Damage to infrastructure**, residences, key industries, and economic activity in low-lying areas due to sea level rise and increased flooding

Overall climate change is predicted to pose significant challenges to eThekwini Municipality's social, economic, and ecological sustainable development goals (CSIR, 2006 a).

As seen here in the northern suburb of La Lucia, Durban is already battling beach erosion. Significant amounts of infrastructure and housing are already located too close to the coast. Rising average sea levels, seasonal storms, and equinox high tides will further exacerbate the situation in the future.

WHAT CAN WE DO ABOUT IT?

What are we doing about it?

To reduce the negative impacts of human induced climate change, two types of action need to be taken:

Mitigation refers to reducing the amount of GHGs entering the atmosphere from human activities. This will reduce the amount of excess warming and related impacts the Earth will experience. Mitigation includes actions that:

- ***Reduce GHG emissions*** by decreasing or eliminating fossil fuel use and other activities that produce GHGs.

Examples:

- Increasing the use of public transport and more fuel efficient cars will reduce the amount of petrol burned in transportation.
- Increasing the efficiency of electricity use at home or in industries will decrease

the amount of coal burned in electricity production.
- Using solar panels or wind turbines to produce electricity without emitting GHGs or switching from fuels that produce a lot of GHGs, like coal, to those that produce less, like natural gas, will reduce GHG emissions from energy use.
- Preventing deforestation and loss of other functioning ecosystems will prevent carbon stored in vegetation and soils from being released into the atmosphere.

- ***Increase carbon sequestration,*** which removes CO_2 from the atmosphere.

Example:
- Restoring forests, wetlands, and other ecosystems will remove CO_2 from the atmosphere because plants absorb CO_2 and use the carbon to build their body structures.

Adaptation refers to changing human activities and planning to take climate change into account and minimize the negative impacts it may have on quality of life.

Examples:
- Because water availability will decrease we can start using drought resistant crops to reduce crop failure.
- Because the intensity and number of storms will increase and sea levels will rise, we can stop building new developments in vulnerable floodplains and coastal areas.
- Because health problems like heat stroke and diseases like malaria and cholera are predicted to become more prevalent, we can prepare hospitals, health care workers, and health education programs to address these problems more effectively.

Mitigation will reduce the severity of climate change, but even if we stop producing GHGs today, some global warming will still occur because the GHGs we've already emitted will remain in the atmosphere for a long time. For example the CO_2 emitted today can continue to trap heat in the atmosphere for 500 years or more!
Both *mitigation* and *adaptation* measures need to be taken to reduce future climate change and the negative impacts of these changes on the well being of humans and other species.

International Level Action

What are world policy makers doing?

At an international level, governments from around the world have been meeting to discuss the problem of climate change since the early 1990s. These discussions have raised global awareness about climate change, increased research on its causes, and established some mechanisms that encourage nations to reduce GHG emissions *(mitigation)*. While international action to promote *adaptation* activities has been discussed, no system for implementing this has been established. As international negotiations and policies provide frameworks for national level action, some key international agreements and institutions are described below.

United Nations Framework Convention on Climate Change (UNFCCC)

The UNFCCC (http://unfccc.int) was established by the United Nations in 1992. Since then 189 nations have signed the convention, including South Africa.

The UNFCCC directs nations to:

- Acknowledge that climate change is occurring and is influenced by human activity.
- Produce and publish **national GHG emissions inventories** that assess contributions from industrial and agricultural sectors, transportation, energy production, land cover change, and forest losses and growth within their borders.
- Promote sustainable development that reduces emissions of GHGs.
- Agree to meet regularly to discuss and cooperate around climate change mitigation, adaptation, technology transfer and research.

Intergovernmental Panel on Climate Change (IPCC)

The IPCC (www.ipcc.ch) is a panel of hundreds of scientists from all over the world created by the United Nations Environmental Program (UNEP) and World Meteorological Organization (WMO) in 1988. It was tasked by the UNFCCC to compile and review current studies related to climate change. The IPCC publishes updates on the scientific knowledge regarding climate change causes, future impacts, and mitigation and adaptation measures to inform policy makers. So far four of these have been published: 1990, 1995, 2001, and 2007. The IPCC also publishes special reports to go into further detail on key issues, such as methodologies and best practice for conducting emissions inventories or land use land cover change assessments, promoting technology transfer, or measuring climate change impacts.

IPCC scientists at a press conference.
Source: www.iisd.ca/climate/cop11/dec06.html

Kyoto Protocol

The Kyoto Protocol (http://unfccc.int/kyoto_protocol/items/2830.php) was drafted by the United Nations in 1997 to provide a *'global action plan'* to implement GHG reduction activities recommended by the UNFCCC. The protocol recognizes that industrialized nations hold the greatest responsibility for emitting GHGs, while the developing world will suffer the most from the effects of climate change and have fewer resources with which to adapt (UNFCCC, 2006).

Under the protocol:

- **Industrialized nations** (41 nations listed in Kyoto Protocol Annex I) are directed to reduce their carbon emissions by the year 2012 down to levels that are below what these nations emitted in 1990 (the average commitment is to reduce emissions to 5.2% below 1990 levels). National governments are left to decide how these reductions will be made in their own countries. A national carbon emissions inventory and accounting system must be established.

- **Developing nations** were not given reductions targets for 2012, but were directed to maintain national GHG inventories. South Africa is currently considered a developing nation under the protocol.

Over 168 nations have *ratified* (officially agreed to implement) the Kyoto Protocol, 35 of which are Annex I industrialized nations that must reduce their emissions. The protocol entered into force, meaning that member nations would be held responsible for their reduction commitments, in 2005. The United States, which produces over 20% of global anthropogenic GHG releases (WRI, 2006), has not ratified and is not implementing the Kyoto Protocol at a national level. However, several city and state governments, such as the state of California, are proposing legislation to limit GHG emissions in areas under their jurisdiction.

GHG emissions trading

Emissions trading means that one entity (a person, a company, an industry) does not reduce their GHG emissions enough, so instead pays a second entity to either reduce GHG emissions, or increase carbon sequestration, in the name of the first entity. Atmospheric GHGs have global climatic

effects regardless of where they are released and emissions reductions or sequestration activities benefit the global climate no matter where they are implemented. The rationale behind trading is that it may be cheaper and/or easier for one entity to reduce emissions than it is for another one to do so; therefore, if one entity can pay another to reduce emissions and make up for its excess, the global benefit will be achieved at a lower monetary price.

Example:
A country's government passed a law to limit the amount of GHG individual companies can emit, but it permits emissions trading between companies.
Company A is *burning coal* to power its factories and *emits more* CO_2 than it is allowed. **Company B** invests in *solar panels* to power its operations and is *emitting less* CO_2 than it is allowed. Company B now has *credits* for these extra emission reductions that it can sell.
Company A has several options to reduce its effective emissions. It can:

- Increase the efficiency of its operations to use less energy and therefore burn less coal.
- Install new technologies to produce energy in a way that produces fewer GHGs (e.g. use solar or wind energy or burn a cleaner fuel).
- Pay Company B to take the credit for the extra emissions reductions that B had made.

National governments can establish their own internal emissions trading systems if they decided to allow trading within their country as part of an emissions reduction plan. The Kyoto Protocol allows some forms of emissions trading between nations as a means to reach their 2012 targets, but specifies that the bulk of a nation's reductions must occur within that nation.

The two Kyoto Protocol 'flexibility mechanisms' are called **Joint Implementation (JI)**, which allows trading between industrialized nations, and the **Clean Development Mechanism (CDM)**, which allows industrialized nations to fund emissions reduction projects in developing nations in return for emissions credits. The nations of the European Union (EU) are implementing the Kyoto Protocol and have established an active emissions trading market between EU countries called the EU Emissions Trading System (EU-ETS).

Clean Development Mechanism (CDM)

The CDM (http://cdm.unfccc.int/index.html) is a mechanism for GHG emissions trading permitted under the Kyoto Protocol. It allows industrialized nations to fund GHG emission reduction activities in developing nations in return for **certified emissions reduction credits (CERs)**. CERs help the industrialized nation achieve its emission reduction target and the funded projects should promote sustainable, low GHG, development in the developing nation. Such projects include the establishment of:

- Energy efficiency improvements
- Cleaner/renewable energy production and industrial manufacturing methods
- Reforestation activities
- Productive plantations or agro-forestry systems with sustainable harvesting rates

For projects in a developing nation to qualify for CERs under the CDM, they must:

- Produce measurable *net* GHG emissions reductions that would not have occurred without the extra funds the project will get from selling CERs (**additionality requirement**).
- Be approved by the host nation's government by satisfying social, economic, and environmental **sustainable development criteria** through a project proposal review process by the developing nation's **Designated National Authority (DNA).**
- Have a project plan that has been open for public comment and that has addressed stakeholder concerns.
- Have a project plan, a GHG monitoring methodology, and a third party auditing certification that is accepted by the CDM's Executive Board (elected representatives from the United Nations).

The CDM has been active since the Kyoto Protocol came into force in 2005 and since then over 600 projects have been registered by the Executive Board (http://cdm.unfccc.int/Projects/projsearch.html). It is predicted that over one billion tons of carbon emissions will be offset by CDM projects by 2012 (UNFCCC, 2006).

Voluntary (Carbon) Market

There is also an international **voluntary carbon trading market** in which entities that are interested in mitigating climate change, but are not legally bound to do so, fund GHG emission reduction or carbon storing projects. Emissions reduction funders in this market include aid agencies, NGOs, environmentally conscious companies, and even individuals. For example, although the USA is not party to the Kyoto Protocol, several American industries have funded international forestry projects to counteract their

National Level Action

What is the South African government doing?

South Africa will be strongly impacted by climate change, but the country also contributes to causing the problem. It is therefore important for the nation to engage in both mitigation and adaptation activities. The South African government has taken some initial steps to tackle climate change by engaging in the international conventions and mitigation incentive mechanisms:

- South Africa ratified the UNFCCC in 1997 and the Kyoto Protocol in 2002.
- The **Department of Environmental Affairs and Tourism (DEAT, www.deat.gov.za)** submitted the first national carbon inventory to the UNFCCC in 2000 and prepared a *National Climate Change Response Strategy for South Africa* in 2004. This provided a general government action plan to integrate and capacitate various departments to engage in adaptation, mitigation, education, research, and emissions trading activities.
- The **Department of Minerals and Energy (DME, www.dme.gov.za)** was established as the Designated National Authority (DNA, www.dme.gov.za/dna/index.stm), to review emissions offset projects in 2004. It has established a project review and approval process with a set of sustainable development criteria that projects must comply with to receive approval from South Africa as a project host nation.

Greenhouse Gas Emissions and Sequestration in South Africa

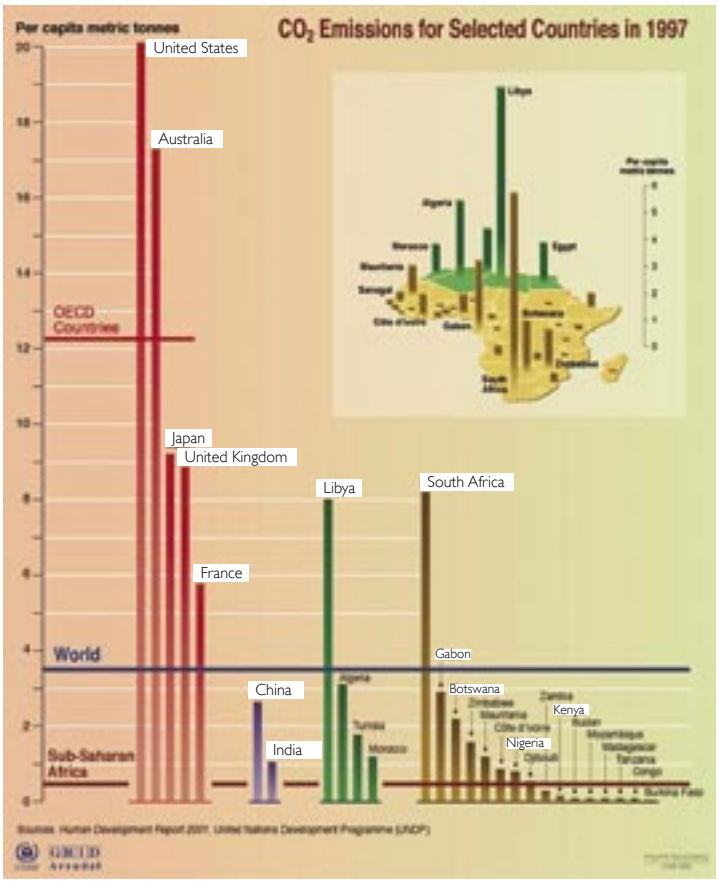
Emissions: Countrywide emissions were estimated in 2000 as part of South Africa's commitment to the UNFCCC. Our nation as a whole emits approximately 380 million tons of GHGs (CO_2, CH_4, NO_2, etc) every year (DEAT, 2000), which is more than the rest of Sub-Saharan Africa combined. South Africa is ranked 14th in the world for annual national CO_2 emissions (WRI, 2006). Electricity production and industrial processes account for 86% of South Africa's GHG emissions (DEAT, 2000).

Top 20 Total Carbon Emitting Nations

(Data from: WRI, 2006)

Global rank	Country	Total annual CO_2 emissions 2002 (million tons CO_2/yr)	Proportion of global total (%)
1	United States	5,773	23.4%
2	China	3,783	15.3%
3	Russian Federation	1,534	6.2%
4	Japan	1,213	4.9%
5	India	1,106	4.5%
6	Germany	863	3.5%
7	United Kingdom	541	2.2%
8	Canada	518	2.1%
9	Korea	499	2.0%
10	Italy	450	1.8%
11	Mexico	396	1.6%
12	France	379	1.5%
13	Iran	370	1.5%
14	South Africa	364	1.5%
15	Brazil	343	1.4%
16	Australia	337	1.4%
17	Indonesia	332	1.3%
18	Spain	324	1.3%
19	Ukraine	314	1.3%
20	Saudi Arabia	310	1.3%
	Global total	**24,706**	**100%**

Emissions from electricity production:
The majority of electricity in South Africa is produced by **coal burning** and many large industries and mining operations use coal to power their factories. Coal burning is a very 'dirty,' or inefficient, way to produce energy because for every unit of electricity produced, more CO_2 is released than with other fuels or methods.
The cleanest methods of producing electricity are using **renewable energy sources**, such as solar energy, hydrological dams, or wind power, which don't burn any fuel. Less than 1% of South Africa's electricity comes from renewables. Nuclear power production also avoids GHG emissions; however, unlike renewable energy, nuclear power results in hazardous nuclear waste and high safety and security risks.



While South Africa emits far less CO_2 than the United States and many European nations, our nation emits far more than any other country in Sub-Saharan Africa. South African per capita emissions (average emissions per person) are high for a developing country.

Amount of CO_2 emitted when producing energy from different sources

(Data from: EThekwini Municipality State of Energy Report 2006 and Eskom 2006)
*The electricity figure includes the emissions from power lost in transforming and transmitting electricity from the power station through the grid to get a kW-hr of power to the end user

Energy Source	CO_2 Emission Factor (kg CO_2/ kWh power provided)
Electricity (from South African grid)*	0.98
Coal (Bituminous)	0.30
Heavy Fuel Oil	0.26
Diesel	0.25
Petrol	0.24
Liquefied Petrol Gas (LPG)	0.21
Paraffin	0.20
Woodfuel	0.16
Woodfuel, sustainable (harvest rate = regrowth rate)	0.00
Solar, Wind, Hydropower	0.00

Sequestration and storage: While sequestration hasn't been thoroughly assessed in detail on a national scale, it is safe to say South Africa is emitting much more GHG than it is sequestering.

The national GHG inventory did not account for emissions and sequestration involved in land cover change in South Africa. Only changes in the tree plantation industry were included. Plantation establishment was estimated to be sequestering 18 million tons of CO_2 each year (DEAT, 2000). This figure may be an overestimate because it does not account for factors affecting emissions associated with industrial plantations: the lifespan of the paper and timber products, the proportion of harvested wood used for fuelwood or left to decompose, the energy use of managing plantations or processing its products, or the carbon storage of the landscape before plantation establishment.

Mitigation Activities

South Africa is not currently obliged by *international* policy to reduce its carbon emissions, however, there is growing international pressure for developing nations with high GHG emissions rates, such as India, China, Brazil, Mexico and South Africa, to limit their emissions. Currently, no national emissions restrictions have been set, but some existing national policies do encourage the reduction of GHG emissions. A few examples are the:

- **National Energy Efficiency Strategy** of 2005, which presents the ***National Energy Efficiency Standards (NEES)***. These are targets for different energy using sectors (industrial & mining, commercial & public buildings, electricity, residential, transport) to reduce energy use by 2015. The targets are percentage reductions from the energy use increases predicted if business were to continue as usual. The targets are meant to direct national and local government planning.

- **White Paper on Renewable Energy** of 2003, which sets a renewable energy target for the country. By 2013, 10,000 GWh of the nation's annual electricity consumption (4% of current production) should come from renewable energy sources such as solar, wind, hydro, and biomass.

- **National Forest Act** of 1998 and **National Water Act** of 1998, which make it illegal to clear and develop on many indigenous forest and wetland areas without obtaining a permit. These areas store large amounts of carbon in their trees and rich soils that would be released into the atmosphere if they were cut down, burned, ploughed, or dried out.

South Africa is also participating in the international **emissions trading** market by acting as a host nation for emissions reduction projects. By February 2007, six CDM emissions offset projects had been approved by the DME and had been registered by the CDM Executive Board. In total, these projects will reduce annual CO_2 emissions in the country by 244,600 tons (equal to the annual emissions of 31,359 South Africans, or the emissions of burning 1.2 million trees or 400 hectares of Durban's coastal forest annually).

Clean Development Mechanism (CDM)
emission offset projects registered in South Africa

Project	Activity	Emissions reduced (tons CO_2 / yr)
Kuyasa Low cost Urban Housing Energy Upgrade	Solar panels, solar water heaters, and energy efficient light bulbs were used in low cost housing near Cape Town.	6,580
Tugela Mill Fuel Switching	Sappi's Tugela pulp and paper mill will switch from burning coal to biomass to power the mill.	19,159
Lawley Fuel Switching	Corobrik Ltd.'s Lawley brickworks will switch from coal and petrol to cleaner burning natural gas.	19,160
PetroSA Biogas-to-energy	Waste gas from PetroSA to be harvested and used to produce 4 MW of electricity to be used on site rather than using grid electricity.	29,930
Durban Landfill-gas-to-electricity	Methane gas produced in the Mariannhill and La Mercy Landfills will be harvested and used to produce 2 MW of electricity for the municipality, which would otherwise come from coal fired plants.	68,830
Rosslyn Brewery Fuel Switch	South African Breweries' Rosslyn facility will switch from coal power to natural gas and biogas.	100,940

Kuyasa Solar Water Heater Project, (Source:. http://www.un.org/Pubs/chronicle/2006/webArticles/ga/2f.jpg)

The emissions reductions from these projects are being *traded* to *offset* excess emissions that are occurring elsewhere in industrialized nations. The projects have been made possible with international funding from the offset trade and in theory would not have occurred without the CDM. This means that while these projects physically reduce emissions here in South Africa, they should be seen as reducing the total *global* GHG emissions, and not be seen as national mitigation.

Adaptation Activities

The need to adapt to the impacts of climate change has been recognized by the national government in the *National Climate Change Strategy* (DEAT, 2004), which identifies adjustments that need to be made in sectors ranging from disaster management and healthcare services to agriculture and irrigation and development planning. DEAT has a Sub-Directorate for Global Climate Change that is tasked to build capacity in other national departments to take climate change into account in their activities and planning.

Little direct action has been taken to specifically address climate change at the national level as yet, but there are some existing national projects and policies that can aid the country to adapt to increasing temperatures and water stress. A few examples of national projects and policies that are active in eThekwini Municipality and will have local adaptation benefits are given below:

- The **Department of Water and Forestry (DWAF)** runs several projects that will help the nation deal with decreasing water availability.
    - **Working for Water** aims to both remove invasive alien plants that use excessive amounts of water and to provide employment in removal activities.

Removing invasive alien plants that have high water uptake rates from water catchment areas can improve water levels in rivers, lakes, and dams.

    - **Integrated Water Resource Management (IWRM)** aims to help various sectors, from industry to agriculture, to use water resources more efficiently.
    - **Catchment Management Forums (CMF) / Catchment Management Agencies (CMA)** are in the process of being established. These will gather government departments and other stakeholders like community groups, industries, and agriculturalists to assess and plan water use and development within river and dam catchment areas in order to maintain and improve water quality and quantity.

- The **National Environmental Management Act (NEMA) Environmental Impact Assessment (EIA) regulations** aim to restrict developments from destroying important ecosystems. Open spaces with functioning ecosystems, especially in and around urban areas, provide many services such as city cooling, erosion prevention, and storing and filtering water that will become increasingly important in terms of adaptation to climate changes. In addition these regulations are supposed to prevent new developments from being built too close to the coastal zone, which is particularly vulnerable to climate change.

Local Level Action

What is eThekwini Municipality doing?

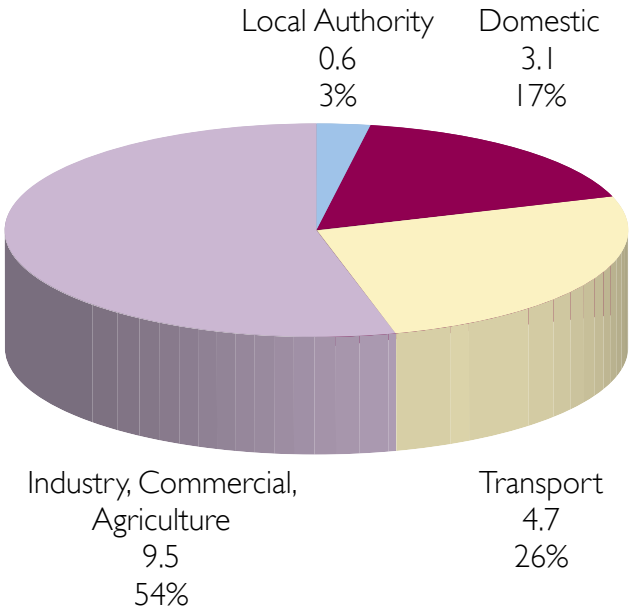
As a city committed to improving quality of life and sustainable development, the eThekwini Municipality is obligated to address the challenges climate change will pose in the eThekwini Municipal Area (EMA). The Integrated Development Plan (IDP) of the city identifies climate change mitigation and adaptation planning as a strategic focus area (eThekwini Municipality 2006 a).

Greenhouse Gas Emissions and Sequestration in eThekwini

The eThekwini **Environmental Management Department (EMD)** has commissioned several studies of GHG emissions: an inventory of emissions from municipal activities and an initial estimate of city-wide emissions was completed in 2003, the ***EThekwini Municipality State of Energy Report*** estimated CO_2 emissions from energy use in the EMA in 2006, and a full GHG emission inventory for the EMA will be completed by 2007.

Emissions: In 2006 it was estimated that the EMA was emitting 17.8 million tons of CO_2 annually, which is almost 5% of the country's annual emissions (EThekwini Municipality, 2006 b). Approximately 53% of all emissions came from industry, commerce, and agriculture and 26% came from transport. Local authority activities accounted for 3% of the city's emissions. More than half of the total annual emissions resulted from electricity use, predominantly produced in coal burning generators. Renewable energy production was almost non-existent in Durban.

Estimated annual carbon emissions for eThekwini Municipality
(millions tons CO2 / yr)



Data from: *EThekwini Municipality State of Energy Report 2006.* This report assessed the amount of energy of different types, such as electricity from the municipal grid or the direct burning of petrol or coal to run machines, used by different sectors, such as transport, industry, municipal functions, and domestic users. Estimates of the amount of GHGs emitted by energy types (emissions factors) were used to approximate citywide emissions.

Sequestration and storage: The eThekwini Municipality has identified an open space system in the EMA consisting of forests, woodlands, grassland, wetlands, beaches, rivers, and estuaries, which covered 64,037 ha in 2006. An inventory of all the carbon stored in the vegetation and soils of terrestrial ecosystems in the municipal open space system was completed in 2006 and it was found that system contains approximately 6.6 million tons of carbon, equivalent to 24.3 million tons CO_2 (EThekwini Municipality, 2006 c). Protection of the open space system will prevent land cover change from becoming a major source of carbon emissions in the EMA.

Some ecosystems in the open space system are still growing and gaining biomass, especially those that are recovering from disturbance. It was estimated that plant growth in the open space system is sequestering about 31,000 tons CO_2 per year. This is about 0.2% of the municipality's annual CO_2 emissions. There are some opportunities to increase sequestration by rehabilitating degraded habitat areas, but because of the limited area dedicated to natural ecosystems in the municipality, sequestration will never be able to keep up with emissions.

Mitigation Activities

The eThekwini Municipality has identified that the development of an efficient ***public transport system*** and an increase in use of ***renewable energy sources*** will be key to the city's mitigation effort (eThekwini Municipality, 2006 b). The city is already engaged in several other projects and policies that will help reduce the city's GHG emissions, such as:

- **EThekwini Environmental Services Management Plan (EESMP):** The Environmental Management Department, the Parks, Leisure, and Cemeteries Department, conservancy groups, and private landholders cooperate to conserve and manage the open spaces in the municipality. This helps to protect the biodiversity and ecosystem services delivered by the open space system. As described above, this system both stores (24.3 million tons CO_2) and sequesters carbon (31,000 tons CO_2 per year). Protecting it from land use changes and degradation prevents carbon dioxide emissions that would occur if the land were developed and allows sequestration that offsets 0.2% or more of municipal emissions annually.

- **Energy Strategy:** The municipal Environmental Management Department is conducting meetings with municipal departments and external stakeholders to develop an Energy Strategy and Action Plan to be completed in 2007. This plan will guide municipal departments and major energy users in increasing their energy efficiency and their use of renewable energy sources in line with National Energy Efficiency Standards. If achieved, this will reduce GHG emissions associated with energy production by as much as 2 million tons CO_2 annually, equivalent to the carbon stored in 9.8 million trees or 3.3 thousand hectares of coastal forest.

Adapting the National Energy Efficiency Standards 10-year energy use reduction targets to energy use in the eThekwini Municipal Area (EMA)

(State of Energy Report 2006)

Sector	**Target reduction in energy use** (% of predicted use)	**Target reduction in energy use** (MWh / yr)	**Associated emission reductions** (tons CO_2 / yr)
Industry & Commerce	15%	1,967,074	1,423,501
Public Buildings	15%	99,508	88,549
Transport	9%	1,724,938	422,040
Domestic/Household	10%	499,865	308,909
Total	**11%**	**4,291,385**	**2,242,999**

- **Municipal Buildings Energy Efficiency Project:** Energy use in municipal buildings was identified as an area where GHG emissions could be reduced with low cost or no cost activities. Several municipal buildings received energy audits to assess how energy was being used. It was found that energy efficiency measures, such as minimizing unnecessary use of air conditioners and fans, could reduce energy use by more than 15%. A cut back in air conditioning time was implemented in eleven major municipal buildings in 2006 and will reduce 914 tons CO_2 emissions (4,517 trees worth) *per year* and save R236,600 per year on electricity bills. Other suggestions have been reported to building managers and were accompanied by an energy efficiency education campaign for employees in a pilot building.

- **Landfill-gas-to-electricity Project *(CDM project)*:** Organic matter in landfills decomposes without much oxygen present and so produces large amounts of methane gas (CH_4), which is a stronger GHG than CO_2. Build-up of CH_4 can be dangerous because it is very flammable (catches fire easily), so it is often flared (burned in the presence of oxygen) to turn it into CO_2. The energy produced in flaring is usually not used, but at Durban's Mariannhill, La Mercy, and Bisasar Road Landfills, CH_4 will be flared and the energy will be used to produce 10 MW of electricity for the municipality (enough to supply over 18,000 households). This lowers GHG emissions because it converts CH_4 into a weaker GHG and also produces power that would have otherwise come from coal burning power plants. The emissions reductions are equivalent to 549,484 tons CO_2 (equivalent to carbon stored in 902 hectares of coastal forest) per year. This project has been locally driven, but because credits for these emissions reductions are being sold internationally (the Mariannhill and La Mercy projects are now CDM approved), the emissions reductions are technically not offsetting local emissions.

- ***(Coming soon)* Greening of 2010 FIFA World Cup:** FIFA (International Federation of Association Football) began its Green Goal initiative in the 2006 Football World Cup held in Germany. It is an effort to make the event more environmentally friendly, including making it *carbon neutral* by reducing and offsetting emissions produced as a result of the tournament. The eThekwini Municipality has taken on the challenge of making the 2010 World Cup events in Durban *carbon neutral*. Plans are being developed to cut the emissions of the event through energy efficiency, use of renewable energy sources, and enhancing public transport. It is intended that the emissions that the event does produce will be offset, through reforestation projects and/or funding emissions reduction activities elsewhere in the municipality.

Estimated carbon emissions reductions from mitigation projects and policies in the eThekwini Municipal Area (EMA)

	Carbon dioxide or equivalent (tons CO_2 / yr)	**% of 2006 city emissions**
City-wide emissions (2006)	17,858,772	
Mitigation activities emission reductions		
Energy strategy	2,242,999	12.6%
Landfill-gas-to-electricity project (CDM)	*549,484*	*3.1%**
EESMP open space sequestration	31,000	0.2%
Municipal buildings energy efficiency project	128	0.001%

* Because credits for the emissions reductions made in the landfill-gas projects are being sold internationally to offset emissions being made outside the country, they do not actually offset municipal emissions.

Adaptation Activities

There are several existing initiatives within eThekwini Municipality that will aid the city to stay functional and liveable as the climate changes:

- Water availability will be threatened by the changed climate Durban will experience. The eThekwini Water and Sanitation (EWS) Department has initiated programs to reduce water losses from municipal water systems. The EWS **Water Loss Management Project**, which includes improved water pressure control and leak surveys, has and will continue to reduce losses. The EWS **Waste Water Education Program** educates communities about preventing sewer blockages and leaks which will help prevent water contamination and waste.

- The eThekwini Environmental Management Department (EMD) works to plan and secure open spaces in the municipality through the implementation of the **eThekwini Environmental Services Management Plan (EESMP)**. The open space system provides valuable ecosystem services such as city cooling, erosion prevention, and storing and filtering water (*described further below*), that will become even more important as temperatures and extreme rainfall events increase.

- Food security will become an increasingly big issue as the climate changes. Through cooperation between several municipal departments and community based cooperatives, an **eThekwini Urban Agriculture Program** has grown to support community farming initiatives that will help enhance local food provision.

- The Parks, Leisure, and Cemeteries Department, the Working for Water Program, and the Environmental Management Department, often in partnership with community initiatives, are working to **control and eradicate alien invasive plants** in the municipality. These plants often use excessive amounts of water, degrade soils, and out-compete indigenous species leading to degraded habitats.

- The Health Department is mapping predicted changes in **areas vulnerable to malaria** due to future changes in climate. Early identification of new malaria areas will help target malaria prevention campaigns and ensure awareness and availability of treatment.

It is clear from the impacts of events already being seen in the EMA, such as flood damage and erosion from unusual heavy rainfall events, that more directed climate change adaptation measures will be needed. To help municipal departments identify, plan, and initiate these activities, a *Headline Climate Change Adaptation Strategy* was prepared (CSIR, 2006 b). Managers and members of municipal sectors that will be put under significant pressure by predicted changes were asked to identify key adaptation measures that would help them continue to function. All sectors identified the need for increased public education and further research into adaptation measures and technologies.

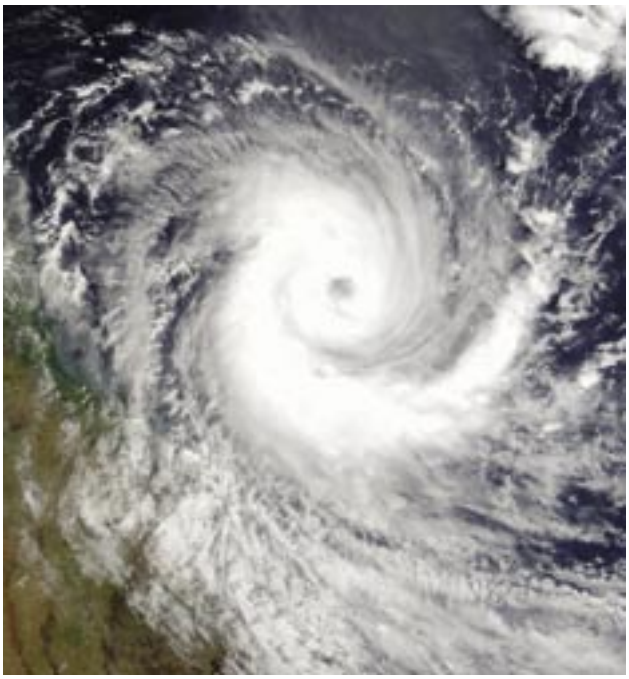
Key sectors for climate change adaptation in eThekwini Municipality, and some suggested adaptation measures from the *Headline Climate Change Adaptation Strategy*

Sector	Adaptation measures
Health	• Expand the existing malaria prevention programme. • Secure sustainable energy and clean water sources for healthcare provision. • Identify the sizes and distributions of key vulnerable groups in the population (e.g. children, the elderly, and immuno-compromised). • Develop community-wide heat emergency plans. • Initiate education campaigns about heat stress and environmental health problems associated with climate change.
Water & Sanitation	• Increased use of water recycling methods (filtering processes to make used water drinkable or suitable for agriculture). • Promote water storage in cisterns and rainwater catchment tanks. • Reduce water losses from municipal water systems through better leak detection and flow and pressure controls. • Reduce the water demand from sanitation systems by using dry sanitation systems like urine diversion toilets, developing systems that use grey-water (used water) for toilet flushing, and requiring that all new developments use low flush toilets. • Assess the effect reduced future water availability will have on new proposed developments in the city during municipal planning and development assessments. • Initiate water conservation education campaigns and community water efficiency programs. • Promote water conservation and possibly water trading for industries and increase the connectivity of industries to allow water trading and sharing. • Assess the effects that increased heat, storms, and sea level rise will have on water provision and sanitation infrastructure, and upgrade or relocate where necessary.

Sector	Adaptation measures
Biodiversity	• Assess vulnerability of indigenous habitats and species to predicted climactic changes. • Revise the municipal open space system to ensure protection of refuge areas for climate sensitive species and maintain corridors that will allow these species to migrate to refuge areas as the temperatures and rainfall change. • Increase removal of alien invasive species, particularly those that negatively affect water supplies and those that are adapted to warmer, drier climates.
Coastal, Stormwater, & Catchment Management	• Reassess areas vulnerable to flooding using predicted future rainfall changes and notify property owners and restrict proposed developments in these areas. • Keep developments proposed in the coastal zone out of areas predicted to be affected by 1:50 year sea storms and 50 years of sea level rise by adjusting setback lines to climate change scenarios. • Develop flood prevention and emergency response plans for areas that will become more prone to flooding. • Insist that new developments have stormwater management plans and flood attenuation features (structures that account for extra run-off in extreme rain events). • Where possible, incentivise and assist those in the most flood prone areas to relocate.

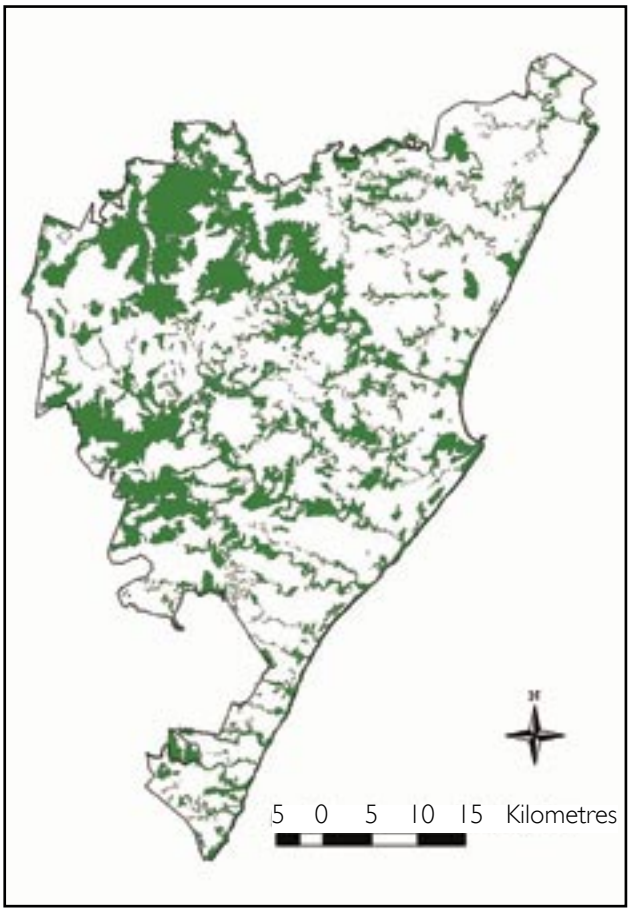
Sector	Adaptation measures
Infrastructure (e.g. Electricity, Transportation, Solid Waste)	• Ensure new or upgraded infrastructure, like roads, electricity lines, or landfills, are not located in flood prone, low lying or coastal areas and that the materials and designs used account for increased temperatures and severe weather. • Reduce energy demand in new developments through promoting efficient design and technologies, such as on site renewable energy production. • Encourage use of public transport such of bus and rail, through upgrades, incentives, and education, to both reduce GHG emissions and decrease demands on road systems.
Food security & Agriculture	• Promote local food production within the municipality through small-scale farmers' programmes. • Educate farmers on drought resistant crops, erosion prevention, and efficient water use practices to maintain production in a changed climate. • Establish community food reserves for emergency situations.

Sector	Adaptation measures
Strategic Planning & Economic Development	• Revise the Spatial Development Framework for eThekwini Municipality to prevent new developments in potentially hazardous areas by rezoning them. • Assess vulnerability of key industries to climate changes (sugar cane, tourism, refineries, etc.) and promote efficiency in these sectors. • Establish a coordinating mechanism, such as a Climate Change Office, to ensure that climate change predictions are accounted for in all sectors of municipal planning.
Disaster Risk Reduction	• Improve early detection systems for storms and other natural disasters. • Enhance early warning communication to public. • Develop community disaster management plans and ensure awareness of plans in vulnerable locations. • Establish effective post disaster recovery and support plans across sectors. • Assess and improve resistance of infrastructure to extreme weather events and landslides.



EThekwini Environmental Services Management Plan (EESMP): Durban's open space system plays an important role in both adaptation and mitigation

The **eThekwini Environmental Services Management Plan (EESMP)** aims to protect and plan an open space system that provides both climate change adaptation and mitigation services. In 2006, the open space covered in this plan spanned 64,037 ha and it contains a variety of ecosystems, including beaches, grasslands, wetlands, woodlands, and forests, on both public and private land. The Environmental Management Department (EMD) works to keep this open space system intact and functioning by reducing development pressures on these areas. Areas in the open space system are maintained by the Parks, Leisure, and Cemeteries Department as well as a range of conservancies, private landholders, and other parties.

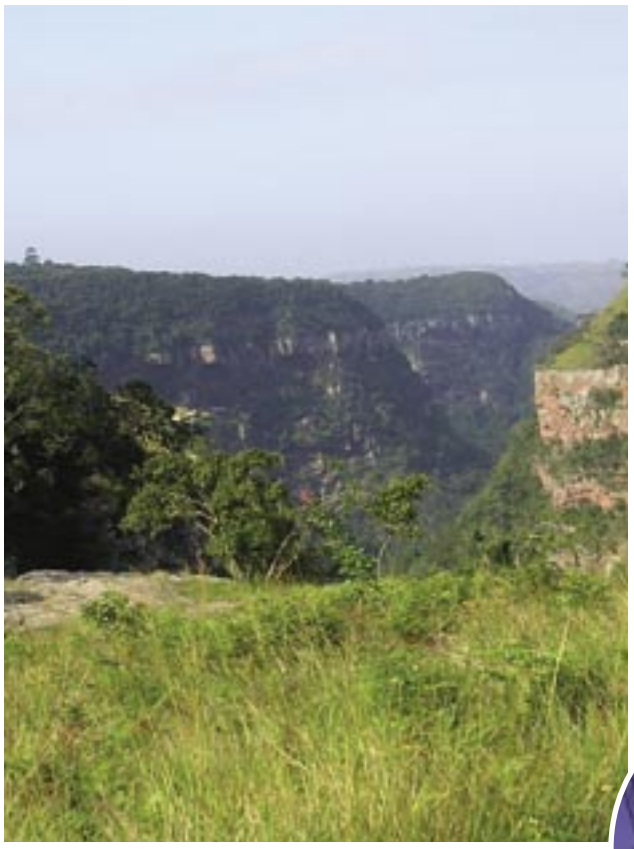


Durban's Open Space System (2006)

Adaptation: The ecosystems in the EESMP provide a variety of services to the inhabitants of eThekwini Municipality. These include cleaning air and water, absorbing and slowing run-off water to prevent flooding (*flood attenuation*), providing medicinal and food plants, fuelwood, and building material. These services would be very difficult and costly to provide in any other way. **Ecosystem services** will become increasingly important in helping eThekwini Municipality *adapt* to the impacts of climate change.

Climate change adaptation services of the eThekwini Municipality's open space system

Climate change impact	Useful ecosystem services provided by the EESMP
Increased temperatures • Health problems • Increased energy demand from cooling systems	**Cooling effects:** Vegetated areas provide shade and remain much cooler than developed *hardened surfaces*, such as pavement, tarmac, concrete, and building roofs. These open spaces significantly reduce the build up of heat and the average temperatures in cities. Urban parks have been found to be 5-10°C cooler than their surroundings (Sproken-Smith & Oke, 1998; Eliasson & Svensson, 2003)!
Increased number of intense rainfall events • Increased flooding • Increased water pollution from city stormwater runoff • Increased erosion from stormwater runoff	**Flood attenuation:** Vegetated areas slow stormwater much more than hard surfaces and allows some of the water to soak into the soil (percolation) rather than running directly into the river. This means that stormwater has to move slowly through the soil before reaching a river channel and as a result rivers are filled gradually after a storm. On hardened surfaces, stormwater runs quickly down to the river and if a river channel isn't big enough to contain this entire flow at once, there will be a flood. **Water filtering:** Rain water that runs over areas like roads and factories will pick up pollutants, such as oils and chemicals, from these surfaces. If this water soaks through the soil of a vegetated area before hitting a river channel, many of these pollutants will be filtered out and will not end up in the river (and our drinking water!) **Erosion prevention:** Vegetation both slows water and holds onto soil with its roots. This prevents erosion of slopes in storms.



Climate change impact	Useful ecosystem services provided by the EESMP
Increased length of dry periods • Decreased water availability from reduced dam and groundwater recharge (and increased evaporation from dams at high temperatures) • Drying of soils causing wind erosion and dust problems	**Water percolation to groundwater:** Indigenous vegetation allows rainwater to soak into the soil. In some cases this water will soak further down into the subsoil or porous rock layers where it is stored as groundwater over long periods of time. This groundwater can recharge rivers or be accessed with wells during dry periods when the surface water is not recharged by rain. Hardened surfaces do not allow rainwater to be stored in the ground so reduce the water available in dry periods. Areas infested with alien species can also prevent groundwater recharge because many alien plants, such as gum trees (*Eucalyptus* species), remove large amounts of water out of the soil. **Slowed soil evaporation:** Vegetated areas are cooler and more shaded than bare soil, crop rows, or hardened surfaces, so less soil moisture will be lost from these areas from evaporation in dry, hot periods. This, plus the roots holding onto the soil, will prevent wind erosion.
Decreased agricultural production (related to all the above)	**Provision of useful plants:** Decreased agricultural food and plant resource production will further disadvantage Durban's rural poor. Access to sufficient supply of indigenous medicinal and food plants, as well as fuel and building material, from ecosystems in the open space system will sustain the livelihoods of many people. **Production of fertile soils:** By adding leaf litter and dead plants to the topsoil, vegetated ecosystems increase the fertility of the soils in and around them. Intact river systems, without large dams or canalization, deposit fertile silt and nutrients to their floodplains in periodic low-level floods, which will be key to maintaining agricultural production.

Climate change impact	Useful ecosystem services provided by the EESMP
Sea level rise • Flooding damage of infrastructure and housing in storms and high tide • Coastal erosion • Land permanently lost **Habitat range changes** (related to all the above)	**Buffer area:** Preserving coastal dune forest ecosystems will keep further development away from the rising high water mark, reducing the likelihood of future damage. **Erosion prevention:** Vegetation on coastal dunes will help stabilize sands that will otherwise be washed away in storms as the sea level rises. **Corridors for species migration:** Changes in temperature and rainfall will change the areas where different plant and animal species can survive. An intact, well-connected open space system that includes all major ecosystem types will allow species to move from their current ranges to areas that may remain cool and wet enough to support them (such as higher altitude areas).

Mitigation: The open space system of the EESMP provides another important ecosystem service that helps eThekwini Municipality *mitigate* climate change in the form of **carbon storage** and **sequestration**. Natural ecosystems store carbon in their vegetation and soils that could otherwise be released as CO_2 if converted to urban cover or agriculture. Protecting ecosystems is an important part of preventing further GHG emissions and mitigating climate change. The majority of the human-caused increase in CO_2 in the atmosphere comes from fossil fuel burning, but it has been estimated that **land-use change**, primarily the loss of forest cover, has been responsible for 20-30% of the increase (Houghton, 1997). Globally, in 2000-2005, roughly 9 million hectares of tropical forest was lost to deforestation each year (FAO, 2007) emitting between 4 and 6 billion tons of carbon.

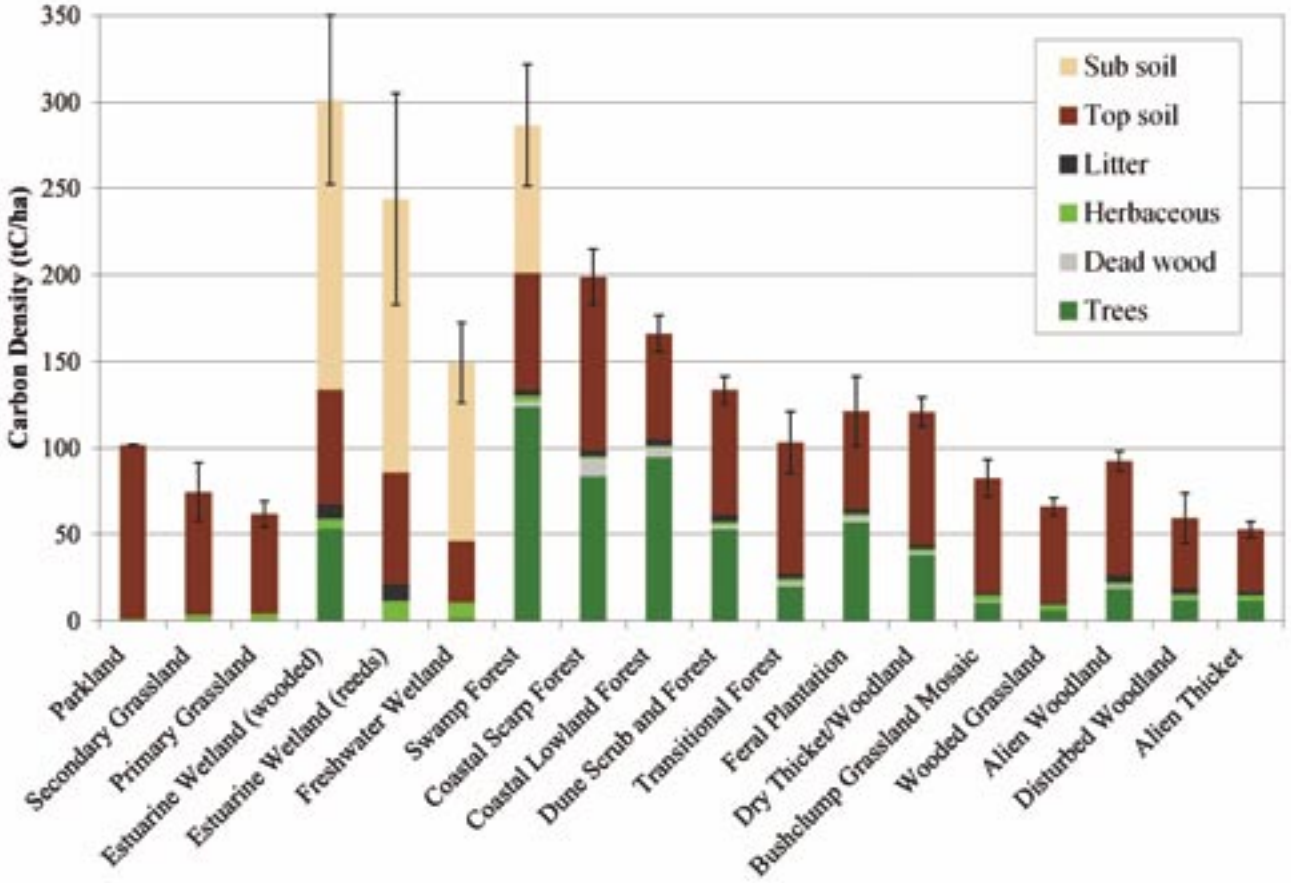
To assess how to preserve and maximize the climate change mitigation service in the EESMP, the EMD performed a **carbon storage inventory** (EThekwini Municipality 2006 c). The vegetation and soils at characteristic sites in each ecosystem type in the municipality were sampled to estimate carbon density (amount of carbon stored per unit area). Through a collaboration with the University of Stellenbosch, a computerized ecosystem model (CENTURY model: http://www.nrel.colostate.edu/projects/century/) was used to predict ecosystem growth and carbon sequestration rates.

Key findings of the open space carbon storge inventory:

- The EESMP open space system stores 6.6±0.2 million tons of carbon, equivalent to 24.3 million tons of CO_2.
- Most mature ecosystems in the open space system may have reached a point where they are not sequestering additional carbon (are not carbon sinks). Disturbed and regenerating ecosystems, assumed to be growing, are likely to be sequestering at least 8,900 tons of carbon or 31,000 tons of CO_2 per year, offsetting 0.2% of the municipality's annual CO_2 emissions or the annual emissions of 4,600 average South Africans (WRI, 2006).
- Predicted future changes in temperature, rainfall, and atmospheric CO_2 are likely to cause some ecosystems (Dune and Coastal Lowland Forest, Coastal Bushclump Grassland, and Dry Valley Thicket) to sequester carbon at slightly faster rates, which would increase annual sequestration by the EESMP to 36,000 tons of CO_2 per year.
- Durban's forests and wetlands have significantly greater carbon densities than other ecosystem types. Fortunately forests and wetlands are generally protected by zoning and environmental legislation. Nevertheless wetlands can be damaged and dried by developments in their water source areas (catchment basins). Wetlands store large amounts of carbon in their soils because organic matter (like dead plants) decomposes very slowly in waterlogged soil due to the lack of oxygen. Drying wetlands causes them to lose large amounts of this soil carbon because the increased aeration and warmth will increase the rate of decomposition.
- About 58% of the EESMP carbon pool is stored on land that could potentially be developed, primarily on unprotected, high carbon density, Dry Valley Thicket/Broadleaf Woodland, mostly located in the Outer West of the EMA. Protecting these areas will be important for preventing further GHG emissions and continuing sequestration.
- Alien infested and disturbed ecosystems store significantly less carbon than other cover types growing in similar conditions. These areas provide opportunities to increase the carbon storage of the EESMP through rehabilitation activities, converting disturbed ecosystems to appropriate indigenous cover.

Carbon densities of ecosystem types in the eThekwini Environmental Services Management Plan

Carbon densities estimated from field sampling at sites across the municipal open space system. Topsoil (0-30cm) was sampled in all ecosystems, but subsoil (30-100cm) was only sampled for wetlands because wetlands are generally known to have significant deep soil carbon storage.



INDIVIDUAL LEVEL ACTION

What can you do?

Tackling climate change will take large-scale behaviour change of the world's population, but these changes start with individuals becoming aware and acting on their knowledge. Although we might not always think about it, we all emit GHGs and participate in the carbon cycle through our normal day-to-day activities. Any activity that requires the use of electricity, fuel, or a change in land cover, or that involves a product that needed the use of electricity, fuel, or a change in land cover to be produced or to reach us, will affect the carbon cycle. The average South African emits *7.8 tons of CO_2 each year* (WRI, 2006) or the amount of carbon stored in 38 trees in Durban's open space system.

The following table gives an idea of the carbon emissions an individual in Durban can produce through normal activities and shows how simple actions, like switching off lights when they aren't needed, can cut a significant amount of emissions over time. The number of trees that would need to grow to sequester these emissions is also estimated.

Estimated CO_2 emissions for common activities and number of new trees needed to offset emissions

Activity	CO_2 emitted (kg)	*Scenario*	CO_2 emitted (kg)	Number of trees to sequester emissions
Making a cup of tea				
stove top	0.18	*2 cups of tea a day for 10 years*	1,256	**6**
electric kettle	0.06		426	**2**
Having a light on (1hr)				
normal light bulb (60 W incandescent)	0.06	*6 lights on in a house from 9 AM to 9 PM everyday for a year*	1,545	**8**
energy efficient bulb (15W CFL)	0.01		386	**2**
normal light bulb (60 W incandescent)	0.06	*6 lights on in a house from 4 PM to 9 PM everyday for a year*	644	**3**
energy efficient bulb (15W CFL)	0.01		161	**1**
Watching TV (1hr)				
average TV (180 W)	0.18	*watching TV 2 hours a day, 4 days a week, for 5 years*	367	**2**
Using a computer (1hr)				
monitor, computer, printer all on	0.2	*office computer left on 24 hours, 5 days a week for a year*	1,223	**6**
		office computer left on 8 AM - 4 PM, 5 days a week for a year	408	**2**
Having an air conditioner on (1 hr)				
Central AC unit (3.5kW)	3.4	*office AC on 7AM - 5 PM, 5 days a week for a year*	8,918	**44**
		office AC on 8AM - 4 PM, 5 days a week for a year	7,134	**35**
Driving a car (1km)				
average passenger car using petrol	0.017	*driving 20,000 km in a year*	336	**2**
		driving to Cape Town 4 times (roundtrip)	216	**1**
		driving to Johannesburg 10 times (roundtrip)	190	**1**
Flying in a plane (1km)				
local flight passenger plane	0.45	*flying to Cape Town (roundtrip)*	1,460	**7**
		flying to Johannesburg (roundtrip)	515	**3**

Calculations used (You can apply these to your own energy use)

Using electricity	**kg CO_2 emitted** = [energy used by appliance (kW, 1000 Watts)] x [time used (hours)] x [electricity emissions factor (kg CO_2 / kW-hr)]
	emissions factor, Durban grid electricity (coal power) = 0.98 kg CO_2/kWhr
Using fuel for transport	**kg CO_2 emitted** = [distance travelled (km)] x [fuel efficiency of vehicle (L fuel/km)] x [emissions of fuel per litter (kg CO_2/L)]
	Assumed petrol emissions in above calculations = 2.3 kg CO_2/L
Carbon storage in trees	*Average tree CO_2 storage, eThekwini Municipality open space = 203 kg CO_2*

TAKE ACTION!

Ways you can reduce your impact on the climate

There are lots of simple things we as individuals can do to reduce the severity of climate change for ourselves, our communities, our children, and our grandchildren. Many of these activities will not only benefit the environment and promote sustainable development, but they can also save you money!

- **Save electricity *(burn less coal)***
  - Turn off lights, TVs, computers, air conditioners, geysers, and other appliances when you aren't using them. For short idle periods, use stand-by mode or energy saver modes if machines have them and turn off computer monitors, but turn everything off overnight. Turn off the geyser when staying away from home.
  - Set air conditioners on reasonable temperatures (around 21°C), not so cold that everyone has to put on a jersey! If it's nice outside, turn the air conditioner off and open the window! Heating and cooling systems are the biggest electricity users in buildings so use these only as needed.

  - Switch to energy efficient light bulbs, such as compact fluorescent (CFL) bulbs, available in most stores.
  - Buy energy efficient appliances; look for energy saver stickers when shopping. Some do cost more, but you will recover the money because your electricity bills will drop.
  - Avoid using a tumble drier. Dry your clothes in the sun or on a rack inside the house if it's raining.
  - Just boil what you need. Don't overfill the kettle or the pot when boiling water.
  - Use cooler water washing dishes or clothes and even when showering or bathing.
  - Adjust your geyser temperature down to 45-55°C. Having to dilute near boiling water from the hot tap with cold water shows a big waste of energy used to heat the whole geyser full of water to an unusable temperature.
  - Insulate your geyser or water heater

with an insulating blanket so it needs less energy to keep the water hot.

- Recycle your household waste. Recycled paper, cardboard, plastic, cans, and glass take less energy to produce than new materials.
- Switch to renewable energy sources, such as solar panels or solar water heaters in your house or business.

- **Save fuel** ***(burn less fossil fuel)***

  - Use public transport.
  - Join a lift club.
  - Bike or walk when travelling shorter distances.
  - Buy a fuel-efficient vehicle. Larger cars generally guzzle more gas than small ones.
  - Plan your journeys so that you can be efficient with your car use.
  - Check your tires are inflated properly. This will ensure you get the most kilometres for your petrol use.

- **Save water** ***(adapt to decreased water availability and reduce energy use in water treatment and irrigation)***

  - Take showers instead of baths.
  - Install dual flush toilets and low flow showerheads.
  - Fix leaky taps, pipes, and toilets as soon as possible.
  - Don't leave taps running unnecessarily, such as while brushing teeth or washing dishes.
  - Water lawns and plants in the late afternoon or evening, so less water is lost to evaporation in the day. Don't water when it has just rained or is about to rain. If using automatic watering systems, turn them off or set them on lower frequencies in rainy seasons.
  - Grow or promote use of drought resistant plants and food crops. Pick indigenous species for your garden. Try foods from more drought resistant crops. For example, cassava, sweet potato, sorghum, and millet are more drought resistant than maize.
  - Don't keep a swimming pool that is rarely used or maintained. Use public pools or the beach to cool off!

- **Preserve ecosystems** ***(preserve carbon stores, promote carbon sinks, maintain ecosystem services)***

  - Plant an indigenous tree on your property (trees sequester carbon, create habitat for birds, and shade your house to keep it cool).
  - Replace alien plant species with indigenous species on your property.
  - Avoid developing or buying into developments that result in the loss of indigenous ecosystems.
  - Support local conservancies and parks.
  - Recycle and make efficient use of paper and timber products.

• Shop and eat wisely

- ✣ Choose recycled and second-hand goods. These take less energy to produce (e.g. recycled paper uses 60% less energy to make than new paper!) and also reduce the amount of energy, transport, and land needed to dispose of Durban's solid waste.
- ✣ Choose products that have less packaging and don't use plastic bags. Take a bag or basket with you when you go shopping. If you buy take-out food or drinks often, talk to shop owners to allow you to bring your own container or travel mug. It takes large amounts of energy to both produce and dispose of packaging!
- ✣ Choose foods and products that are produced locally and are in season. This saves on fuel use in transport and energy use in refrigeration, plus it will support local livelihoods.
- ✣ Eat less meat. Meat production is very resource intensive relative to the amount of food produced, using large quantities of water, land, grain for feed (with the water, land, pesticides, fertilizers, and processing that go with grain), and antibiotics, as well as energy and fuel for refrigeration, processing machinery, and transport. Livestock digestion and manure also produce methane and nitrous oxide, stronger GHGs than CO_2. The meat industry accounts for 18% of the world's GHG emissions!

• Tell a friend

- ✣ We all contribute to climate change, we are all effected by it, and we can all be part of the solution. Share what you know and be an example to others.

• Tell a politician

- ✣ Let your mayor, your city manager, or your ward councillor know that you see climate change as an important issue. It is their job to respond to your concerns.

IMPORTANT TERMS

Atmospheric concentration – the amount of a substance, usually a gas, in the atmosphere compared to the total amount of all substances in the atmosphere. *See parts per million.*

Biodiversity – the variety of organisms in a location, assessed on different levels by the number of species, the number of functional groups, the number of feeding levels, and even the range of genetic differences in all the living things in an area. Generally speaking, greater biodiversity increases the likelihood an ecosystem can continue to function and provide services when it is disturbed.

Carbon density – the amount of carbon present in a certain area of a land cover type. *Example:* There are about 166 tons of carbon in every hectare of Coastal Lowland Forest in eThekwini Municipality on average, so the carbon density is 166 t C/ha.

Carbon dioxide (CO_2) – a gas composed of molecules that have one atom of carbon and two atoms of oxygen, typically produced when organic materials, such as plant matter or fossil fuels, are decomposed (broken down) or burned in the presence of oxygen. CO_2 is the most common *greenhouse gas*.

Carbon neutral – an activity is considered carbon neutral when it either emits no carbon or all the carbon that is emitted is offset by sequestration activities or by ensuring additional emissions reductions in other activities (possibly through carbon trading).

Carbon pool – a place or material where carbon is present. *Example:* The atmosphere, the ocean, the soil, plants, and fossil fuel deposits are all carbon pools.

Carbon sequestration – the process of converting the carbon in CO_2 gas into another form so that it is removed from the atmosphere. Example: Plants sequester carbon through the process of photosynthesis, absorbing CO_2 and using the carbon to make plant matter (wood, leaves, etc).

Carbon sink – a carbon pool where carbon is entering the pool faster than it is leaving it. *Example:* An area that is being reforested is a carbon sink because young trees are growing and taking in carbon faster than decomposition of dead plant matter is releasing carbon back to the atmosphere.

Carbon storage – the amount of carbon that is maintained in a carbon pool determined by the balance of processes that add and remove carbon to the pool. If storage is growing, the pool is a sink, but storage can be constant if the rates of sequestration and emission are equal.

Carbon trading (Carbon emissions offset trading) – a type of *emissions offset* trading in which a party that is emitting more CO_2 than they are permitted to, or would like to, pays a second party for taking actions that reduce this second party's emissions or that increase sequestration. The first party then takes the credit for the emissions reduction. The payment is proportionate to the amount of emissions reduced.

Certified emissions reduction credits (CERs) – credits for tons of GHG emissions reduced or carbon sequestered in projects certified by the Executive Board of the *Clean Development Mechanism* (part of the United Nations *Kyoto Protocol*). CERs can be bought by industrialized nations as a means of reaching their GHG emissions reduction targets under the Kyoto Protocol. Projects in developing nations get awarded CERs if they prove that they reduced GHG emissions over and above what would have happened without the funding that will come from selling the CERs.

Clean Development Mechanism (CDM) – a *carbon trading* system set up as part of the United Nations *Kyoto Protocol* in which industrialized nations can buy *certified emissions reductions credits* (CERs) earned by projects in developing nations. The CERs can be used to reach the industrialized nation's emissions reduction targets, but the bulk of their reductions must be made in their own nation. Projects participating in the CDM must be approved by the host developing nation as contributing to sustainable development in their country.

Climate change – a warming in global average temperatures that will result in different changes in local climate patterns worldwide. These increased temperatures are caused by a build up of *greenhouse gases* in the atmosphere, which are being produced in increasing amounts by human activities like fossil fuel burning.

Decomposition – the break down of a substance into simpler substances. *Example:* Dead organic material, like dead wood and leaves in a forest, which is made of complex carbon based molecules, will decompose over time until much of it is transformed into CO_2 gas. Bacteria and other organisms speed the process. Light, warm temperatures, oxygen, and moisture also speed decomposition.

Ecosystem - all of the living species, such as plants, animals, insects, and micro-organisms, and all of the non-living factors, such us geology and climate, in an area as well as all the relationships between and among them. Ecosystems are often classified into different types by their vegetation components, such as forests, woodlands, or grasslands.

Ecosystem services – benefits that ecosystems provide to human communities that live in and around them. *Examples:* erosion control, *flood attenuation,* water filtration, clean air, fertile soil, shade and cooling, *carbon storage*, building material, medicinal and food plants, recreation and spiritual spaces.

Emissions factors – the amount of a substance, in this case CO_2, emitted to produce a certain amount of energy (kilowatt-hour, kWh) using a certain method, such as burning wood, petrol, or coal or using solar radiation or wind power.

Emissions offset – an activity that counteracts emissions, such as GHG emissions, from another activity. *Example:* Planting trees can sequester some of the carbon emitted by driving a car.

Evaporation – the process of a liquid transforming into a gas when the molecules of the liquid gain energy. *Example:* When water is heated, the water on the surface will evaporate into the air as water vapour (steam). As temperatures increase with climate change more water will evaporate from dams, lakes, oceans, and even from soils.

Flood attenuation – the process of slowing down stormwater that is moving toward a river or water body. If rainwater runs into a river channel very quickly during a storm, there may be too much water for the channel to hold at once and surrounding areas will flood. If the water moves slowly and reaches the channel more gradually over time, there are fewer flooding events. *Example:* Vegetated areas, like forests, grassland, and wetlands, absorb rainwater into their soils and provide flood attenuation, whereas hard surfaces, like pavements and roofs, cause water to run quickly off the surface to a river or stream channel.

Fossil fuels – partially decomposed *organic material* which has been buried deep in the ground for *millions* of years over which time it has been concentrated and chemically altered into substances that release a lot of energy when burned compared to their parent materials (plant matter, etc). *Examples:* coal, petrol, natural gas

Greenhouse gases (GHGs) – gases which form a layer in the upper atmosphere that allows solar radiation (light) to pass into the atmosphere but prevents heat from leaving. *Examples:* CO_2, CH_4, N_2O

Greenhouse effect – the warming provided by the layer of heat trapping *GHGs* in the atmosphere. The name refers to the similarity between this layer to the glass of a greenhouse, which allows light through, but keeps heat in. Without this process the Earth would be too cold for life as we know it, but human activities have enhanced the greenhouse effect, making the Earth warm up quickly compared to historic and pre-historic changes.

Intergovernmental Panel on Climate Change (IPCC) – a panel of hundreds of scientists from all over the world, formed to assess and report on scientific knowledge about climate change.

Industrial revolution – the invention and widespread adoption of steam and then fossil fuel driven engines and machines that began in Europe in the 1700s, and allowing for mechanized production.

Infrared radiation (heat) – energy in the form of a wave with a wavelength that is too long to be perceived by the human eye, but causes molecules to vibrate, which is what we sense as heat.

Kyoto Protocol – an action plan to reduce global emissions of *GHGs* drafted by the *UNFCCC* in 1997 in Kyoto, Japan. The Protocol mandates industrialized nations to reduce their emissions to below 1990 levels by 2012.

Methane (CH_4) - a gas composed of molecules that have one atom of carbon and four atoms of hydrogen, typically produced when *organic materials,* are broken down without the presence of oxygen. CH_4 is a stronger heat trapping *greenhouse gas* than CO_2, but is less abundant.

Net carbon emissions – the effective amount of CO_2 released into the atmosphere by a certain area or a process, calculated as total emissions minus total sequestration in that area or process.

Nitrous oxide (N_2O) - a gas composed of molecules that have two atoms of nitrogen and one atom of nitrogen, typically produced when nitrogen containing *organic materials*, are broken down or burned in the presence of oxygen. N_2O is a stronger heat trapping *greenhouse gas* than CO_2 but less abundant.

Organic materials/matter/compounds – complex carbon based substances built by living organisms. For example, wood and leaves are made from organic materials built by plants during *photosynthesis.*

Photosynthesis – the process of using CO_2 and water to build organic materials. The process is carried out by plant cells using energy from light and it produces oxygen (O_2) as a by-product.

Parts per million (ppm) or billion (ppb) - the number of molecules of a particular substance, often a gas, in a million or a billion molecules of air. *Example:* 379 ppm CO_2 means that there are 379 molecules of CO_2 in every 1,000,000 molecules in the air.

Percolation – the process of a liquid being absorbed by and moving through a porous solid material (a material with air spaces, like loosely packed soil)

Radiative forcing - the effect a factor has on the amount of heat the Earth gains from solar radiation. E.g. Snow has *negative* radiative forcing because it reflects sunlight instead of absorbing it, while GHGs have *positive* radiative forcing because they prevent heat from leaving the atmosphere.

Renewable energy - refers to energy produced using renewable resources, which are resources that can be used without depleting their supply.

Examples:

- Oil is *NOT renewable* because there is a limited amount of oil in the Earth and it takes millions of years for oil to form from organic matter buried deep in the ground. Oil supplies will run out because we are burning it in cars and factories much faster than it is being created.
- Solar and wind energy are renewable because when energy is harvested from the sun or the wind, this doesn't decrease the potential for the wind to keep blowing or the sun to keep shining.
- If trees are planted and grow just as fast as they are cut down, fuelwood can also be a renewable energy resource.

Solar radiation – the energy emitted from the sun. This energy travels in the form of waves of all different sizes, or wavelengths, some of which are visible to the human eye as light.

United Nations Framework Convention on Climate Change (UNFCCC) – an agreement drafted by members of the United Nations in 1992 which directs nations that sign to acknowledge human-induced climate change and to take steps reduce its negative effects.

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The Mechanisms under the Kyoto Protocol: The Clean Development Mechanism, Joint Implementation and Emissions Trading. http://unfccc.int/kyoto_mechanisms/items/1673.php

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United Nations Framework Convention on Climate Change (UNFCCC)
Homepage: http://unfccc.int
Climate change background: http://unfccc.int/essential_background/feeling_the_heat/items/2917.php
Kyoto Protocol: http://unfccc.int/kyoto_protocol/items/2830.php
Clean Development Mechanism: http://cdm.unfccc.int/index.html

Intergovernmental Panel on Climate Change (IPCC)
Homepage: www.ipcc.ch

Department of Environmental Affairs and Tourism (DEAT)
Homepage: www.deat.gov.za
Climate page: www.deat.gov.za/ClimateChange2005/home.htm

Department of Minerals and Energy (DME)
Homepage: www.dme.gov.za
Designated National Authority page: www.dme.gov.za/dna/index.stm

EThekwini Environmental Management Department (EMD)
Homepage: www.durban.gov.za/durban/Municipality/environment/

World Resources Institute (WRI)
Homepage: www.wri.org
Online calculator to work out your emissions: http://www.safeclimate.net/calculator/

An Inconvenient Truth (Al Gore's 2006 Climate Change Documentary)
Homepage: www.climatecrisis.net

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