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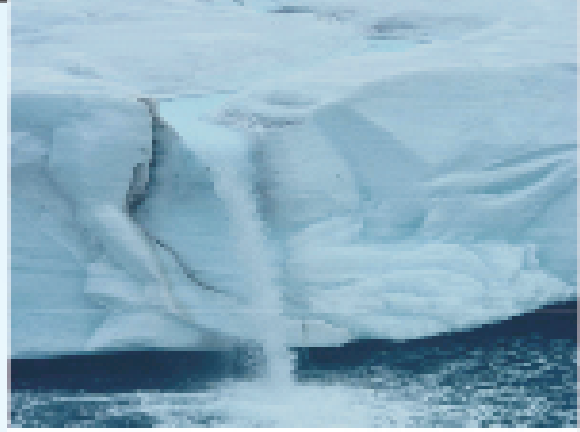

TEACHER'S GUIDE
ON
CLIMATE CHANGE & ENERGY

WWF for a living planet®

Tetra Pak protects what's good™

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Our partners in this initiative

Tetra Pak is a leading food processing and beverage carton manufacturing company belonging to the Tetra Laval Group, founded in the year 1943 by Ruben Rausing in Sweden and currently headquartered in Switzerland. Tetra Pak has innovated and pioneered the usage of aseptic technology in preserving perishable food materials since 1961. The technology helps in preserving food without the application of preservatives. Tetra Pak conducts its operations in an environmentally sustainable manner and adheres to the principles of Renewability, Recycling and Energy Conservation. Tetra Pak has partnered with WWF internationally in the WWF Global Forest and Trade Network and the Climate Savers programme by setting a unilateral 10% emission reduction target by 2010. Following up on its commitment to substantially reducing emissions, Tetra Pak India has partnered with WWF-India to initiate the Young Climate Savers programme across schools in India.

CONTENTS

FOREWORD

Human induced climate change is confronting our planet with its gravest peril ever, threatening widespread extinction of species and destruction of habitats. Our insatiable hunger for development, fueled by the extensive consumption of natural resources such as forests, fossil fuels, rivers and land has discharged enormous quantities of greenhouse gases into the atmosphere, causing a progressive rise in temperatures after the industrial period. This rise in temperature will continue unabated for centuries to come, even if we arrest all emissions immediately. The impacts of climate change are already being witnessed everywhere, and will gradually begin to worsen. Ironically, despite bearing witness to the various indications of climate change such as rising sea levels, increase in frequency of extreme weather events, and change in precipitation patterns, the world is still a fair distance away from mitigating climate change. We are still continuing to emit increasingly large quantities of greenhouse gases, exacerbating the impacts of climate change.

WWF-India, the country's largest and oldest conservation organization, recognizes the urgency of addressing climate change. WWF-India has pioneered efforts towards documenting the various impacts of climate change in vulnerable habitats such as the Himalayan high altitude glaciers and the Sunderbans deltaic region. WWF-India aims to contain global warming below 2 degrees in order to prevent the most dangerous impacts. WWF-India believes that imparting environmental education amongst students will greatly help in not only reducing emissions in society, but will also prepare them in adapting to and spearheading mitigation efforts in future.

In realizing this vision, WWF-India has partnered with Tetra Pak in designing the Young Climate Savers programme, aimed at imparting education on climate change in 200 schools across 10 cities in India through teacher training workshops and mainstreaming climate issues in the academic curriculum. It is hoped that this project will have a lasting impact on students, and through them, the larger society, changing mindsets of producers and consumers alike. This teacher's manual on climate change is an essential step in this process. The manual provides latest information on the science, impacts and mitigation steps of climate change in an easy to understand fashion, and also lists activities that can be carried out in schools to create a better understanding of issues related to climate change amongst students.

I sincerely hope that teachers will make use of the science and activities spelled out in this manual while teaching climate change in their schools. The combined efforts of us all will definitely have a cumulative effect in reducing emissions and ultimately in combating the impending peril of climate change.

Ravi Singh
Secretary General & CEO

ACKNOWLEDGMENTS

WWF-India had taken upon itself the responsibility of communicating the complex and multidisciplinary science of climate change in a coherent and convincing manner. This manual is the realization of this endeavour. Mr. Ravi Singh, CEO and SG of WWF-India has been instrumental in motivating and providing ideas that helped immensely in the creation of this manual. Ms. Madhur Das, Head, Business Development Division, WWF-India has played a significant role in the initial conception and early development of this unique project, and continues to provide timely support and encouragement. We deeply appreciate her commitment, support and continued involvement. Ms. Sejal Worah, Programme Director, WWF-India, has at every step given her inputs for keeping the Young Climate Savers initiative on the right track.

This teacher's manual on climate change has materialized due to the untiring efforts of several dedicated individuals. We acknowledge the support and inputs of Mr. Peter Hane-Weijman, Managing Director, Tetra Pak India, Mr. Amit Deep Singh, Head Environment, Tetra Pak India and Mr. Jaideep Gokhale, Programme Manager, Tetra Pak India. His commentary on the experiences of Tetra Pak in reducing emissions by incorporating energy efficient technologies and measures have proved invaluable in the development of this text. Mr. Sinchai Thiensiri of Tetra Pak Thailand has also provided significant inputs on his experiences with energy efficiency and recycling in Tetra Pak.

Mr. Shirish Sinha, Head; Dr. Prakash Rao, Senior Coordinator; Ms. Shruti Shukla, Coordinator and Mr. Rajneesh Sareen, Programme Officer, Climate Change and Energy Division, WWF-India have provided valuable technical support and guidance during the preparation of this guide book, and have ensured that the facts represented in this book are in strict accordance with the latest internationally accepted science. Their guidance and supervision during the preparatory phase of the guide book is deeply appreciated.

This book was envisaged as a teacher friendly manual that translated the issue of climate change at a level that could be easily comprehended by schoolteachers and their students alike. Our external reviewer, Prof. Valli Manickam of the Institute of Energy, Ecology and Environment at the Administrative Staff College of India, Hyderabad, has spent her valuable time in reviewing and providing constructive criticism, and has helped us immensely in improving the text of this manual. We extend our deepest gratitude to her and look forward to her future engagement in our initiatives.

Mr. Arnab Roy has industriously designed the artwork and illustrations used in this manual. We extend our gratitude to him and appreciate his efforts.

Our heartfelt gratitude to those who have not been named here, but their contributions and moral support remain immense. We thank one and all.

WORLD WIDE FUND FOR NATURE

Ever since its inception in 1962, WWF has grown into the world's largest and most respected conservation organization with nature conservation as its prime concern. With almost five million supporters in five continents, WWF has a global network active in over 90 countries and occupies a major position in the evolution of the international conservation movement. Since 1985, WWF has invested over US$1,165 million in more than 11,000 projects in 130 countries. With this vast support and taking strength from its mission, "The promotion of nature conservation and environmental protection as the basis for sustainable and equitable development.", WWF has been attempting to protect nature through its conservation and environmental awareness programmes world wide, including India, the most noteworthy being the declaration of the Eco-regions and the Global Conservation Programmes.

Working in India as a charitable trust since 1969, WWF has done considerable pioneering work to save species such as the Great Indian Bustard, Asiatic Lion, Himalayan Newt, Red Panda and the Mountain Quail amongst others. It has been engaging with the government in tiger conservation through Project Tiger and the prevention of wildlife trade through the 'TRAFFIC' programme, which assists enforcement agencies to curb illegal wildlife trade. WWF also actively engages in combating climate change through proposing pragmatic policy responses towards reducing greenhouse gas emissions, documenting the impacts of climate change on fragile ecosystems and imparting climate awareness in schools across the country.

Today, WWF-India is not only the country's largest conservation organization, having taken on diverse activities from education and capacity building, enviro-legal action, policy research and advocacy and field conservation projects, but has also grown into a nationwide network. WWF's work is channeled through its five national initiatives Species Conservation Initiative dedicated to priority species conservation, Freshwater and Wetlands Initiative working towards sustainable management of freshwater resources, Forests Conservation Initiative directed towards effective forest management, Climate Change and Energy Initiative addressing the issue of climate change and energy efficiency, and the Oceans and Coasts Initiative having the conservation of marine life as its mandate. In addition to these initiatives, WWF-India also operates a vast environment education programme, the Center for Environmental Law, and the Indira Gandhi Conservation Monitoring Center. WWF-India in Andhra Pradesh has been working with school students through its Nature Clubs of India (NCIs) programme which allows students to interact with and appreciate nature.

WWF believes that schools are the torchbearers for addressing environmental priorities like mitigating climate change, adopting renewable and efficient energies and ensuring the sustainable usage of natural resources in India. Schools participating in the Young Climate Savers programme will be trendsetters for other schools to emulate. Through participation, schools will be able to inculcate increased sensitivity amongst students on climate change and energy issues. Through this unique partnership, WWF envisions a future in which educational institutions become a center of learning for addressing climate change and make a positive contribution to the well-being of the planet.

ACRONYMS

BEE	Bureau of Energy Efficiency
CCS	Carbon Capture and Storage
CDM	Clean Development Mechanism
CER	Certified Emission Reductions
CFL	Compact Fluorescent Lamp
COP/MOP	Conference of parties serving as meeting of parties to the Protocol
CNG	Combustible Natural Gas
CSIRO	Commonwealth Scientific and Industrial Research Organization
ENSO	El Nino - Southern Oscillation
ESP	Electrostatic Precipitator
GCM	General Circulation Model
GHG	Greenhouse Gases
GLOF	Glacial Lake Outburst Flood
IPCC	Intergovernmental Panel on Climate Change
IREDA	Indian Renewable Energy Development Agency
KWh	Kilowatt hour
LPG	Liquified Petroleum Gas
MOC	Meridional Overturning Circulation
MW	Megawatt
NTPC	National Thermal Power Corporation
PPBv	Parts per billion by volume
PPMv	Parts per million by volume
UNCED	United Nations Conference on Environment and Development
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
WMO	World Meteorological Organization
WWF	World Wide Fund for Nature

Shocking Evidences of Climate Change

- With the increase in concentration of greenhouse gases in the atmosphere since the pre-industrial period, the planet has warmed by about 0.76° C. The eleven hottest years in the past 6,50,000 years have occurred between 1991 and 2006. The hottest year on record was 2004 and the second hottest year on record was 2005. It is projected that the warming will continue to occur and by the end of this century the planet will warm by a further 1.4° to 5.8°C.

- Thanks to global warming, glaciers and ice packs all over the world are shrinking much faster in the last three decades than they did in the past. We have already lost the magnificent 'Snows of Kilimanjaro', the glaciers straddling Africa's highest mountain peak. Even the Arctic sea ice has reduced by 40% since 1950, and the Arctic ocean may very soon become ice free. The highly unstable West Antarctic ice sheet and Greenland ice sheet are also projected to disappear if there is a further increase in temperatures by 1.2°C above pre- industrial levels of 1850.

- With the melting of glaciers and polar ice sheets and due to the heating up of oceans (thermal expansion as liquids expand with rise in temperature), the average sea level is predicted to rise sharply. Over the last 150 years, global sea level has risen by about 20 cm. A further rise of up to 59 cm is projected by 2100 due to global warming. This would mean that as many as 90 million people around the world could have their homes flooded every year!

- Over four million square kilometres of vegetation is projected to die back within the next 100 years which is practically equivalent to the whole of the Brazilian Amazon leading to a massive venting of carbon into the atmosphere, as much as one billion tonnes of carbon within a century!

- Nearly 16 million tonnes of carbon dioxide is emitted into the atmosphere each day. If worldwide CO_2 emissions continue to double every 30 years, it will exceed 1,000 parts per million by volume (ppmv) of CO_2 in the atmosphere by the end of the century which is about four times the pre-industrial levels, and nearly three times higher than the present CO_2 levels!

- As a result of erratic climatic conditions such as heavier rainfall, longer periods of drought and increased frequency and intensity of storms and hurricanes, crop production would be severely affected especially in regions like Asia and Africa. This could result in more frequent and severe famines. It is predicted that agricultural production could drop by 25% this century. Coupled with a rising population and decreasing land area available for agriculture, this itself could spell doom for the human population.

- In many countries the amount of rainfall received may change drastically. Consequently, about 3 billion people would suffer and have problems getting the water that they need for drinking, cooking, washing and for watering their crops.

- Higher temperatures are expected to expand the range of some dangerous "vector-borne" diseases, such as malaria, which kills 1 million people annually, most of them children.

- This could all happen within a century from now if we do nothing to curb our growing emissions. Such a future would be catastrophic! We have no more time to waste. A delay of five to ten years in cutting greenhouse gas emissions could make stabilization of the atmosphere almost impossible. If that were to happen, the planet would soon become a Human-free Zone!!!

Purpose of the Manual

An overwhelming body of scientific evidence now clearly indicates that climate change is a serious & urgent issue. The Earth's climate is rapidly changing, mainly as a result of increase in greenhouse gases caused by human activities. Climate change is a very complex issue with numerous social, environmental & economic parameters & implications, & is thus often difficult to comprehend fully.

Today we may be witnessing one of the most profound climatic changes in the Earth's history. Certainly, larger changes in global climate have occurred in the past, but over much longer time periods. The danger facing the global society today is that anthropogenic global warming may be too fast to allow humans, & other species, to adapt to its detrimental impacts. In addition, through enhanced greenhouse forcing, we may be pushing the climate system towards a bifurcation point, where climatic responses may become highly non-linear through complex feedback processes, driving the system to a completely different, & most probably, inhospitable state for humankind.

The challenge for scientists is to understand the climate system, & ultimately predict changes in global climate. To this end, greater collaboration is required between modellers, empiricists & policy makers. Ultimately, the climate system may be too complex to simulate reliably, & the study of global climate change will remain an imprecise science. In light of this, the precautionary approach to mitigate the threats of anthropogenic global climate change must be fully recognized & adopted by the international community. In addition, increased emphasis will need to focus on the study & modelling of the impacts of future global warming. Greater integration between scientific & policy scenarios will be beneficial for the management & control of future impacts to society. Greater emphasis on impact scenarios at the regional level is also needed, if society is truly to “think globally” & “act locally”. Indeed, the challenge for society as a whole is to respond to current dangers regarding global warming, & ultimately to “manage” the climate system in a sustainable & responsible manner.

The purpose of this module on climate change is to furnish sufficient information on climate change to teachers who have different levels of understanding of this issue. This module provides detailed yet easy-to-understand information on various aspects of climate change. The larger aim of this module is to generate awareness amongst children on the issue & to achieve substantial reductions in greenhouse gas emissions. To facilitate this, a number of activities have been designed to provide knowledge on climate change. These activities can be incorporated into different subjects in the school curriculum (Science, Geography, Social Studies, Language Arts, & Environmental Education), or may be carried out separately. This manual is geared towards students & teachers of Class 6 9.

The key to understanding global climate change is to first understand what global climate is, & how it operates. This is the purpose of chapter 1, which reviews the history & science of climate Change. Chapter 2 forms the basis for understanding the Greenhouse Effect & Global Warming & identifies the human activities that contribute to global warming. Chapter 3 discusses the global impacts of climate change & global warming while chapter 4 reviews the impacts of climate change in India. Finally, chapter 5 is concerned with finding solutions to Climate Change & reviews the global initiatives to minimize climate change. It also provides tips to combat climate change at an individual level.

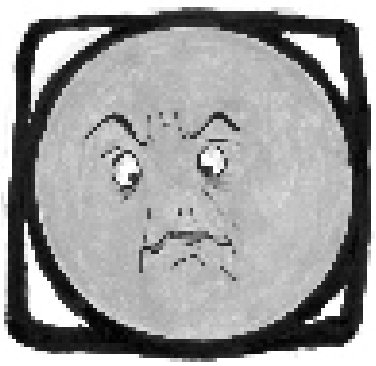
This guide represents an up-to-date review of climate change. Throughout, the focus has essentially been on global climate change, although reference to regional scale climatic change has been made wherever necessary. On its own, each chapter is a broadly self-contained discussion of a specific sub-issue of importance. Although it is not a complete guide, but it serves to review & illustrate the key factors of climate change over time & space. It contains an extensive list of references which the student is urged to consult. The authors recognize that the study of global climate change is a rapidly developing discipline, & recent empirical evidence of climate change & modelling evidence of the causes of climate change may have been omitted. In this sense, the guide represents a snapshot in time of the current understanding of climate change, which is open to future development. The opportunity therefore exists for readers of this guide to comment upon its content, both regarding improvements to the existing material & new ideas for additional entries. Comments & responses regarding the Global Climate Change Student Guide should be sent to the address provided on the front cover page.

- The Authors

CHAPTER - I

History and Science of Climate Change

1.1 Objectives



Understanding the concept of climate change

Appreciating the fact that although Earth has experienced climate change during the past, the present climate change is more human-induced than natural.

1.2 Keywords

Climate, Weather, Climate Change.

1.3 Content

> **Climate Change** does not necessarily mean that everything around us will get hotter. Instead, there will be more erratic & extreme weather conditions, which will result in heavier rainfall, more snow in some places, longer periods of drought, more storms and hurricanes, and more frequent heat waves.

Weather is the state of the atmosphere at a specific time and place. For instance, how much sunlight and rainfall it gets, how windy it is, and so on. Climate is the pattern of weather or the average weather taken over a long time period for a given place or region. Climate change is the long-term alteration in the average weather conditions for a particular location.

The world's weather is entirely controlled by the Sun. The Earth rotates on a tilted axis. As a result, all parts of the planet do not get equal amount of heat. Different parts of our planet are heated by different amounts of Sun's energy at different times of year, making some regions hotter than others and causing the seasonal changes. The temperature variations between one part of the world and another gives rise to differences in air pressure, thereby producing winds and storms The Sun's heat also warms up the seas unevenly, driving ocean currents from one place to another.

Scientists believe that greater amounts of carbon dioxide and other greenhouse gases in the atmosphere and hotter temperatures on Earth will significantly change the climate across the whole planet. Therefore, climate change refers to any significant change in the climate (temperature, rainfall, or wind) that lasts for an extended period of time. Climate change may result from:

Natural factors such as changes in the sun's intensity or slow changes in the Earth's orbit around the sun;

Natural processes within the climate system (e.g. changes in ocean circulation);

Human activities that change the composition of gases in the atmosphere such as burning of fossil fuels, deforestation, industrialization, etc.

Is the Earth really getting heated up?

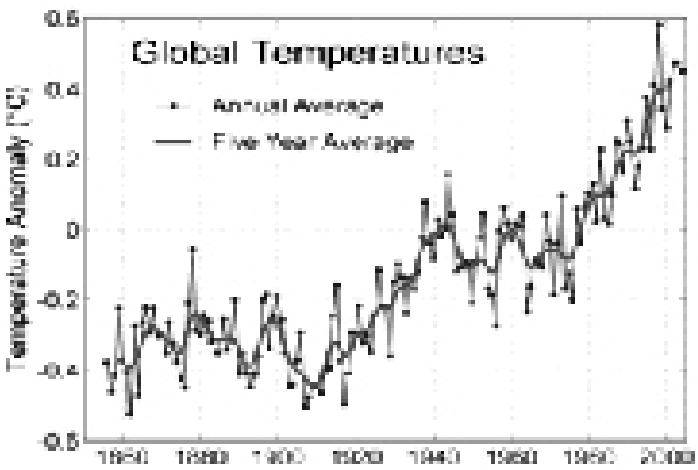
During the past 150 years, the global average surface temperatures have increased by about 0.76°C. In addition to warming up of the Earth's surface, there have been increased incidences of heat waves; accelerated melting of continental glaciers and polar ice caps; rise in sea level of up to 20 cm; heavy rainfall in some regions, resulting in frequent floods; reduced rains in other regions of the world, resulting in severe drought. Some plants and animals have even changed their location or the timing of seasonal activities. For instance, in the Alps, some plant species have been migrating upwards by 1 to 4 m every decade in search of cooler climes. Sadly enough, some plant species that were previously found only on mountain tops have already disappeared and have possibly become extinct. Similarly, in Europe, the mating and egg-laying of some bird species is occurring earlier every year when compared to the previous year.

The temperature change is not just measured using regular thermometers. There are several **Natural Thermometers** also that are sensitive to changes in our climate, and that have helped scientists learn more about global warming. Examples of such natural thermometers are the tree rings and coral rings.

TREE RINGS: The tree rings indicate how much a tree has grown each year, with each ring representing one year. In warmer, wetter years, the tree will grow more so the ring for that particular year will be wider than the ring formed during a colder year. By studying the width of the tree rings, scientists can learn about the changes in weather over the tree's lifetime.

CORAL RINGS: Corals build up rings made of calcium carbonate as they grow. If the sea temperature is warm the coral rings will grow faster than if the temperature is cold. So, warmer years will produce wider growth rings and colder years will create thinner rings. By studying these rings we can get an idea of what the sea, and therefore the surface temperatures, were like each year.

ICE CORES: Ice is formed during glaciations through the process of continuous deposition and compaction of snow layers. Since permanent 'pack ice' rarely melts even in summer, it is a reliable indicator of climatic conditions in the earth's history, with the age of deposition increasing with depth. A circular sample of such permanent ice drilled to study the ice layers is called an 'ice core'. Greater density in ice layers indicates cooler temperatures, and lower density, or the presence of the heavier Oxygen 18 isotope, indicates warmer climates. In the past 50 years, scientists have noticed that the growth rings in corals as well as the width of the tree rings have been getting wider, which indicates that the global temperatures have been increasing.



The graph here shows the trend of temperature change since 1860. Notice how the global temperatures have increased during the past 100 years. (Source: http://www.transportscotland.gov.uk/defaultpage1221cde0.aspx?pageID=268&rlID=796&pubID=63&ChptId=761)

History of Climate Change

Climatic shifts have been a regular occurrence in the earth's history. Though highly reliable instrument records have only been maintained for the past 300 years, naturally occurring geological, cryogenic and stratigraphic evidences indicate dynamic shifts in the earth's surface climates over several thousand years. These changes have been caused by various factors, such as variations in the earth's orbit around the sun, tectonic movement, variations in solar output, eruption of volcanoes and meteorite impacts. The most repetitive cause was change in concentrations of greenhouse gases in the atmosphere. All of these factors caused a significant cooling or warming of the earth's atmosphere, and resulted in massive planetary changes. The most well known of such phenomena are the infamous and intriguing ice ages.

Ice ages that occurred in the past provide ample evidence of changing climates and phenomenon associated with them. Ice is excellent at preserving occurrences over millions of years, and studying ice reveals lots of information about conditions and events in the earth's history, especially during ice-ages. There have been four major ice ages in the earth's history, during which extensive ice cover was found on earth. Ice ages occur over millions of years, and are punctuated by glacial periods during which colder temperatures occur and glaciers advance, and inter-glacial periods, during which warmer climes prevail and glaciers retreat.

The present ice age began 40 million years ago with the growth of an ice sheet in Antarctica. It intensified during the late Pliocene, around 3 million years ago, with the spread of ice sheets in the Northern Hemisphere. Since then, the world has seen cycles of glaciations with ice sheets advancing and retreating on 40,000 and 100,000-year time scales. Glacial periods are also region specific, such as the Riss (180-130,000 years ago) and Wurm (70,000-10,000 years ago), which occurred largely in the European Alps. Their end signaled the start of the Holocene inter-glacial period (10,000 years ago present day), which is continuing till date.

The most recently documented period of an ice age was the Little Ice Age (LIA). Starting in the 13th century in Europe, the LIA was a minor event of global cooling that lasted for nearly 2 centuries, and serves as an encore for the immediate future. The effects were primarily felt in Europe and the Northern Hemisphere, with Arctic ice packs and Greenland ice sheets advancing southwards & glaciers in the Swiss Alps engulfing entire villages.

The winters in Europe were particularly harsh, with entire populations succumbing to food shortages and cold related deaths. Glaciers covered several mountain ranges in tropical latitudes such as the Ethiopian highlands, and the famous 'snows of Kilimanjaro' advanced rapidly during this period. Established evidence points towards natural causes. The LIA was caused by heightened volcanic activity, emitting ash clouds and blocking solar radiation, causing worldwide cooling and triggering a small ice age.

However, it is virtually certain from the highly reliable Intergovernmental Panel on Climate Change (IPCC) reports that present climatic shifts are human originated, and are being accelerated by human activities. The current concentrations of carbon dioxide in the atmosphere, at 379 ppm, have far exceeded the historic range of 230 300 ppm observed over the past 650,000 years. Cumulative greenhouse gas concentrations have reached an unprecedented 430 ppm, and are rising at 2 ppm per year (greenhouse gases are gases such as water vapour, carbon dioxide, methane and nitrous oxide that allow incoming solar radiation to pass through the Earth's atmosphere, but prevent most of the outgoing infrared (heat) radiation from the surface and lower atmosphere from escaping into outer space). If nothing is done to control greenhouse gas emissions right away, we may witness the advent of an ice-age in our own lifetime.

1.4 Activity

Climate Then and Now

a. **Duration of the Activity** - 1 month (3-4 Hours per week for 4 weeks).

b. **Overview** - Students interview older residents in the community about climate changes that they have experienced during their lifetime and compare the results to a climate change index that is based on historical temperature measurements.

c. **Objectives** - Students will:

1. Explore the factors that determine human perceptions of weather and climate;

2. Compile community survey results on local climate change;

3. Examine the historical record of climate change in their area;

d. **Background Information** - Weather is the state of the atmosphere at a specific time and place whereas climate is the average weather taken over a long time period for a given place or region. Climate change is the long-term alteration in the average weather conditions for a particular location. To evaluate whether or not climate is changing, scientists study historical records of temperature and precipitation or the timing of weather-related events such as lake ice formation and ice-out, animal breeding or migration, and the length of the growing season.

The “Common Sense Climate Index” is a simple measure of the degree to which practical climate change is occurring. The index is a composite of several everyday climate indicators. It is expected to have positive values when warming occurs and negative values for cooling. If the Index reaches and consistently maintains a value of 1 or more, the climate change should be noticeable to most people who have lived at that location for a few decades. The climate index for individual stations is available at this website - http://data.giss.nasa.gov/csci/stations/

e. **Curriculum Links** - Geography, Social Science. For instance, in the chapter titled 'Environment and Society', the teacher can explain how weather parameters (like temperature, rainfall, etc) and climate change can affect the human beings and the ecosystem in which they live.

f. **Intended Learning Outcomes** - Through this activity, students will learn to improve their use of spoken, written and visual language (e.g. style, vocabulary) to communicate effectively with a variety of audiences and for different purposes. Students will get a better insight about how changes in the physical systems (climate change) affect human systems (human life, health and occupation).

g. **Class/Grade** - Class 7 to 9

h. **Materials Required** - Computers with Internet access and Survey Forms for conducting interviews.

i. **Procedure :**

WEEK - 1

First of all, **ask the class to characterize the climate of their region.** They should consider factors such as the average temperature and rainfall, proximity to the ocean, large mountain ranges, deserts, etc. For instance, the manner in which a student from Jammu and Kashmir describes the climate in his region will definitely be different from the manner in which a student from Gujarat, Tamil Nadu, or Assam describes the climate in his region.

Then **ask each student to list the ways in which this climate directly affects his/her life** (for example, low temperatures during winters allows me to sit out in the lawn and enjoy the warm sunlight, pleasant weather during the spring lets me bike to school and enjoy festivals like Holi, monsoon rains flood the playground in which I play).

Ask the students to make a judgment, based on their own observations, as to **whether the climate now is significantly different from when they were younger**, and if so what was different about it. Have each student record their answer on a sheet of paper and then tally the results for the entire class.

WEEK - 2

Ask students to **write a short essay** discussing the results of the class survey. The essay should include a combination of all significant individual responses, in particular considering how different lifestyles affect the manner in which people perceive weather and climate. For instance, a student who stays in a centrally air conditioned house, travels in an air conditioned car and attends a school with AC classrooms might not be able to perceive the changes in climate as much as a student who is exposed to the harsh heat of the sun throughout the day, walking/ cycling his way to school, quenching his thirst and wiping away his sweat.

Ask the class how they might **design a study to look more closely at human perceptions of climate change**. Students can interview older local residents to see if they have perceived any changes in climate during their lifetimes. Divide the class into small groups and ask them to design a questionnaire for the survey. The goal is to determine if people living in the area for a long time believe there has been a noticeable change in climate, and how the change in climate has affected their life.

WEEK - 3

Ask each student to interview two or three older residents in their locality. If possible, students should interview people who have been in the area for at least three decades.

Ask the students to compare the results of the survey to climate change in their region as measured by the "Common Sense Climate Index", which is available at
http://data.giss.nasa.gov/csci/stations/ You can type the name of your nearest station (Cuttack, Bombay, Hyderabad, Delhi, etc) and find the climate index of that region. Alternatively, you can click anywhere in the map to find out the climate index of that region.

WEEK - 4

Ask each student to summarize his/her survey results and share with the rest of the class.

1.5 Discussion

After the sharing is over, the class must collectively discuss the results of this activity. Do all surveys yield a common opinion indicating a significant change in climate, or is there a difference of opinion? If there is any difference, then the teacher must help the class look for causes for this difference. For instance, the cause can be related to the length of time during which the resident lived in the area, difference in lifestyle, occupation, or other factor.

Sample Climate Change Survey

1. How long have you lived in the area?
2. What is your occupation? Has your occupation changed?
3. How much time do you spend outdoors now? Did you spend more/less time outdoors in the past?
4. How much would you say your life today is affected by climate? (Significantly/ Somewhat /Not at all)
5. How much was your life in the past affected by climate? (Significantly /Somewhat /Not at all)
6. How often do you follow weather forecasts?
7. Overall, would you say that climate has changed significantly during your lifetime? If so, how has it changed?
8. How would you respond to the following statements?
   - Compared to the past, today's summer temperatures are: Much hotter /somewhat hotter/same /somewhat cooler /much cooler /not sure
   - Compared to the past, today's winter temperatures are: Much colder /somewhat colder /same /somewhat warmer /much warmer /not sure
   - Compared to the past, the number of unusually hot days now is: Much more /somewhat more /same /somewhat fewer /fewer /not sure
   - Compared to the past, the number of unusually cold days now is: Much more /somewhat more /same /somewhat fewer /fewer /not sure
   - Compared to the past, our climate today is: Much wetter /somewhat wetter /same /somewhat drier /much drier /not sure
   - Compared to the past, the first frost now occurs: Much earlier /somewhat earlier /same time /somewhat later /much later /not sure
   - Compared to the past, bird migration in the spring now occurs: Much earlier/somewhat earlier/same time/somewhat later/much later/not sure
   - Compared to the past, ice breakup in spring now occurs: Much earlier /somewhat earlier /same time /somewhat later /much later /not sure
   - We have more heavy downpours now than in the past: Strongly agree /Agree /Disagree /Strongly disagree /not sure

- We have more droughts now than in the past: Strongly agree /Agree /Disagree /Strongly disagree /not sure
- We have more snow now compared to the past: Strongly agree /Agree /Disagree /Strongly disagree /not sure

1.6 Extensions/Modifications

The results of the class project could be written up as an article for the school or local newspaper, presented to local radio or television stations, or posted on the Web. If an article is written for the local newspapers or posted on the Web, students could also include a copy of the survey questionnaire for other interested people to fill up and return to the school. In this way students could add to the results from their interviews.

The teacher could invite a local employee from the Meteorological Department or weather forecast expert to speak about his/her job and explain the various ways in which climate influences people's lives. The speaker may also be requested to show maps and graphs on local historical climate trends.

1.7 Take a Message Home

Weather is the short term pattern of local atmosphere. It is what we expect to happen today, whereas climate is the long term pattern of the existing weather. It is something that we expect to happen from season to season. Climate change is the long-term alteration in the average weather conditions and is something that is noticeable over a period of time.

Classroom Activity 1.1: WORD SEARCH

WORD SEARCH - 1 : Search for the following weather related words in the scrambled matrix of letters below: Atmosphere, Radiation, Greenhouse, Trees, Gases, Industry, Weather, Smog, Carbon, Vehicles, Ozone, Ocean, Haze.

I	N	D	U	S	T	R	Y	B	A	K	U	W
Q	Z	M	V	E	H	I	C	L	E	S	E	O
O	O	G	R	E	E	N	H	O	U	S	E	O
G	B	S	Q	V	U	E	D	F	K	N	X	Z
O	C	E	A	N	M	Y	N	B	S	O	X	O
C	I	K	Q	G	H	H	P	E	T	I	S	N
E	R	E	H	P	S	O	M	T	A	T	W	E
R	P	S	E	S	A	G	B	C	V	A	E	S
P	K	H	K	S	F	M	A	X	W	I	A	E
H	S	K	H	O	G	R	B	Z	Z	D	T	E
H	A	Z	E	H	B	P	Q	B	O	A	H	R
L	W	A	T	O	C	U	P	Q	M	R	E	T
O	T	U	N	C	B	J	E	D	M	S	R	L

WORD SEARCH - 2 : Search for the following renewable energy related words in the scrambled matrix of letters below: Solar, Biomass, Biogas, Wind, Renewable, Waves, Energy, Hydro, Tidal, Carbon, Panels, Fossil fuel.

Z	S	S	A	M	O	I	B	Y	A	R	U	T
E	Z	M	S	E	L	C	I	H	E	E	E	I
U	T	Z	R	H	Y	D	R	O	M	N	E	D
E	N	E	R	G	Y	E	D	F	K	E	F	A
W	A	V	E	S	M	Y	N	B	S	W	O	L
C	I	K	Q	G	H	H	P	E	T	A	S	R
E	R	E	H	P	S	O	M	T	A	B	S	O
R	P	S	O	L	A	R	B	P	C	L	I	T
P	K	H	K	S	F	M	A	X	A	E	L	I
H	S	K	H	O	G	N	B	Z	R	P	F	E
W	I	N	D	H	E	P	Q	B	B	F	U	E
L	W	A	T	L	C	U	P	Q	O	U	E	R
O	T	U	S	A	G	O	I	B	N	O	L	P

Source: This activity has been adapted from the following website: http://edugreen.teri.res.in/play/wordsrch/main.htm

a. Duration of the Activity 30 minutes (15 min each)

b. Curriculum Links English Language, Social Studies

c. Class/Grade - Class 6 - 8

d. Discussion Explain the meanings of the terms related to Weather (in Word Search 1) and terms related to renewable energy (in Word Search 2) after the completion of this classroom activity.

Solution to Classroom Activity 1.1

I	N	D	U	S	T	R	Y	B	A	K	U	W
Q	Z	M	V	E	H	I	C	L	E	S	E	O
O	O	G	R	E	E	N	H	O	U	S	E	O
G	B	S	Q	V	U	E	D	F	K	R	X	Z
O	C	E	A	N	M	Y	N	B	S	A	X	O
C	I	K	Q	G	H	H	P	E	T	D	S	N
E	R	E	H	P	S	O	M	T	A	I	W	E
R	P	S	E	S	A	G	B	C	V	A	E	T
P	K	H	K	S	F	M	A	X	W	T	A	R
H	S	K	H	O	G	R	B	Z	Z	I	T	E
H	A	Z	E	H	B	P	Q	B	O	O	H	E
L	W	A	T	O	C	U	P	Q	M	N	E	S
O	T	U	N	C	B	J	E	D	M	S	R	L

Solution to Word Search 2

Z	S	S	A	M	O	I	B	Y	A	R	U	T
E	Z	M	S	E	L	C	I	H	E	E	E	I
U	T	Z	R	H	Y	D	R	O	M	N	E	D
E	N	E	R	G	Y	E	D	F	K	E	F	A
W	A	V	E	S	M	Y	N	B	S	W	O	L
C	I	K	Q	G	H	H	P	E	T	A	S	R
E	R	E	H	P	S	O	M	T	A	B	S	O
R	P	S	O	L	A	R	B	P	C	L	I	T
P	K	H	K	S	F	M	A	X	A	E	L	I
H	S	K	H	O	G	N	B	Z	R	P	F	E
W	I	N	D	H	E	P	Q	B	B	F	U	E
L	W	A	T	L	C	U	P	Q	O	U	E	R
O	T	U	S	A	G	O	I	B	N	O	L	P

Classroom Activity 1.2: EARTH'S CLIMATE

Match the descriptions below with the correct word in the Answer Bank.

1. _____[1] is the average weather we experience over a long period of time.
2. _____[2] is the air above the Earth's surface, which naturally contains "greenhouse gases."
3. _____[3] and _____[4]are the two common greenhouse gases that warm the Earth enough for us to live comfortably, but nowadays increased concentration of these gases is causing a rise in the Earth's _____[5].
4. _____[6] is a word describing sunny skies, rainfall, snowfall, and drought. If the Earth's temperature rises, it would disrupt these patterns.
5. _____[7] is the chemical deterioration of our garbage after it is dumped in a landfill and in the process large quantities of methane is released into the atmosphere.
6. A _____[8] releases methane into the atmosphere (when it burps) as a result of digestion of food, during which the bacteria present in its stomach produce methane!

Answer Bank

Atmosphere, Carbon Dioxide, Climate, Cow, Decomposition, Humans, Methane, Products, Temperature, Weather,

a. Duration of the Activity 10 minutes.

b. Curriculum Links Social Studies

c. Class/Grade - Class 7-8

d. Discussion Explain the difference between weather and climate to the students. Also discuss about the various greenhouse gases and their sources of production.

Solution to Classroom Activity 1.2:

1. Climate	2.Atmosphere	3.Carbon-dioxide	4.Methane	5.Temperature
6.Weather	7.Decomposition	8.Cow		

Source: http://www.epa.gov/epaoswer/osw/k00-001.pdf

Classroom Activity 1.3: QUIZ ON CLIMATE CHANGE

Q1. Following is the most widely discussed impact of climate change:

A. Increase in average sea level

B. Deforestation

C. Soil erosion

D. None of the above

Q2. Sea level is expected to rise because of warmer climate due to:

A. Oceans expand as they get warmer

B. Glaciers and ice-sheets melt

C. Both the above

Q3. Over the last 100 years global sea level has risen by about

A. 20 - 25 cm

B. 10 - 12.5 cm

C. Both the above

D. None of these

Q4. Climate change may have an impact on the following:

A. Agriculture, natural terrestrial ecosystems, and water resources

B. Air quality, oceans, and coastal zones

C. Energy and human health

D. All of the above

Q5. Which sector is the largest emitter of greenhouse gases in India?

A. Transport

B. Domestic

C. Agricultural

D. Electric power generation

Q6. Which landmark global conference was the FIRST major step towards a global agreement on greenhouse gas emissions reduction and the first to recognize the atmosphere as a natural resource?

A. The Vienna Convention in 1985

B. The Montreal Protocol in 1987

C. The 'Earth Summit' in Rio in 1992

Q7. CFCs (Chloro Fluoro Carbons) are one of the greenhouse gases that have caused a rise of 0.3 °C in the global temperatures in the past century. Name the CFC that is used in refrigerators.

A. Carbon dioxide

B. Freon

C. Methane

D. Ammonia

Q8. The massive hole in Ozone Layer over Antarctica was first discovered in

A. 1976

B. 1985

C. 1960

Q9. India would phase out the production and consumption of Ozone Depleting Substances within the time frame and limits specified in the

A. Vienna Convention

B. Basel Convention

C. Montreal Protocol

D. Agenda 21

Q10. By 2100 AD, global temperature is expected to rise by about 2°C and consequently, the sea level is also expected to rise. How is a rise in temperature expected to increase the level of the sea?

A. By expanding ocean water

B. By melting mountain glaciers

C. By causing ice sheets of Antarctica and Greenland to melt and slide into the oceans

D. All of the above

(Solutions provided on next page...)

Solution to Classroom Activity 1.3: QUIZ ON CLIMATE CHANGE

Answer 1: (A) The most widely discussed global impact of climate change is the increase in average sea level. It is expected to rise because glaciers and ice sheets melt and oceans expand as they get warmer. The global sea level has risen by 200 mm most of which can be attributed to temperature increases. It is estimated that the average global surface temperature would rise by 2°C between 1990 and 2100, with the average rate of warming greater than any seen in the past 10 000 years. A warmer climate would lead to a very high sea-level rise, estimated to be about 500 mm by 2100.

Answer 2: (C) Coastal areas and small islands are among the most densely populated parts of the world. They are now also the most threatened due to the rise in sea levels caused by global warming. The heating of oceans and melting of glaciers and polar ice sheets is predicted to raise the average sea level by about half a metre over the next century. Sea-level rise could have a number of physical impacts on coastal areas, including loss of land due to inundation and erosion, increased flooding, and salt-water intrusion. These could adversely affect coastal agriculture, tourism, freshwater resources, fisheries and aquaculture, human settlements, and health. The rising sea levels threaten the survival of many low-lying island nations, such as the Maldives and Marshall Islands.

Answer 3: (B) The sea level is said to be gradually rising over the years and this has been attributed to the polar ice cap melting and water flow from other sources. In fact, in the climatic cycle, according to scientists, there has been a sea level rise during the earlier phases of the earth's life, which has been attributed to natural causes.

Answer 4: (D) The direct impacts of climate change include rising temperatures, increasing precipitation levels, and sea-level rise. These, in turn, have an impact on the natural ecological systems, agriculture, human health, soil erosion, water resource use, power generation, tourism, industry, and infrastructure. There is no agreement regarding the magnitude and rate of occurrence of these impacts. Climate change will affect the agricultural yield directly through changes in temperature and precipitation, and indirectly through changes in soil quality, pests, and diseases.

Answer 5: (D) Since the Industrial Revolution, human activities have been releasing more and more greenhouse gases into the atmosphere. Carbon dioxide is released when we burn such fuels as coal, oil, and natural gas. Industrial processes also release artificial and new greenhouse gases like the CFCs (chlorofluorocarbons), while automobile exhaust fumes lead to ozone generation. The resulting enhanced greenhouse effect is more commonly referred to as global warming or climate change.

Answer 6: (C) In 1992, the Earth Summit organized by the UNCED (United Nations Conference on Environment and Development), was held in Rio de Janeiro in Brazil. The gathering momentum on environmental issues was given support and global focus, and Agenda 21 was set out as a blueprint for action for the 21st century. The Rio conference was significantly different from the Stockholm conference: it was not about the environment itself but about the world economy and its effects on the world environment. The developed countries came to Rio to solve the issues of climate, forests, and endangered species but this did not happen. This time the south was in a position to demand that if the north wanted them to check their consumption of oil and coal and stop deforestation then the north would have to pay for it.

Answer 7: (B) Chloroflorocarbon or CFC is said to be one of the main gases responsible for the greenhouse effect. It is emitted mainly from air conditioners, refrigerators, and aerosols or spray can propellants. Another widely used chemical that is a threat to the ozone layer is methyl bromide. This can release bromide, which is 30-50 times as destructive to ozone as chlorine.

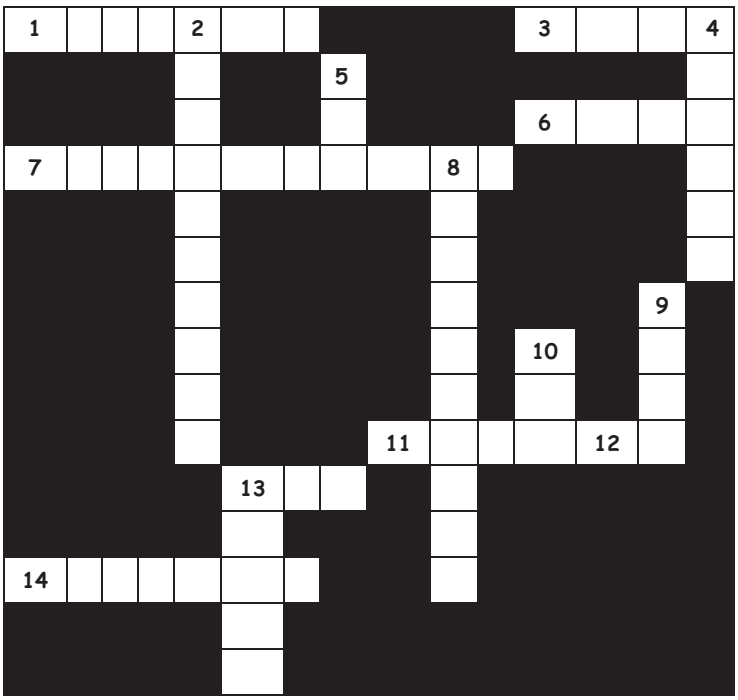
Answer 8: (B) The ozone layer has determined the temperature structure of the stratosphere and safeguarded life on the planet by absorbing the harmful ultraviolet rays of the sun. It is believed that for millions of years the atmospheric composition had not undergone much change. But in the past half-a-century, humans have upset the delicate balance of nature by releasing into the atmosphere harmful chemicals that are gradually destroying this life-protecting layer. The presence of ozone in the stratosphere is more concentrated and dense near the equator and decreases gradually as one moves towards the poles. This is determined by the movement of the prevailing winds, the shape of the earth, and rotation of the earth. Towards the poles, it varies depending upon the season. Depletion of the ozone layer is clearly seen in the South Pole, that is, at Antarctica where there is a large ozone hole. As the atmosphere has no international boundaries, it was realized that remedies should be discussed and decided at an international level.

Answer 9: (C) The Montreal Protocol on Substances that Deplete the Ozone Layer is a landmark international agreement to protect the stratospheric ozone layer. The treaty was opened for signature on September 16, 1987 and entered into force on January 1, 1989 followed by a first meeting in Helsinki, May 1989. Since then, it has undergone seven revisions. It states that the production and consumption of compounds that deplete the ozone in the stratosphere - CFCs (chlorofluorocarbons), halons, carbon tetrachloride, and methyl chloroform - are to be phased out by 2000-10, depending upon the country. Scientific theory and evidence suggest that, once emitted in the atmosphere, these compounds could significantly deplete the stratospheric ozone layer that shields the planet from the damaging UV-B radiation.

Answer 10: (D) A warmer climate will change rainfall and snowfall patterns, lead to increased droughts and floods, cause melting of glaciers and polar ice sheets, and result in accelerated sea-level rise. This, in turn, will affect water resources, forests, and other natural ecological systems, agriculture, power generation, infrastructure, tourism, and human health.

Source: http://edugreen.teri.res.in/play/play.htm

Classroom Activity 1.4: CROSSWORD ON CLIMATE CHANGE



Clues Across

1. _____ Change (7)
3. Something you can ride instead of a car (4)
6. Plant a _____ (4)
7. This means the study of weather (11)
11. _____ Fuel (6)
13. The ___ Provides heat and light (3)
14. You can _____ Your glass bottles (7)

Clues Down

2. Part of the climate system _____ (10)
4. Solar is one type of _____ (6)
5. A fossil fuel made _____ (3)
8. A type of gas _____ (10)
9. Used as fuel; comes from fossils _____ (4)
10. Greenhouse ___ (3)
12. ___ Age (3)
13. _____ Energy comes from the sun (5)

(Solutions on next page…)

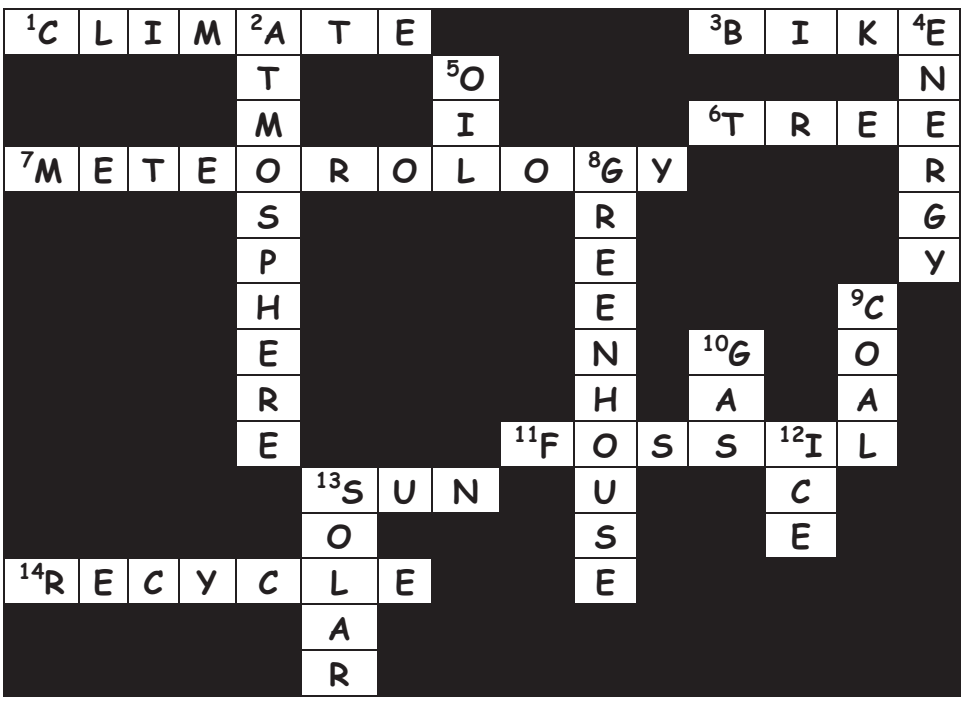
a. **Duration of the Activity -** 15 minutes.

b. **Curriculum Links -** English Language, Social Studies

c. **Class/Grade** - Class 6-7

d. **Discussion** - Just before commencement of this activity, explain the concept of climate change to the class for 5-10 minutes, emphasizing on the relevance of terms like climate, fossil fuels, Greenhouse effect, greenhouse gases, renewable sources of energy, etc.

Solution to Classroom Activity 1.4: CROSSWORD ON CLIMATE CHANGE



Source: http://www.epa.gov/climatechange/kids/games/crossword/crossword.html

1.8 References

NCDC Extreme Weather and Climate Events - This website is a gateway to climatic data and reports on extreme weather events throughout the U.S. and the world.

http://www.ncdc.noaa.gov/oa/climate/severeweather/extremes.html

GLOBAL WARMING: EARLY WARNING SIGNS, a science-based world map depicting the local and regional consequences of global climate change.

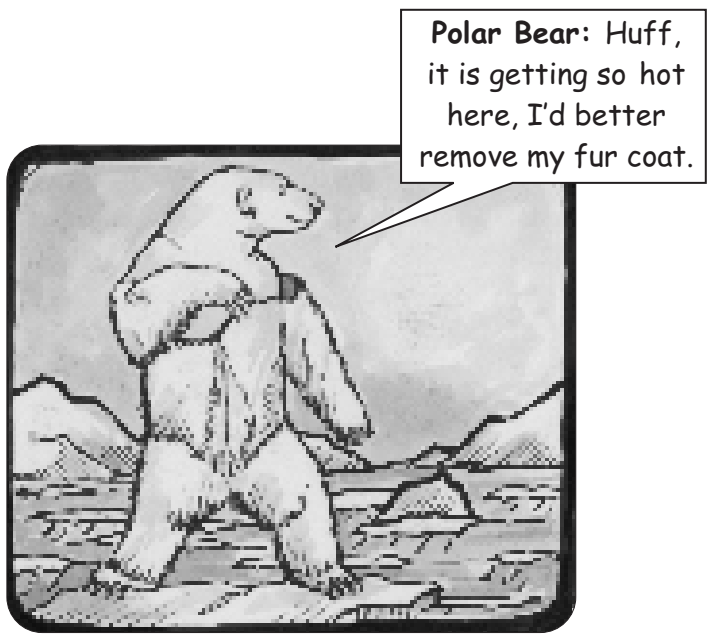
http://www.climatehotmap.org/index.html

NASA GISS provides the Common Sense Climate Index and world average climate index data

http://data.giss.nasa.gov/csci/

EPA provides a wealth of materials for teachers and students

http://www.epa.gov/epaoswer/education/index.htm



CHAPTER - II

Greenhouse Effect and Global Warming

2.1 Objectives

- Understanding the Greenhouse Effect and its importance
- Identify the human activities which contribute to Global Warming & Climate change

2.2 Keywords Greenhouse Effect, Greenhouse Gases, Global Warming

2.3 Content

THE GREENHOUSE EFFECT

When visible light from the Sun hits the earth, some of the radiations are absorbed and used to heat the earth. The heated earth, in turn, gives off infrared radiations, which is reradiated back into space. However, certain gases in the atmosphere absorb the infrared heat that would normally be radiated back into space. This progressive heating of the earth's surface due to the gradual building up of infrared radiations within the atmosphere, caused largely by the accumulation of Greenhouse gases is known as **Greenhouse Effect**. The Greenhouse Effect is so called, as it is similar to the warming of air inside a greenhouse compared to the air outside. The greenhouse effect is critical for the survival of life on earth, as it keeps the surface temperature about 33°C warmer than it would be without the greenhouse effect. This is essential for the evolution and proliferation of life. The gases such as carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), Halofluorocarbon (HFC) & Sulphur hexafluoride (SF_6) which absorb the solar infrared radiation, are known as the **Greenhouse Gases**.

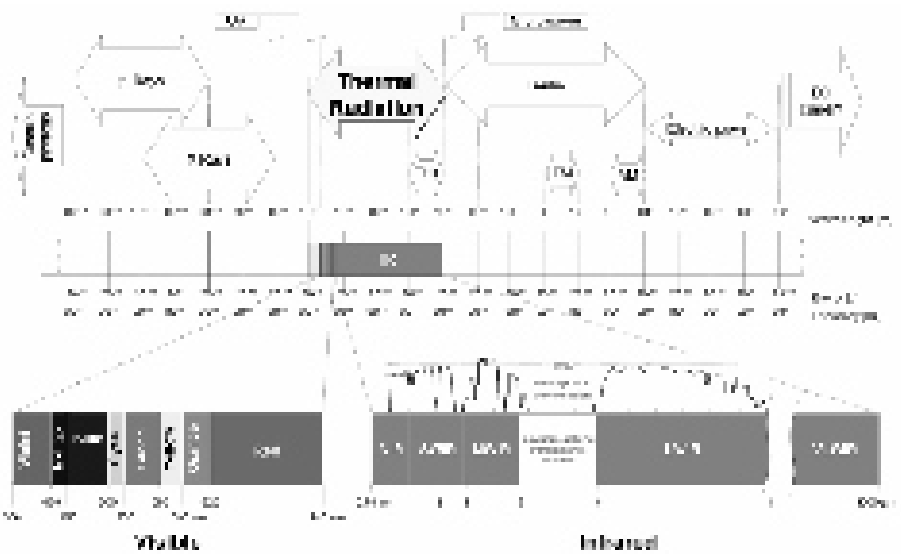


Figure: The Electromagnetic Spectrum.

Source: http://www.theses.ulaval.ca/2005/23016/apb.html

The greenhouse gases act like a blanket, preventing much of the heat reflected by the earth's surface from escaping directly into space. By slowing the release of cooling radiation, these gases warm the Earth's surface. While this is a natural process that is essential to life on Earth, the trouble starts when the concentration of these Greenhouse gases in the Earth's atmosphere increases. The result is an increase in the Earth's temperature, also known as - Global Warming.

Global Warming is the gradual increase of the average temperature of Earth's atmosphere and oceans, which can contribute to changes in global climate patterns. Global warming in turn interferes with the Earth's climatic systems, resulting in climate change. Global warming could have disastrous effects on the environment (polar ice melts, changes in amount and pattern of rainfall, sea level rise, frequent floods and droughts, hurricanes and typhoons). It would cause large-scale species extinction and have serious impacts on human lives (freshwater availability, agricultural yields, increases in the spatial and quantitative ranges of disease vectors), as well as on economic infrastructure (such as energy, transport and industry).

Major Greenhouse Gases

Our planet is surrounded by a thin layer of atmosphere, which comprises of a layer of constantly moving gases that provides us with the air that we breathe. Almost the Earth's entire atmosphere is made up of Nitrogen (about 78%) and Oxygen (about 21%). The rest of the 1 % is made up of trace gases (including the greenhouse gases).

Carbon dioxide

Of all greenhouse gases, carbon dioxide is singly responsible for over half the effect of global warming (about 77%). Although it is naturally present in the Earth's atmosphere and in oceanic and terrestrial 'sinks' (such as forests), the trouble starts when carbon dioxide concentrations increase beyond limits that can be absorbed by the Earth's natural cycle. Carbon dioxide concentrations have been increasing rapidly in the atmosphere since the start of the industrial revolution, when the world became heavily dependent on carbon-based fossil fuels for economic growth. Ever since then, human beings have been emitting carbon dioxide into the atmosphere in their pursuit for industrialization, economic growth, and better lifestyles. The amount of carbon dioxide in the atmosphere is about 30% higher now than 200 years ago at about 379 ppmv.

Methane

The level of Methane (which is the second biggest contributor to Global Warming (about 20%) in the atmosphere) is about 145% higher now than 200 years ago at about 1774 ppbv. The main causes of this increase are the digestive processes of cattle and sheep (enteric fermentation in their rumens produces methane, collectively adding about 100 million tons a year), cultivation of rice, decomposition of waste in garbage dumps and landfills, and the escape of natural gas into the atmosphere.

Nitrous Oxide

The Nitrous Oxide level in the atmosphere is 15% higher now than 200 years ago at about 319 ppbv. The main causes for this increase are indiscriminate use of nitrogenous fertilizers in agriculture, burning of vegetation and emissions from industries.

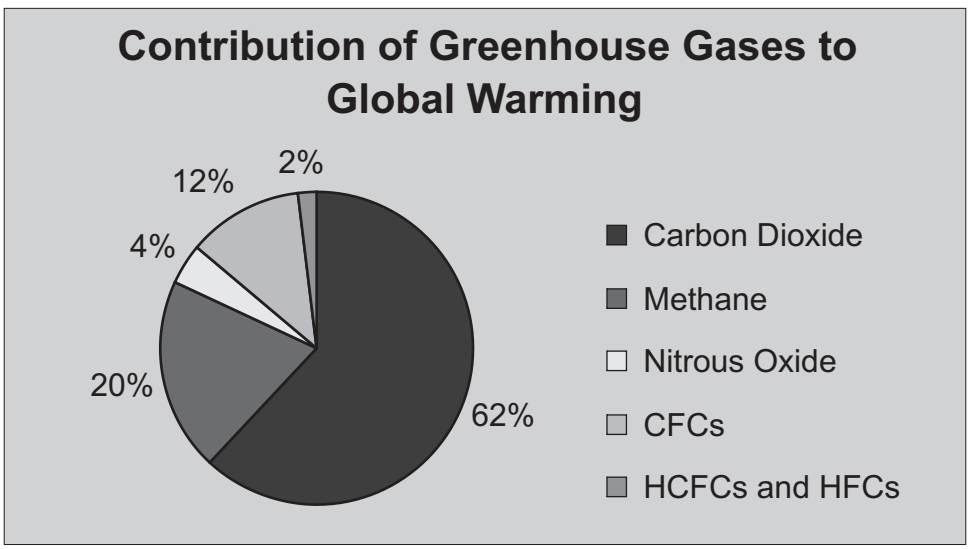
Chlorofluorocarbons

Chlorofluorocarbons are one of the greenhouse gases that have caused a rise of 0.3 ºC in the global temperatures in the past century. Their concentration ion the atmosphere has been reduced since they were phased out to protect the ozone layer. However, fluorocarbons like Perfluorocarbons (emitted during aluminium production) and Halofluorocarbons continue to be emitted into the atmosphere.

Water Vapour

Although Water Vapour is the most important greenhouse gas with the highest concentration in the atmosphere, human activity has little or no direct impact on its concentration in the atmosphere. However, increasing global temperatures inevitably result in greater water vapour concentrations in the atmosphere through a positive feedback, wherein higher temperatures increase evaporation rate and release larger volumes of water vapour into the atmosphere.

Figure: Graph showing contribution of various greenhouse gases to global warming

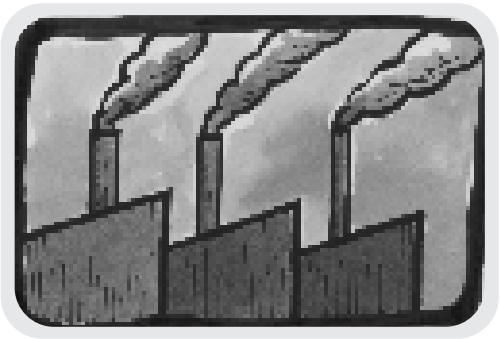


Source: http://www.ace.mmu.ac.uk/Resources/Teaching_Packs/Key_Stage_4/Climate_Change/01p.html

How do human activities contribute to Greenhouse Gas Emissions & Global Warming?

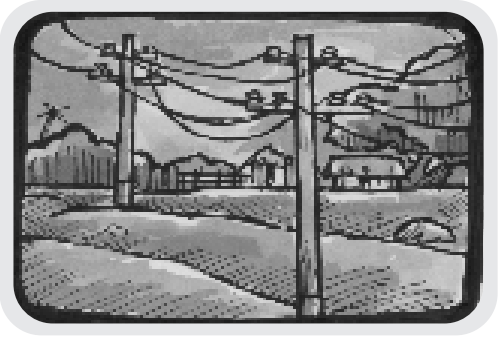
Global warming can occur from a variety of causes, both natural and human induced. Volcanic eruptions, changes in the earth's orbit and earth's orientation toward the sun, are some of the natural causes of Global Warming. However, since the beginning of Industrial Revolution, the concentrations of greenhouse gases (GHGs) in the atmosphere have escalated drastically due to human activities such as:

DEFORESTATION - Forests act as the largest sink as well as source of carbon. However, by depleting almost 70% of the earth's forest cover for agriculture and other development projects, we have caused two-way damage. Firstly, slashing trees releases vast amounts of carbon (that was previously stored in the plant body) in the form of carbon dioxide into the atmosphere; Secondly, due to deforestation, the number of trees available to absorb and recapture the atmospheric carbon dioxide is reduced drastically. As a result, the carbon dioxide concentrations in the atmosphere increase drastically.



FOSSIL FUEL USAGE - Coal, oil and natural gas have originated from the decomposition of plant and animal matter. These fossil fuels are rich in carbon and emit vast amounts of carbon dioxide, nitrogen oxides and sulphur dioxide when ignited. Carbon rich fossil fuels are being extensively used for generating electricity for artificial power as well as at homes and industries as a fuel. Almost 70% of rural and semi-urban India is still dependent on coal, Kerosene and wood for satisfying their everyday energy requirements.

ENERGY - Every human activity involving electricity like watching TV, switching on the fan etc, emits GHGs. It is estimated that in India, nearly 80% of the energy requirements are satisfied by fossil fuels alone. Renewable sources of energy have not yet attained popularity in our country. Most of our power comes from thermal power stations that use coal, are one of the largest emitters of carbon dioxide. The energy sector alone accounts for 21.3% of annual greenhouse gas emissions globally.



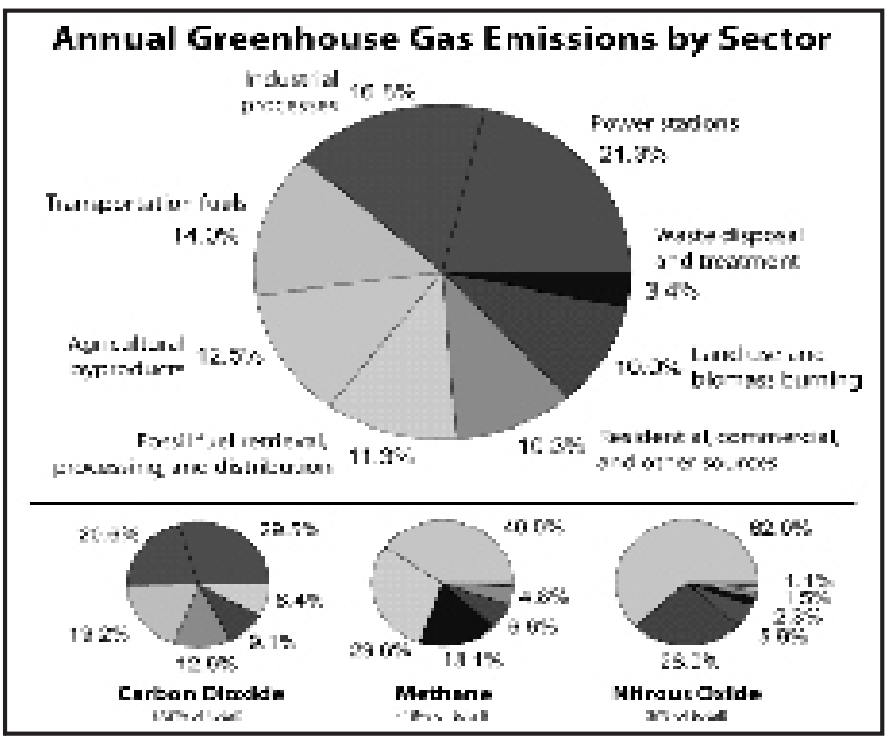
TRANSPORTATION - The transportation sector is responsible for about 14% of global GHG emissions every year. Road transportation sectors like cars and buses are responsible for emission of huge volumes of GHGs. However, it is the aviation sector that emits the most GHG per traveler/ km and is responsible for nearly 2% of all GHG emissions.

INDUSTRY - Industrial emissions account for 16.8% of annual greenhouse gas emissions. The industries are largely dependent on fossil fuels for their energy needs. They consume vast amounts of coal and other fossil fuels and ultimately emit huge quantities of greenhouse gases. Apart from captive power generation, the production cycle and industrial transport also contribute significantly to GHG emissions.

AGRICULTURE - Agriculture is responsible for nearly 12.5% of annual GHG emissions. Particularly cultivation of paddy in flooded rice fields emits significant quantities of methane gas, the second largest greenhouse gas. Even cattle and other farm animals generate small quantities of Methane (from belching). Clearing of vegetation for agriculture (slash and burn method) and biomass burning contributes to almost 10% of the annual GHG emissions.

WASTES - The decomposition of wastes in the municipal garbage dumps and sanitary landfill sites (especially the anaerobic decomposition of organic waste) emits large quantities of methane gas. Open burning of solid wastes, which is quite common in our country, generates a lot of smoke in addition to emission of gases like carbon dioxide, carbon monoxide, sulphur dioxide, dioxins, etc.

The graph clearly shows that power stations are the largest contributors of greenhouse gases. The other significant contributors to GHG emissions are the industries, transport sector closely followed by the agricultural sector.



Source: http://www.tree-nation.com/community/product.php?id=163386&item_id=163386&lang=es

2.4 Activity 1

Understanding the Greenhouse Effect

a. **Duration of the Activity -**120 minutes

b. **Overview -** Students conduct an experiment to understand the greenhouse effect using a glass jar to simulate a greenhouse.

c. **Objectives -** To help students understand how greenhouse effect works.

d. **Background Information -** A greenhouse is an enclosure made up of glass within which plants are grown. Sunlight enters the glass enclosure and heats up the plants and soil, which get warmed up and give out heat. Some of this heat is transmitted through the glass while the rest of it gets trapped inside and heats up the green house. Enhanced temperatures within the green house increase the growth and productivity of the plants placed within the green house.

e. **Curriculum Links -** Science

f. **Intended Learning Outcomes -** The students will learn how to use and read a thermometer.

g. **Class/Grade -** Class 6

h. **Materials Required -** 2 thermometers; a large clear glass jar; pen, paper.

i. **Procedure**

- On a sunny day, lay two thermometers side by side on the same kind of surface outdoors. Label them as T1 and T2.
- Immediately record the temperatures shown by both the thermometers.
- Then cover the thermometer labeled T2 with a large clear glass jar (which simulates a greenhouse). Wait for 30 minutes.
- Then read the temperature of the two thermometers.
- Carefully replace the glass jar over the thermometer labeled T2. Wait for another 1 hour and read the temperatures of the two thermometers again.
- Observe and carefully record the difference in temperatures between the two (if any).

j. **Observation -** The thermometer T2 will depict higher temperatures than thermometer T1. This is due to the phenomenon called "Green House Effect". Although the same amount of sunlight hits both the thermometers, the sunlight entering the glass jar heats up the air within the jar. The glass jar covering the thermometer T2, traps the heat and does not allow it to escape, as in a green house. As a result, the temperature levels within the glass jar is higher than the usual atmospheric temperature. Therefore, thermometer T2 which is placed within the glass jar shows greater temperature level than thermometer T1 which is placed uncovered in the open.

2.5 Discussion After the experiment is over, emphasize why plants need to be kept in a greenhouse; explain the difference between the plants that are kept inside and outside the greenhouse. Ask the students to relate their experience about the difference in heat they felt inside and outside a greenhouse. Discuss the role of different kinds of human activities in causing Global Warming and climate change.

2.6 Extensions/Modifications

Instead of a glass jar to simulate a greenhouse in this activity, the students may be asked to repeat the experiment using a car or a real glass greenhouse.

Students may be taken on a visit to a Greenhouse site.

2.7 Take a Message Home

The 10 warmest years globally since 1856 have occurred in the last 15 years. The year 2005 was the hottest year ever.

The Caribbean saw its warmest ever ocean temperatures in 2005, combined with the worst coral bleaching ever.

March 2006 showed the smallest Arctic sea ice cover ever measured. The sea ice extent had reduced by 300,000 square km in comparison to March 2005, meaning sea Ice about the size of Italy was lost!

2.8 References

"Climate Change Science: Questions Answered" - Australian Greenhouse Office, the Department of Environment and Heritage.

http://www.greenhouse.gov.au/science/faq/pubs/science-faq.pdf

"Climate Chaos Information for Teachers" WWF UK

http://www.wwflearning.org.uk/data/files/climate-chaos-293.pdf

"Trash and Climate Change" Environmental Protection Agency, USA

http://www.nowpap.org/data/ML%20ref/3R%20for%20Kids%20EPA.pdf

If you want to find out more about global warming in general, visit these websites:

http://www.epa.gov/globalwarming/kids/index.html

http://globalwarming.enviroweb.org/games/index.html

http://www.defra.gov.uk/environment/climatechange/schools/7-11/index.htm

http://www.oneworld.net/penguin/global_warming/climate_home.html

Classroom Activity 2.1: GLOBAL WARMING SKIT

a. Duration of the Activity 40 minutes.

b. Overview Students perform a skit to understand the role of different factors (such as the greenhouse gases, human activities involving burning of fossil fuels, etc) in causing the Global Warming.

c. Objective - To help students learn about global warming by "acting" out the greenhouse effect.

d. Curriculum Links English Language, Social Studies

e. Class/Grade - Class 6-7

f. Materials required - Cardboard or poster board, string, punching machine, marker pens or crayons in assorted colors.

g. Procedure Each child must choose a role and then use the cardboard and marker pens or crayons to create his or her costume, name or any other characteristic to define his identity.

Cast: Atmosphere, Cars (two), Earth, First Heat, Greenhouse Gases (three), Narrator, Plane, Second Heat, Space, Sun.

Narrator: What is the greenhouse effect? How does it work? Well, first of all, the sun warms the Earth.

(Enter Sun, Earth and the two Heats) The Sun sends both Heats toward the Earth.

Sun: I'm the sun, and I warm the Earth.

Narrator: Sun is very important in sustaining life upon our planet. Without the sun, people wouldn't be able to live here as the planet would have been freezing cold. But too much heat from the sun isn't good, either. The Earth sends back some heat into space and that helps to keep the Earth from getting too hot.

(Enter Space) One Heat goes toward Space.

First Heat: I'm heat, and I go back into space.

Space: I'm space, and some of the heat comes back to me.

Narrator: The gases in the atmosphere act like a blanket and prevent most of the heat from escaping into space. Thus the earth's temperatures are maintained at comfortable levels.

(Enter Atmosphere) The Atmosphere holds the second Heat and prevents it from running towards space.

Atmosphere: I'm atmosphere, and I keep most of the heat from going back into space.

Second Heat: I'm am heat and I stay in the atmosphere and warm it.

Narrator: The atmosphere contains substances called greenhouse gases.

Enter Greenhouse Gases (three)

Greenhouse Gases: We're greenhouse gases, and we trap Sun's heat.

Narrator: Some of the gases also trap heat from the sun. Because those gases cause the greenhouse effect, they are called "greenhouse gases." Some greenhouse gases are produced by human activities, such as deforestation, burning of fossil fuels, driving and flying.

Enter two Cars and Plane. The Cars act as if they are driving and the Plane acts as if he is flying.

Cars: We're cars, and we emit greenhouse gases.

Plane: I'm a plane, and I emit huge volumes of greenhouse gases as I fly...

Narrator: We make greenhouse gases by using fossil fuels such as coal, oil and gasoline. However, Fuel is required for most of our daily activities like cooking, driving and even for heating our homes. But when we use fuel we emit greenhouse gases into the atmosphere and add to the greenhouse effect, which ultimately warms up our Earth too much.

Greenhouse Gases follow Cars and Plane and then move toward the Atmosphere. Now, when the second Heat moves toward the Space, it's trapped by the Greenhouse Gases and the Atmosphere.

Greenhouse Gases: We go into the atmosphere and trap the heat from escaping into space.

All the characters together: We help make the greenhouse effect!

Discussion After the skit is over, the teacher must discuss the role of different kinds of human activities in causing Global Warming and climate change.

Source: http://www.epa.gov/climatechange/wycd/downloads/SA_Skit.pdf

Classroom Activity 2.2: BAD GAS WORD PUZZLE

GREEN WORDS

Hidden inside this word puzzle are eight greenhouse words. Fill in the clues then see if you can find the answers in the puzzle.

F	M	R	T	E	T	R	E	E	S
W	E	U	A	Z	M	L	G	S	1
N	T	A	Q	C	A	R	B	O	N
I	H	B	F	L	H	O	V	C	K
B	A	C	T	E	R	I	A	X	S
M	N	Y	D	A	J	R	Z	E	A
Z	E	A	N	R	W	G	E	G	T
K	L	U	B	I	O	R	D	Q	C
G	R	E	E	N	L	F	S	M	X
S	E	W	A	G	E	H	B	J	A

CLUES

1. Trees and plants breathe in _ _ _ _ _ _ [1] dioxide.
2. _ _ _ _ _ _ _ [2] is the second bad greenhouse gas.
3. Sheep and cows have _ _ _ _ _ _ _ _ [3] in their stomachs that produce methane.
4. Carbon _ _ _ _ _ _ _ 4 take carbon dioxide out of the atmosphere.
5. We need to use more _ _ _ _ _ _ _ 5 energy.
6. Lots of methane comes from human _ _ _ _ _ _ _ 6.
7. Chopping _ _ _ _ _ _ _7 down releases carbon dioxide.
8. We should plant forests instead of _ _ _ _ _ _ _ 8 them.

(Solutions on next page...)

a. Duration of the Activity 15 minutes

b. Curriculum Links English Language, Social Studies

c. Class/Grade - Class 6 - 8

d. Discussion Explain the information provided in the fact sheet to the class before commencement of this classroom activity.

FACT SHEET: BAD GAS

If there's one big baddy in the greenhouse story, it's fossil fuels. The burning of coal, oil and gas to make electricity has been blamed for getting us into such hot water, but there is a lot more to the greenhouse story than just fossil fuels. The way we use the land has a big effect on global warming - more precisely, what we do with the trees and plants on the land. Trees and plants breathe in carbon dioxide and use the carbon to grow bigger and stronger. When land is cleared for farming or building, plants and trees are chopped down, burnt or left to rot, and all the carbon stored away in the wood is turned back into carbon dioxide gas. Activities such as land clearing and ploughing to plant crops also disturbs the soil. This causes the carbon in the soil to be released into the atmosphere as carbon dioxide gas.

One way of removing some of this extra carbon dioxide is to plant forests instead of clearing them. Forests are called carbon sinks because they take carbon dioxide out of the atmosphere and store it in trees and plants. As long as trees are growing, they soak up and store carbon dioxide.

Methane is the second big baddy of greenhouse gases. Most of the methane produced comes from cow and sheep stomachs. Sheep and cows eat large amounts of grass and leaves. This sort of food is not easy to digest, so they have special bacteria in their stomachs to help them break down the food.

These bacteria produce lots of methane gas as they break down the tough fibre in the grass and plants. Scientists at the CSIRO are now working on ways to stop sheep and cattle breathing out so much methane, which may also help make the animals healthier and bigger.

Cows and sheep aren't the only animals that can be blamed for producing methane. Humans also produce huge amounts of methane from our sewage and garbage, which are also broken down by bacteria. Scientists are now working on ways to collect and use this gas to produce energy, so reducing the greenhouse gases in the atmosphere instead of adding to them.

Reducing how much greenhouse gas we put into the atmosphere is a challenge, but it is one that you can take up. Perhaps the most important step you can take is to reduce the amount of electricity you use each day - for example, switching off lights that aren't in use. Or, you can start using green sources of energy.

Green power is an alternative to electricity from fossil fuels, which produce lots of greenhouse gases. Solar power, wind power and hydro power are clean and green and may yet give us a happy ending to the greenhouse story.

Growing trees soak up carbon dioxide and produce oxygen and are called 'carbon sinks'.

Sheep & cows produce methane in their stomachs as they digest their food.

Human sewage and garbage waste give off lots of methane.

Solution to Classroom Activity 2.2:

1. CARBON	3. BACTERIA	5. GREEN	7. TREES
2. METHANE	4. SINKS	6. SEWAGE	8. CLEARING

Source: This activity has been adapted from the following
website:http://72.14.235.104/search?q=cache:0lUdhadgdngJ:www.greenhouse.gov.au/education/factsheets/pubs/bad_gas.pdf+BAD+GAS+FACT+SHEET&hl=en&ct=clnk&cd=2&gl=in&client=firefox-a

Classroom Activity 2.3: CHANGING FOR THE FUTURE WORD PUZZLE

CAN YOU FILL IN THE SPACES AND FIND THE WORDS IN THE WORD PUZZLE?

Check up and down, sideways and diagonally!

E	G	R	Y	W	P	O	E	G	U
G	R	O	L	A	E	N	G	T	N
A	E	N	I	G	T	T	R	B	E
W	E	T	T	E	R	G	O	I	N
A	N	Y	H	W	O	I	L	H	E
R	H	O	R	T	L	U	N	C	R
M	O	W	A	T	E	R	B	M	G
E	U	T	N	E	T	L	I	K	Y
R	S	E	M	A	T	T	E	W	Y
C	E	R	I	R	H	C	Z	O	O

CLUES

1. Global warming means that temperatures will get_ _ _ _[1].
2. Some areas will get _ _ _ _ _ _[2] while some areas will get drier.
3. _ _ _ _ _ _ _ _ _ _[3] gases are responsible for the greenhouse effect.
4. Car manufacturers are now trying to make cars that don't run on _ _ _ _ _ _[4].
5. Fossil fuels are _ _ _[5], natural gas and petrol.
6. One of the possible ways in which we can help slow down global warming is to use less _ _ _ _ _ _[6].
7. In dry areas, we will need to use _ _ _ _ _[7] more wisely because it will be in shorter supply.

(Solutions on page 43)

a. Duration of the Activity 15 minutes

b. Curriculum Links Geography, Social Studies

c. Class/Grade - Class 7 - 8

d. Discussion Explain the information provided in the fact sheet to the class before commencement of this classroom activity.

FACT SHEET: CHANGING FOR THE FUTURE

With the whole world warming up, things could soon get really hot and sweaty. The way we live will have to change if we are going to keep up with the changes the Earth is experiencing from the enhanced greenhouse effect - the name for the way the Earth is heating up like a hothouse.

The changes include rising sea levels, which may flood coastal cities and towns, and in some cases may flood entire countries such as low-lying Pacific nations. People who live on the coast may find their homes falling into the seas as sea levels rise. To stop this, larger sea walls - walls that stop the sea from washing on to roads and other places - would have to be built. Roads, houses, buildings and other structures next to the sea will be in greater danger from erosion - wearing away.

Another danger from global warming is storm surges - high levels of water caused by wind, or cyclones. There will be stronger cyclones more often, and they will happen in a wider area than they have before. As a result, we may have to build stronger homes, towns, and cities that are designed to withstand forceful winds.

Global warming will also change the rainfall pattern. Some areas will get less rain, and some will get more and heavier downpours. Although overall conditions will be drier, we will be more likely to get extreme weather conditions such as hail and rainstorms as well as droughts. Areas that receive more rain are likely to be prone to flooding which may mean that we have to increase the size of street gutters and water storages to carry large volumes of water. In dry areas, we will need to use water more wisely because it will be in shorter supply.

Because of the extreme changes in weather that have been predicted, it could cost more money for insurance - money that you get back when things such as storms damage your house or land. In some areas, it may even become difficult to insure your property against damage from weather events, including drought, storms and floods.

The hotter weather could affect sick and elderly people who are more likely to get heat stress - meaning they get sick from the heat. As a result there may be a big increase in the demand for air conditioners. One thing we can do is build homes and offices that don't need as much energy for light and heat and so use much less electricity. Burning fossil fuels to make electricity produces carbon dioxide, a gas that contributes to global warming. Buildings and factories can also be built in a way that uses the sun for energy, by building large windows facing north with an overhanging roof - this lets in the sun to heat the house in winter but blocks out the summer sun. It also helps to have insulation - padding in the walls that create a barrier against the heat.

There are many things we can do to adapt to a warmer world, but it means changing some of the ways we live, such as how we build our cities. In the meantime, we can all do our bit to lessen global warming by reducing the amount of greenhouse gases we produce, and watching out for how much energy we use - by turning off lights, computers and televisions, and by walking and riding a bike.

- Passive solar houses get more light and heat from the sun during winter, but provide protection from the sun during summer.
- Different rainfall patterns means we need to look at the water supply - and make sure there is enough water.
- Rising sea levels will mean more erosion - wearing away of rocks and beaches along the coastline.
- Rising sea - levels, warmer temperatures and different weather patterns will all have an affect on the way we live, and what we build.
- More floods are expected in some areas.

Solution to Classroom Activity 2.3:

1. WARMER	3. GREENHOUSE	5. OIL	7. WATER
2. WETTER	4. PETROL	6. ENERGY	

Source: http://www.greenhouse.gov.au/education/factsheets/changing.html

CHAPTER - III
Impacts of Climate Change

3.1 Objectives

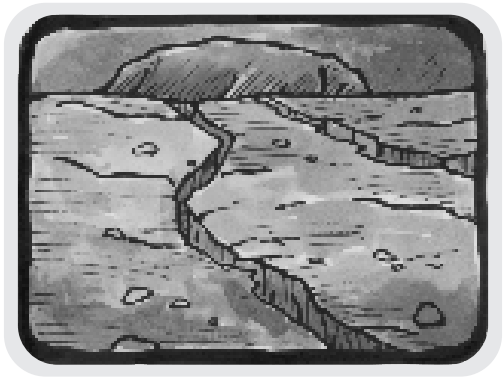
- Understanding the impacts of Global Warming
- Understanding the impacts of Climate Change

3.2 Keywords Agriculture, Climate Change, Coral Bleaching, Cyclones, Displacement, Drought, Ecosystem, Flooding, Glaciers, Global Warming, IPCC, Sea-level rise, Species Extinction.

3.3 Content

Global Warming and the resulting Climate change is a threat to mankind! More frequent and powerful cyclones and hurricanes, more frequent and intense floods and droughts are clear indications that climate change has already begun. The potential impacts of climate change on disasters cover all sectors of human society and functions of ecosystems, as explained below:

3.3.1 Extreme weather



DRY EARTH
http://www.crestock.com/image/74919-dry-earth-aspx

The Intergovernmental Panel on Climate Change (IPCC) expects extreme weather and weather-related events to become more frequent and/or intense, with serious consequences for human health and well-being. Scientists expect heat waves, droughts, wildfires, floods, severe storms, and dust transported between continents to cause locally severe economic damage and substantial social and cultural disruption. The IPCC projects an extended fire season for North America as well as increased threats from pests and disease (which could significantly enlarge the area burned in a fire). Rapid temperature changes would affect the seasons, causing variations in season length. Changes such as shorter winters could lead to mismatches between key elements in an ecosystem, such as feeding periods for young birds and availability of worms or insects for food. Increases in the frequency of droughts and floods would negatively affect local food production, and communities in mountain regions would face an increased risk of floods caused by melting glaciers. In addition, the risk of flood-induced illness and death from diarrheal diseases could rise in South and Southeast Asia. A region's vulnerability to such extreme events depends both on how much the climate changes and whether or not nations develop effective responses to potential threats.

Phenomenon & direction of trend	Examples of major projected impacts by sector			
	Agriculture, forestry and ecosystems	Water resources	Human health	Industry, settlement and society
Increase in frequency of warm spells & heat waves	30% yield reduction in sub tropics & tropics due to heat stress & wildfires	Increased water demand, water shortage and water quality problems	Increased heat related mortality, especially among children and elderly	Devastating impacts on energy, & habitations with excessive heating
Frequency of heavy precipitation events increases	Damage to crops, soil erosion, uncultivable lands due to water logging	Adverse impact on quality of ground/surface water, water supply contamination & water scarcity	Increased risk of deaths, injuries, infectious and respiratory diseases	Disruption of settlements, commerce, and transport from flooding, loss of property and infrastructure
Areas affected by droughts increase	Degraded Land, crop failure, increased livestock deaths & risk of wildfire	Widespread water stress	Increased food & water scarcity, malnutrition, food & water-borne diseases	Water shortages for industry & society, reduced hydropower and displacement
Intense tropical cyclone activity	Crop damage, uprooting of trees coral reef damage	Power blackouts cause disruption of civic services	Increased deaths/injuries, water and food borne diseases	Disruption of infrastructure, property loss & forced migration
Increased risk of extremely high sea levels	Salinization of irrigation and drinking water, & freshwater systems	Decreased freshwater availability due to salt water intrusion	Increased deaths/injuries from drowning & migration related health effects	Costs of coastal protection & land use relocation, mass movement of populations

Source: IPCC, 2007: Summary for Policymakers: Climate Change 2007: Impacts, Adaptation &Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change M.L.Parry, O.F.Canziani, J.P.Palutikof, P.J.van der Linden, and C.E.Hansen, Eds, Cambridge University Press, Cambridge, UK 7-22.

3.3.2 Impact on Agriculture

The impacts of climate change on crops and vegetation depend on the complex interactions among increased levels of CO_2 in the atmosphere, rising temperatures, water and nutrient availability. Elevated levels of CO_2 can essentially fertilize plants and crops. This is termed as the **"CO_2 fertilization effect"**. A mild increase in temperature levels usually enhances growth, while a drastic increase in temperature levels can actually slow down the growth rate of plants. Rising temperatures also increase the photosynthetic rate as well as the rate at which plants release CO_2. As the temperatures increase, there is a subsequent increase in the rate of evaporation, thereby drying out soils. As a result of insufficient water supply, the plant growth is adversely affected.

Climate change will affect agricultural yield directly because of extreme weather conditions (such as high temperature, heavy rainfall, floods, droughts, etc.) and indirectly through changes in soil quality, pests, and diseases. As the temperature rises, pest population would increase and so will the pest related problems.

The IPCC expects food production to decline in low-latitude regions (near the equator), particularly in the seasonally dry tropics, as even a small temperature increase could decrease crop yields in these areas. Crop yield in tropical countries (including India) is projected to reduce by at least 30% by 2050, which will have a devastating impact on the country's food security. Several developing countries in Asia face a continued very high risk of food shortages from a combination of projected declines in crop production, rapid population growth, and urbanization.

The IPCC projections show drought-prone areas of Africa to be particularly vulnerable to food shortages due to a reduction in the land area suitable for agriculture; some rain-fed crop yields could decline as much as 50 percent by 2020. The likely degradation of African coral reefs and mangroves would have negative consequences for fisheries. Rising lake temperatures in Africa combined with over fishing may also decrease fish supplies.

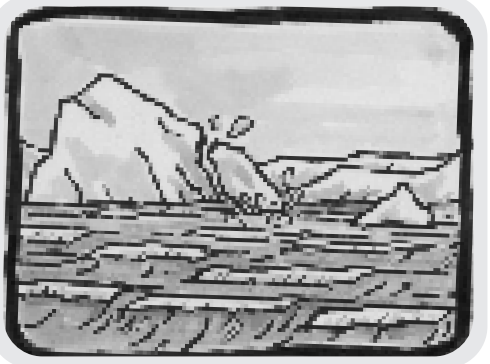
In the higher latitudes, agriculture will benefit with the rise in temperature as the winter season will be shorter and the growing seasons longer. Under local average temperature increases of 2 to 5°F (1 to 3°C), regions such as Northern Europe, North America, New Zealand, and parts of Latin America could benefit from increased growing season length, more precipitation, and/or less frost, depending on the crop. However, these regions can also expect more flooding, and if local average temperatures rise beyond this range, crop yields could decline in some of these areas. Note that these higher-latitude regions warm at a faster rate than the global average.

The populations most vulnerable to climate change-induced food shortages are those that depend on climate-sensitive food and water supplies and also lack the economic resources and government support to plan for or recover from extreme events such as floods or prolonged droughts.

3.3.3 Glacial retreat

Glaciers are the Earth's largest freshwater reservoirs. They are ancient rivers of compressed snow that creep through the landscape, shaping the planet's surface. Glaciers have been retreating worldwide since the end of the Little Ice Age (around 1850), but in recent decades glaciers have begun melting at rates that cannot be explained by historical trends.

Simulations project that a 4°C raise in temperature would cause nearly all of the world's glaciers to melt; a 2-3°C rise in temperature would cause the meltdown of the Greenland ice sheets; a 1°C rise in temperature along with an increase in rain and snow would cause glaciers to lose volume.



MELTING OF POLAR ICE
http://climateprogress.org/2006/11/

Glacier retreat has been observed in all continents. Nearly all glaciers surveyed in Alaska are melting. Thinning rates in the last 5 to 7 years are more than twice those recorded in previous years. The northern Andes contain the largest concentration of glaciers in the tropics, but these glaciers are receding rapidly and losses have accelerated during the 1990s. Glacier melting has accelerated in the European Alps. 10-20% of glacier ice in the Alps has disappeared in less than two decades.

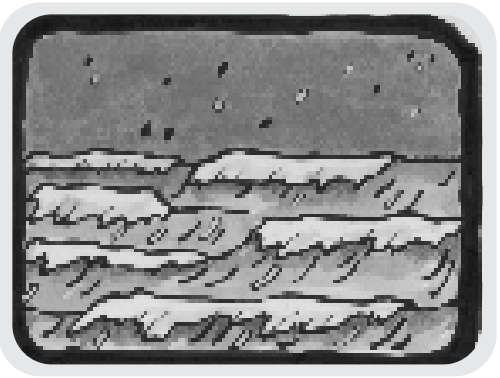
Although only a small fraction of the planet's permanent ice is stored outside of Greenland and Antarctica, these glaciers are extremely important because they are particularly susceptible to climate change and their loss directly affects human populations and ecosystems. Continued and widespread melting of glaciers during this century will lead to floods and water shortages for millions of people. As sea levels rise, coastal communities and habitats will be destroyed.

There are many regions at risk including -

- Ecuador, Peru and Bolivia - shrinking glaciers supply water year-round, and are often the sole source of water for major cities during dry seasons.
- The Himalayas - the danger of catastrophic outburst and flooding, especially of glacial lakes (GLOF) is severe and glacier-fed rivers supply water to one third of the world's population (in Asia).
- Small island nations such as Tuvalu and some of the Solomon Islands - sea level rise is submerging low-lying land and saltwater is inundating vital groundwater reserves.

Rapidly melting glaciers pose a great risk for nature. For instance, the endangered Royal Bengal tiger will lose a large portion of their worldwide habitat as the Sundarbans succumb to sea level rise, thereby threatening their existence. Similarly, many other species such as the Kittlitz's murrelet (rare bird species which nest on top of ice and hunt in cloudy glacier water) and the coral reefs (unique organisms that can be starved of energy from the sun when the sea level rises) would be severely affected. The Golden Toad and the Gastric Brooding Frog, are already presumed to be extinct because of climate related impacts. Amphibians are especially vulnerably to climate change because of their high level of endemicity, restricted microhabitats and range and limited food base. Polar bears will face starvation. Many species of whale depend on the Arctic as their main feeding ground. Currently the Arctic ocean is the most productive marine ecosystem in the world and home to the highest density of birds in the world. Loss of sea ice and rising temperatures will reduce food availability for whales, seals, polar bears and sea birds.

3.3.4 Sea Level Rise



Sea Level Rise
http://www.whatihaveread.net/book.php?1950

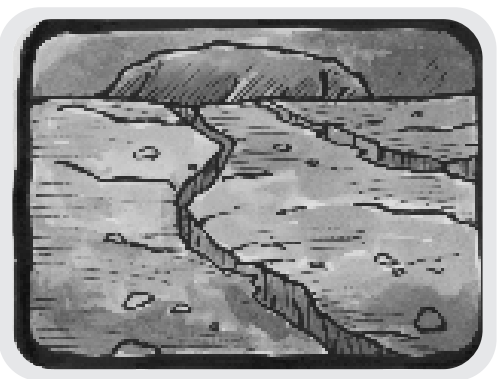
Melting of glaciers and polar ice sheets and heating up of oceans due to global warming is expected to reduce the size and extent of the polar ice caps and raise the average sea level. The Greenland and West Antarctic ice sheets face substantial melting if the global average temperature rises more than 2 to 7°F (1 to 4°C) relative to the period 19902000eventually contributing to an additional sea-level rise of 13 to 20 feet (4 to 6 meters) or more. This would result in the inundation of low-lying coastal areas, including parts of many major cities.

Flooding caused by sea-level rise is expected to affect millions of additional people every year by the end of this century, with small islands and the crowded delta regions around large Asian rivers (such as the Ganges-Brahmaputra) facing the highest risk. Sea-level rise exposes coasts to higher risks of flooding and erosion, which would be exacerbated by growing population, increased human infrastructure within flood-prone areas, and human activities that increase erosion or local subsidence.

As the sea level rises, more and more land will get submerged. Coastal areas and small islands will be at maximum risk because of the rise in sea level. This would result in loss of land due to inundation and erosion, increased flooding, and salt-water intrusion. These would adversely affect coastal agriculture, freshwater resources, fisheries and aquaculture, human settlements, and health. Mangroves and coastal wetlands (which are a home to birds, mammals, crustaceans and fishes, as well as valuable breeding habitat) are very sensitive to sea level rise, as their location is closely linked to the existing sea level. The World Wide Fund for Nature predicts that among the victims of the flooding of mangroves is the famous Bengal tiger in the Sundarbans.

Regions especially at risk are low-lying areas of North America, Latin America, Africa, populous coastal cities of Europe, crowded delta regions of Asia that face flood risks from both large rivers and ocean storms, and many small islands whose very existence is threatened by rising seas. In North America, current preparedness for rising seas, more frequent severe weather, and higher storm surges is low.

3.3.5 Scarcity of Water Resources



DRY RIVER BED
http://tea.armadaproject.org/Images
/hochstrasser/hochstrasser_dry_river.jpg

Climate change would also lead to a reduction in the availability of freshwater. Hundreds of millions of people face water shortage that will worsen as the global temperatures rise. At maximum risk are the current drought-affected regions, areas with heavily used water resources, and areas that get their water from glaciers.

The IPCC expects many Latin American glaciers to disappear entirely over the next couple of decades, and water resource competition to increase in western North America when decreased snow pack in the mountains reduces summer river flow. Several of the African lakes, such as Victoria, Malawi and Chad, will experience shrinking lake area and basins, further exacerbated by over extraction and mismanagement. Many rivers that derive their water from melting glaciers or snow will have earlier peak runoff in spring and an overall increase in runoff, at least in the short term. Such a temporary increase in water flow would not always be

welcome; for example, melting glaciers in the Himalayas would increase flooding and rockslide risks, while flash flood risks could increase in Northern, Central, and Eastern Europe.

The supply of water is very likely to increase at higher latitudes due to glacial melting while it is likely to decrease over the mid-latitudes and dry tropics, which are already water-stressed areas. Such shifts in water availability would drastically affect hydropower generation and industries that require large quantities of water (e.g paper and pharmaceutical industry).

3.3.6 Threats to Human Health

The Climate change will have several direct and indirect impacts on human health. The IPCC expects heat waves, floods, storms, fires, and droughts related to global warming to contribute to increased rates of death, disease, and injuries for millions around the world. It is anticipated that there will be an increase in the number of deaths due to greater frequency and severity of heat waves.

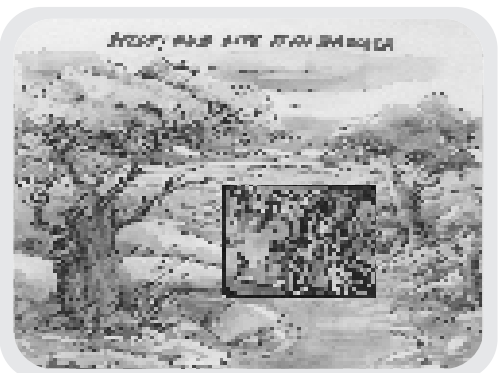
Threats to Human Life
http://new.gbgm-umc.org/umcor/getconnected/resources/cbi/archives05/index.cfm?i=1698

The affect will be more pronounced in urban areas than in the rural areas owing to the formation of urban 'heat islands' that develop in cities owing to the presence of concrete structures and tarred roads. It could also lead to an increase in the incidents of skin cancer, cataract and other forms of eye disorders. Shrinking food and water resources, especially in Africa, could also lead to malnutrition related disorders.

Scientists project an increase in the incidence of cardio-respiratory diseases caused by the higher concentrations of ground-level ozone (smog) that may accompany higher air temperatures. Some infectious diseases, such as Malaria and other vector borne diseases may also become more common in regions where those diseases are not currently prevalent.

Developing countries, many of which are already under stress, could experience increases in the incidence of diarrheal diseases, malnutrition and consequent disorders, affecting child growth and development. The populations most vulnerable to harsh living conditions in any nation (the elderly, children, and poor) may be unable to cope with further climate change.

3.3.7 Ecosystems and Species in Peril



Climate Change has already sounded the death knell for its first victims. The golden toad (Bufo periglenes) and the harlequin frog (Atelopus varius) of Costa Rica have disappeared as a direct result of global warming. According to IPCC, upto 30 percent of plant and animal species could face extinction if the global average temperature rises more than ~3 to ~5°F (1.5 to 2.5°C) relative to the 19801999 period. Many projections suggest the low end of this temperature range could be reached by mid-century.

Many species have already shifted their home ranges to higher latitudes (toward the poles) and higher elevations over the past several decades. Spring has been arriving earlier during this time, influencing the timing of bird and fish migration, egg laying, leaf unfolding, and spring planting for agriculture and forestry in the high northern latitudes. Satellite records since the early 1980s confirm that increased temperatures have produced longer growing seasons.

In the Alps, some plant species have been migrating upward by one to four meters per decade, while some plants previously found only on mountain tops have already disappeared. Butterflies, dragonflies, moths, beetles, and other insects are now living at higher latitudes and altitudes, where previously it was too cold to survive. Changes in climate may bring about a shift in the feeding points and disruptions to the flight patterns of migratory birds.

Scientists expect the magnitude of these changes to increase along with temperatures over this century. Many species and ecosystems may not be able to adapt as the effects of global warming and its associated disturbances (including floods, drought, wildfire, and insects) are compounded by other stresses such as pollution and resource exploitation. Polar and alpine species are especially vulnerable to the effects of climate change, as their unique habitats could shrink due to warming.

The ecosystems that are most likely to be affected by climate change are the ones in the higher latitudes, such as the tundra forests. Polar Regions will be severely affected. It is now an established fact that species are being forced due to climate change to move higher up the latitudes and altitude to find a suitable habitat, thereby reducing the area in which they can live. If the rate of climate change continues to accelerate, then the extinction of some mountain plants and animals is certain.

Natural forests are under severe threat from climate change. Particularly vulnerable are forest systems on remote islands, and fragmented forests surrounded by agricultural or urban development (e.g. Western Ghats), since the species they support have no opportunity for migration. Himalayan forest systems are thought to be equally vulnerable to climate change. In a warmer, drier world, forests from the lower slopes are likely to migrate upwards but forests near the tree line will be squeezed into smaller areas or even disappear altogether.

Some areas, such as the national parks of Australia and New Zealand and many parts of tropical Latin America are likely to experience a significant loss of biodiversity. The Great Barrier Reef could experience such a loss by 2020. By mid-century, tropical forests in the eastern Amazon Basin could be gradually replaced by less species-rich savanna because of rising temperatures and decreasing soil moisture.

Species Endangered by Global Warming

Scientists predict that global warming could contribute to the mass extinction of wild animals in the near future. An overheating world is creating a big change in climatic conditions and this can harm the delicate ecosystems in which species live. Provided below are examples of threatened species from all over the world:

- The Arctic sea ice is melting at a rate of 9% per decade, endangering the **Polar Bear's** habitat and existence.

- **Sea Turtles** lay their eggs on Brazilian beaches, many of which are threatened by rising sea levels. Climate change also threatens the offspring of sea turtles, as nest temperature strongly determines the sex: the coldest sites produce male offspring, while the warmer sites produce female offspring. This nest-warming trend is reducing the number of male offspring and seriously threatens turtle populations.

- The **North Atlantic Right Whale** is one of the most endangered of all large whales, with a long history of human exploitation. Since warming waters contain less plankton for whales to feed on, the non-availability of food due to climate fluctuations is also becoming an increasing cause of mortality.

- The **Giant Panda's** future remains uncertain due to a number of threats. Its forest habitat in the mountainous areas of south-western China is fragmented; giant panda populations are small and isolated from each other; bamboo, the panda's staple diet, is a part of a delicate ecosystem that is being severely affected by global warming; poaching remains an ever-present threat.

- Asia's only ape, the **Orangutan** is in deep trouble. Its last remaining strongholds in the rainforests of Indonesia are being threatened by a range of pressures, including climate change, putting the animal at risk of extinction within a few decades. With global warming increasing the duration and frequency of droughts, bushfires are occurring more often in these heavily logged forests, further fragmenting the orangutan's living space.

- In Africa, **Elephants** face a range of threats including shrinking living space, which brings them more frequently into conflict with people. With diminished living space, elephants will be unable to escape any changes to their natural habitat caused by global warming, including more frequent and longer dry periods, placing further pressure on their existence.

- Climate change is affecting home range, abundance and breeding cycles of many of Australia's **Frog** species. Since frogs rely on water to breed, any reduction or change in rainfall could reduce frog reproduction. Higher temperatures contribute to the drying out of breeding pools, and as a result, to the deaths of tadpoles and eggs. Drier conditions also cause adult frogs to die, due to increased rates of internal water loss through their permeable skin.

- Some of the largest remaining areas where **Tigers** occur are the mangrove forests of India. The projected rise in sea levels could cause these living spaces of the tiger to vanish altogether. Apart from the loss of their habitat, the depletion of the tiger's natural prey and extensive poaching together contribute to the shrinking population of these wonderful species.

- The **Tawny Eagle**, is feared to become extinct in its African habitat in the southern Kalahari due to changes in precipitation predicted with climate change.

- Warming ocean waters and major shifts in species that support the ocean food web are causing a decline in sandeel population (a crucial prey species for the seabirds). This shortage of prey base leads to breeding failure of seabirds (such as **Common Guillemots**, Arctic skuas, great skuas, kittiwakes and Arctic terns) and the starving adult birds are seen eating their own young ones.

- The **Siberian Crane** is a critically endangered migratory wetland bird which breeds in Arctic Russia and Siberia and spends most of the winter in China. This bird's Arctic tundra habitat is forecasted to decline by 70% due to global warming (it becomes colonized by trees). Decreased precipitation coupled with more intense rainfall negatively affects the crane in its habitat in China.

- **Galápagos Penguins** are island seabirds that are highly vulnerable to climate change. Endangered penguin populations have halved since the early 1970s because the adult penguins become emaciated (sometimes dying) and fail to reproduce during severe El Niño years. Because climate change is expected to make El Niños more frequent in future, it is expected to further reduce the populations of Galápagos penguins and threaten them with extinction.

- **Tufted Puffins** are specialist seabirds which are highly vulnerable to climate change. At the world's largest puffin breeding colony, two decades of unusually warm temperatures associated with climate change between 1975 and 2002 led to drastically decreased growth rates of tufted puffin nestlings, with fledging success near zero when waters were warmest. Climate change could eventually make this puffin colony unsuitable for breeding for tufted puffins.

- The southeastern Australian habitat of the endangered **Red-Tailed Black Cockatoo**. It is expected to contract to just 2% of its current extent under climate projections of 3°C of warming with a 10% decrease in rainfall.

3.3.8 Threats to Marine Life

Coral reefs are extremely important for biodiversity, providing a home to over 25% of all marine life. These reefs are effectively the **rainforests of the seas**, with a staggering array of different types of fish and other marine animals living in and around them. They are also vital for people and business. They provide nurseries for many species of commercially important fish, protection of coastal areas from storm waves, and are a significant attraction for the tourism industry.

However, a coral is a living organism, and it is extremely sensitive to changes in temperature. As a result, the coral reefs can tolerate only a narrow temperature range and are considered to be very fragile and sensitive ecosystems.

Warming ocean waters represent serious threat to corals; Ocean warming causes coral polyps to expel the algae that live within their tissues, an action known as **'Coral Bleaching'** because it turns the coral white. Bleaching is also thought to make corals more vulnerable to epidemics. If they are unable to adapt to projected sea surface temperature increases of 2 to 5°F (1 to 3°C), corals would die due to bleaching. Scientists expect coral reefs and mangroves in Africa to be degraded to the point that fisheries and tourism suffer.

A WWF report shows that less than 5% of the Great Barrier Reef will remain by 2050 if the world fails to reduce carbon dioxide emissions. In the Indian Ocean, 70 per cent of coral reefs, harbouring one-quarter of all ocean species and at least 65 per cent of marine fish species - appear to have died. If the situation continues, nearly three-quarters of the ocean's richest biome may disappear in 50 years. In autumn 2005, in the biggest bleaching event in the Caribbean, corals that were alive even when Columbus shipped through these waters were all found dead.

Acidification of the oceans due to increasing atmospheric carbon dioxide negatively affects corals, phytoplanktons and zooplanktons (and also the species dependent on them). Because of acidification of water and the rising ocean temperatures, the Zooplankton population has been fast receding which in turn is having a detrimental impact on the fish population and on the number of sea birds that feed on these organisms. Ocean warming, acidification of the ocean waters, destructive fishing practices, pollution, coastal development and climate change are all taking their toll on this delicate ecosystem. Sadly, there are a few other global warming effects also that threaten coral reefs, which include -

- More frequent tropical storms caused by global warming could wipe off the corals.
- Unusually warm water (by up to 5°C) caused by more frequent El Niño (El Niño - Southern Oscillation) years, would also be an additional stress.
- More frequent heavy rains means more flooding, more river runoff, and therefore more sediment deposit in the seas.
- Finally, climate change could also reduce the ability of corals to form their limestone skeletons. But this is not just an environmental tragedy as coral reefs provide enormous quantities of food for humanity. Around half a billion people - a twelfth of the entire population of the world - relies on fish from coral reefs as their main source of protein. If the reefs are destroyed, so will this wonderful larder for the planet.

3.4 Activity

Experiment to understand Sea Level Rise

a. **Duration of the Activity** - 30 minutes. (Adult supervision is a must when carrying out this experiment).

b. **Overview -** Students perform a simple experiment to understand the logic behind sea level rise caused by Global Warming.

c. **Objectives -** To help students understand that as the Earth's atmosphere traps more heat, glaciers will melt, the oceans will warm and expand, and eventually the sea level will rise.

d. **Background Information -** Global warming will warm up the water in our oceans as well as cause the melting of glaciers and polar ice caps. Water is known to expand when heated. Therefore, with the melting of glaciers and heating up of oceans due to global warming, the average sea level is predicted to rise by about half a metre over the next century.

e. **Curriculum Links -** Science

f. **Intended Learning Outcomes -** Through this activity, students will get a clear understanding of physical heat exchange process (such as transfer of heat from hot to colder objects, expansion of water on heating, etc).

g. **Class/Grade** - Class 7 & 8.

h. **Materials Required** - Electric hot plate, heat-resistant drinking glasses, pan, water, ice cubes.

i. **Procedure -** Class to carry out the experiment as explained below:

- **STEP 1:** Fill a glass with very cold water upto the brim. Place this glass in an empty pan and put the pan on a hot plate. Switch on the hot plate and wait for 10 minutes. Note what happens to the water in the glass.

- **STEP 2:** Put two ice cubes inside a glass and then fill up the glass with water, almost to the brim. Place this glass carefully in an empty pan. Watch what happens to the water level when the ice in the glass melts.

j. **Observation -** In step 1, the water expands on heating and gently overflows from the glass and collects in the empty pan. In Step 2, no water will overflow through the glass at all. The ice does not raise the water level in the glass when it melts because the ice was already floating and displacing water.

3.5 Discussion

After the completion of the experiment, the teacher can relate this experiment to what happens in the case of glaciers and polar ice and how their melting contributes to sea level rise. The teacher can explain that as shown in step 1, ocean water will warm up due to global warming and inundate coastal areas and small islands. Similarly, as shown in Step 2, the ice that is already floating on the ocean does not raise the sea level when it melts because the ice was already floating and displacing water. Instead, for the sea level to rise significantly, ice from a grounded ice sheet has to flow rapidly into the sea.

3.6 Extensions/Modifications

The students can take the help of the teacher and design a science project using the concepts explained above and demonstrate it during a science exhibition or an environmental exhibition. But for doing so, you might require much larger blocks of ice and containers than specified here.

3.7 Take a Message Home

While Global Warming is the process by which the temperature of the planet increases, Climate Change is the overall change in the climate affected by this warming. Each one of us is responsible for the climate change and contributes to it through the energy that we use.

3.8 References

- Findings of the IPCC Fourth Assessment Report: Climate Change Impacts

  http://www.ipcc.ch/SPM13apr07.pdf

- The U.S. Environmental Protection Agency developed an award-winning Kit which contains Introductory material, Case Studies, Trail Talks, Interactive Activities and science experiments related to Climate Change

  http://www.epa.gov/climatechange/wycd/downloads/SA_Experiments.pdf

Classroom Activity 3.1: ICE ACTION WORD PUZZLE

Can you solve the clues and find these words in the word game?
Check up and down, sideways and diagonally!

F	P	S	A	L	T	R	I	E	G
W	O	U	O	C	M	L	G	S	I
N	L	A	Q	U	A	R	B	N	O
B	Y	B	F	R	T	O	V	Z	X
B	N	C	A	R	L	H	A	X	Y
M	Y	H	C	E	J	R	E	E	G
S	A	A	N	N	W	G	E	R	E
N	E	U	A	T	L	R	A	I	N
O	R	E	I	S	Z	H	B	J	K
W	G	E	B	O	T	T	O	M	A

CLUES

1. A gap in the sea ice is called a _ _ _ _ _ _ _[1].
2. Antarctic _ _ _ _ _ _[2] water is very cold, salty water.
3. When sea ice is formed, _ _ _ _[3] is released into the water below.
4. Super cold water can carry lots of _ _ _ _ _ _[4].
5. Antarctica is surrounded by the _ _ _ _ _ _ _ _[5] Ocean
6. Global warming could make more _ _ _ _[6] and _ _ _ _[7] fall over the area.
7. Thermohaline circulation drives the world's deep ocean _ _ _ _ _ _ _ _[8].

(Solutions on next page...)

a. **Duration of the Activity -** 15 minutes

b. **Curriculum Links -** Geography, Social Studies

c. **Class/Grade** - Class 7 - 8

d. **Discussion** - Explain the information provided in the fact sheet to the class before commencement of this classroom activity.

FACT SHEET : ICE ACTION

The surface of Antarctica's sea ice is a place of blizzards, freezing temperatures and icebergs. But the real action is going on beneath the ice. Antarctica is surrounded by a huge ocean called the Southern Ocean. This ocean is part of a giant 'conveyor belt' that controls climate by moving heat around the Earth. This conveyor belt is called **thermohaline circulation**: 'thermo' means 'heat' and 'haline' means salt. Thermohaline circulation works because of differences in water temperature and the saltiness of the water.

Colder water, occurring near the poles, is denser than warmer water and saltier water, occurring away from the poles, is denser that water which has less salt, because of the extra density imposed by the salt content. A precise balance in the quantities of fresh and salt water drives the ocean currents. Aided by prevailing winds, warm waters heated by the sun's heat in the Atlantic Ocean, flow northwards from the equator towards the North Atlantic. Air blowing over the warm waters from west to east (because the earth rotates east to west), carries the heat over Europe, keeping the continent warmer than it would otherwise be. As these warm waters reach the North Pole, they encounter cold waters and lose heat, becoming dense and sinking rapidly to great depths because of the salt. These cold and salty waters travel across the Atlantic oceans along the sea floor till Antarctica, where they are cooled further and eventually well upwards, repeating the cycle.

If human induced global warming increases substantially, the MOC might stop functioning and circulating heat. Melt water from melting ice sheets, ice shelves and glaciers in the poles is continuously adding large quantities of freshwater into the oceans, disturbing density of ocean currents and preventing their flow. If the melting of ice from global warming continues, the ocean currents will shut down, triggering sudden cooling of Europe by as much as 5 degree C in less than a decade, and rapid advancement of glaciers across landmasses.

One important part of thermohaline circulation is Antarctic Bottom Water. Antarctic Bottom Water is the extremely cold, salty water that sinks to the bottom of the Antarctic Ocean. Ice contains almost no salt, so when surface sea water freezes during the Antarctic winter, the salt is released into the water beneath the ice. This makes the water under the ice very salty and therefore very heavy, so it sinks to the ocean floor. This super cold water carries lots of oxygen down to the creatures that live in and near the ocean floor.

Polynyas are gaps in the sea ice that are kept ice-free by strong winds. They are an important source of cold, salty bottom water. They form because strong winds constantly push ice away as fast as it forms, leaving an ice-free gap. This means lots of salt is continually released into the water below the ice. Eventually, the water in the polynya becomes so salty that it sinks straight to the bottom of the ocean. About one quarter of all Antarctic Bottom Water comes from the Adelie polynya.

The system of bottom water and ocean currents could be easily upset by global waming. One possible effect of global warming is that more precipitation (rain and snow) could begin to fall over the Southern Ocean making the water less salty. This might affect Antarctic Bottom Water and stop it sinking down to the ocean floor. This could upset ocean currents and climate around the world.

Less Antarctic Bottom Water also means less oxygen will be delivered to the creatures that live in the deep ocean. These animals are also eaten by other creatures, so changes to deep sea life could have effects all the way up the food chain, affecting even the fish stocks that humans rely on for food.

There is still a lot to be understood about how Antarctic Bottom Water, polynyas and the world's oceans fit together. As scientists continue to explore these mysterious depths, we hope they will bring to the surface more answers about our climate and the changes it could be facing with global warming. The freezing waters of Antarctica are full of creatures such as squid and krill that rely on Antarctic Bottom water to bring them the nutrients they need to survive.

What does it mean?

- **Thermohaline circulation:** The movement of deep ocean currents driven by differences in salt and heat in the water
- **Polynyas:** Gaps in the sea ice around the Antarctic coast that are kept ice-free throughout winter
- **Precipitation:** Rain, hail or snow.

Solution to Classroom Activity 3.1:

1. POLYNYA	3. SALT	5. SOUTHERN	7. SNOW
2. BOTTOM	4. OXYGEN	6. RAIN	8. CURRENTS

Source: This activity has been adapted from the following website:
http://www.greenhouse.gov.au/education/factsheets/ice_action.html

Classroom Activity 3.2: SOMETHING IN THE AIR WORD PUZZLE

CAN YOU FILL IN THE SPACES AND FIND THE WORDS IN THE WORD PUZZLE?

Check up and down, sideways and diagonally!

H	B	F	B	L	T	O	N	W	G
E	Y	R	I	R	M	L	G	S	X
A	E	O	Q	C	A	R	B	O	N
T	O	M	E	P	R	O	H	Z	X
W	I	M	A	L	A	R	I	A	A
A	Y	C	C	L	G	R	E	G	F
V	B	J	K	N	W	J	L	Z	R
E	N	U	A	S	E	R	A	N	I
S	H	A	Y	F	E	V	E	R	C
B	G	E	B	O	D	T	O	M	A

CLUES

a. Pollen from the _ _ _ _ _ _ _[1] plant is bad news for sufferers of _ _ _ _ _ _ _ _[2].

b. Global warming could make _ _ _ _ _ _ _ _ _[3] hotter and more frequent.

c. Creatures such as mosquitoes and _ _ _ _ _[4] might affect our health even more.

d. Mosquitoes carry a disease called _ _ _ _ _ _ _[5].

e. People in _ _ _ _ _ _[6] suffer especially from malaria.

f. More _ _ _ _ _ _[7] dioxide makes plants grow faster.

(Solutions on next page...)

a. **Duration of the Activity -** 15 minutes

b. **Curriculum Links -** Geography, Social Studies

c. **Class/Grade** - Class 7 - 8

d. **Discussion -** Explain the information provided in the fact sheet to the class before commencement of this classroom activity.

FACT SHEET : SOMETHING IN THE AIR

Spring is a bad time if you suffer from hayfever. Pollen from plants such as the ragweed bursting into bloom causes sniffles, sneezes, asthma and itchy eyes. And thanks to global warming, things are just going to get worse. The reason is the increase in carbon dioxide gas in our atmosphere, which is one of the main causes of global warming. Scientists in the United States have discovered the more carbon dioxide there is in the air, the faster the ragweed plant grows and the more pollen it makes. The more pollen that's in the air, the more people will be affected by hayfever.

Allergies are on the increase due to global warming

This is just one of the many ways that global warming may affect our health and comfort. Global warming, as the name suggests, will make our planet hotter. While this might be good news for people living in really cold countries, it is going to make life a lot more difficult for most people. Global warming may mean that we get heatwaves that are not only hotter but that happen more often and for longer. This could be bad news for elderly people and people who don't have air-conditioning, swimming pools or any other way of cooling themselves down. There's another way that global warming might affect our health, through creatures such as mosquitoes and ticks. As well as being extremely annoying during the warm summer months, mosquitoes can be deadly. Some types of mosquitoes carry a disease called malaria in their bodies. If an infected mosquito bites a human, the disease can infect the human too.

Virus- carrying mosquitoes love the hot weather

However, the mosquito and the disease it carries have one weakness - temperature. If it's too hot or cold, the mosquito and its deadly passenger can't survive. Scientists are now trying to work out how global warming will affect malaria around the world. People in Africa suffer especially from malaria. If global warming causes temperatures in Africa to increase, things might get a little too hot for the mosquito and malaria. However countries that used to be too cold for the mosquito to survive could warm up enough to make things just right for malaria to take hold.

Many other diseases are transmitted (spread from an animal or person to another person) through mosquitoes and ticks. In countries like Australia, these sorts of diseases haven't really been a problem but because we don't really know what global warming will do to our climate, we can't predict what these diseases will do either. So, get ready with the mozzie repellent and watch this space!

- Heatwaves are another health hazard on the rise
- As weather gets hotter, the ragweed plant will produces more pollens and allergies.

Solution to Classroom Activity 3.2

1. RAGWEED	3. HEATWAVES	5. MALARIA	7. CARBON
2. HAYFEVER	4. TICKS	6. AFRICA	

Source: http://www.greenhouse.gov.au/education/factsheets/pubs/something.pdf

CHAPTER - IV

Impacts of Climate change in India

4.1 Objectives: Understanding how Climate Change affects a country like India.

4.2 Keywords: Agriculture, Climate Change, Coral Bleaching, Cyclones, Displacement, Drought, Ecosystem, Flooding, Glaciers, Global Warming, Sea-level rise, Species Extinction.

4.3 Content: India's economy is largely dependent on agriculture and is already under stress due to its increasing population, and the resulting increase in demand for energy, fresh water and food. This situation will worsen with the effects of global warming and Climate-related disasters. Climate Change will cause widespread misery and huge economic losses to India, adversely affecting public health, food security, agriculture, water resources and biodiversity. Although limited scientific research has been carried out on the impacts of climate change on India, some of the most obvious effects are listed below:

Increased Temperature

Scientists from the Indian Institute of Technology (IIT), New Delhi, already report that surface air temperatures over India are going up at the rate of 0.4°C per hundred years, particularly during the post-monsoon and winter season. Using models, they predict that mean winter temperatures will increase by as much as 3.2°C by 2050 and 4.5°C by 2080, due to GHGs. They also predict that the summer temperatures will increase by 2.2°C by 2050 and 3.2°C by 2080. However, studies show that the heating up of India will not be uniform across the country. While the winters of north and northwest India may be more than 2°C warmer by the middle of the next century, there could be a cooling of over 1°C in the Northeast.

Extreme temperatures and heat spells have already become common over Northern India, often causing loss of human life and property. In 1998 alone, 650 deaths occurred in Orissa due to heat waves. There could be even more intense cyclones, more intense rainstorms and more intense drought periods. According to M B Lal of the Indian Institute of Technology, Delhi, preliminary results suggest more frequent and heavy rainstorms over the Northeast which could mean even more flash floods in that region.

Effect on Monsoon

India is heavily dependent on the monsoon - to meet its agricultural and water needs, and also for protecting and propagating its rich biodiversity. Scientists of IIT, Delhi warn that India will experience a decline in monsoon rainfall over the north and central plains of India by 2050 because of the general weakening of the monsoon. This is because there will be a decrease in the land-sea thermal gradient. Since summer rainfall accounts for almost 70 per cent of the total annual rainfall over India and is crucial for Indian agriculture, this could have a devastating effect on the Indian economy, and on food security. No significant rainfall decrease is expected during the winter season. But the average annual levels and monsoon season levels of soil moisture could decline significantly in the central plains. There will also be a significant decline in surface runoff in these plains leading to less water in the rivers. However, it is predicted that the semi-arid regions of western India are expected to receive higher than normal rainfall as temperatures soar.

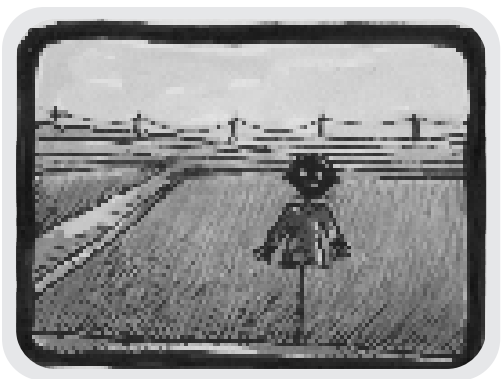
Effects on water resources

Relatively small climatic changes can cause large water resource problems, particularly in arid and semi-arid regions such as northwest India. This will have an impact on agriculture, drinking water, and on generation of hydroelectric power, resulting in limited water supply and land degradation. Rainfall may decline by 5 to 25 per cent during winters, causing droughts during dry summer months. The onset of the summer monsoon over central India could vary in future. If rainfall decreases, water availability will decrease across the country.

Apart from monsoon rain fed rivers, India depends mainly on the water supply from its perennial rivers, which are continuously fed throughout the year by the glacial melt-waters from the Hindukush and Himalayan ranges. But the Himalayan glaciers, which feed the major Indian rivers and keep them perennial, are rapidly shrinking. The Pindari glacier is retreating at a rate of 13 metres a year while the Gangotri glacier is receding at an annual rate of 30 metres. Glacial melting at this rate increases the risk of flash floods.

The problem becomes all the more serious because the melting season coincides with the summer monsoon season. Therefore, any intensification of the monsoon is likely to contribute to flood disasters in the Himalayan catchment. Rising temperatures will also contribute to the raising of the snowline, reducing the capacity of this natural reservoir, and increasing the risk of flash floods during the wet season. Increase in temperatures can also lead to increased eutrophication in wetlands and fresh water supplies.

Effect on Agriculture



Increased temperatures will impact agricultural production. Agricultural productivity can be affected in two ways: one, directly, due to changes in temperature, precipitation or CO_2 levels and two, indirectly, through changes in soil, distribution and frequency of infestation by pests, insects, diseases or weeds.

Higher mean temperatures increased evaporation and transpiration rates. Even a small increase of 1°C could increase the rate of evaporation/ transpiration by 5-15 per cent. With no rainfall to compensate, yields will be reduced. In north India, for instance, a temperature rise of 0.5°C could reduce wheat yields due to heat stress by about 10 percent if rainfall does not increase. Scientists from IIT Delhi predict that a temperature increase of 3°C will result in a 15-20 percent decrease in wheat yields, and also a decrease in rice yields. In northwest India, though higher yields are projected for rice and wheat if carbon dioxide levels in the atmosphere increase. A 3°C and 2°C rise in temperature (for wheat and rice respectively) nearly cancels out this positive effect. Production will go down if water shortage is taken into account.

Similarly, models suggest that soybean production in the country will go up by 50 per cent if atmospheric carbon dioxide concentrations double. But if rainfall decreases significantly and temperature increases, production could go down by 6 per cent. This will severely affect a state like Madhya Pradesh, which produces 72 per cent of soybean grown in India.

Agriculture will be adversely affected not only by an increase or decrease in the overall amounts of rainfall, but also by shifts in the timing of the rainfall. For instance, over the last few years, the Chattisgarh region has received less than its share of pre-monsoon showers in May and June. These showers are important to ensure adequate moisture in fields being prepared for rice crops

Agriculture will be worst affected in the coastal regions of Gujarat and Maharashtra, where agriculturally fertile areas are vulnerable to inundation and salinization. Standing crop in these regions is also more likely to be damaged due to cyclonic activity. In Rajasthan, a 2°C rise in temperature was estimated to reduce production of pearl millet by 10-15 per cent.

Rise in surface temperature will create more conducive conditions for pest infection, which is already a major constraint in achieving higher crop production in India, and hence negatively affecting agriculture.

Impact on Human Health

Climate change simulation models suggest that a rise in temperature and change in humidity will adversely affect human health in India. A warmer and wetter India will see a rise in heat-related and infectious diseases. More people will die due to heat waves. Heat stress could result in heat cramps, heat exhaustion, heat stroke, and damage physiological functions, metabolic processes and immune systems.

Increased temperatures can increase the range of vector borne diseases such as malaria, dengue fever, yellow fever and several types of encephalitis, particularly in regions where minimum temperatures currently limit pathogen and vector development. An apt example to prove this point is the summer of 1994, when western India experienced temperatures as high as 50°C, providing favourable conditions for disease-carrying vectors to breed. Not surprisingly, 1994 was also the year that the town of Surat in Gujarat was hit by an epidemic of pneumonic plague, resulting in 59 deaths. In the same year, as summer gave way to the monsoon and western India was flooded with rains for three months, Surat was hit by a malaria epidemic. The cause could be the numerous unattended puddles (resulting from heavy rainfall), which provides good breeding conditions for mosquitoes.

Water borne diseases, natural disasters, environmental migration, nutritional deficiency could be other major risk factors. Waterborne diseases including cholera and diarrhoeal diseases will increase as rainfall patterns change, restricting human access to water supplies and sanitation. Global warming will increase the incidence of respiratory and cardiovascular diseases in arid and semi-arid parts of India. Cyclones and floods will also cause rise in illnesses, diseases, injuries and loss of life.

Effect on Ecosystems and Biodiversity

As temperatures rise, species which cannot adapt will go extinct, while others will migrate to new locations under changing climatic conditions. Increase in temperatures will result in shifts of lower altitude tropical and subtropical forests to higher altitude temperate forest regions, resulting in the extinction of some temperate vegetation types. One tenth of the world's known species of higher altitude plants and animals occur in the Himalayas.

Increased dry spells could also place dry and moist deciduous forests at increased risk from forest fires. Decrease in rainfall and the resultant soil moisture stress could result in drier teak dominated forests replacing Sal trees in central India. “In any case an increased turnover of forest species is indicated,” says M Lal from IIT Delhi. This could potentially result in species extinction and decline in biodiversity.

The state of Gujarat has the largest area of mangrove forests after West Bengal. The mangroves are threatened by the rise in temperature, which causes decreased tree height and leaf size. Besides temperature stress, the mangroves in the Gulf towards Jamnagar and the Kutch coasts are also threatened by sea level rise and drought.

The district of Kutch in Gujarat has large areas of marine wetlands, which play an important role in maintaining the coastal environment, and in providing sustenance to coastal communities. These could be adversely impacted due to elevation of water temperature and sea level rise. The Rann of Kutch supports large Greater Flamingo colonies. With sea level rise, these salt marshes and mudflats will submerge, decreasing their habitat, and that of lesser floricans. About 2000 Indian wild asses in the Rann of Kutch could lose their only habitat.

Severe coral bleaching will occur all along the Indian coast as a result of seawater warming. Coral reefs are threatened by changes in temperature, rising sea levels and increased concentrations of carbon dioxide in the atmosphere. Already, nearly 30 per cent of the coral reefs in the Gulf of Kutch are 'bleached' as they loose the colourful algae that live on them - an occurrence associated with seawater warming. In future, the entire belt of coral reefs along the south Gujarat coast is in danger of getting bleached.

Effect of Sea Level Rise on Coastal Low Lands and Deltas

A trend of sea level rise due to thermal expansion of seawater in the Indian Ocean is expected to inundate low lying areas, drown coastal marshes and wetlands, erode beaches, exacerbate flooding and increase the salinity of rivers, bays and aquifers.

Deltas will be threatened by flooding, erosion and salt intrusion. The major delta area of the Ganga, Brahmaputra, and Indus rivers, which have large populations reliant on riverine resources, will be affected by changes in water regimes, salt-water intrusion and land loss. Many large Indian cities are situated on the coast, flood plains and river deltas. A one-metre sea level rise will displace approximately 7.1 million people in India and about 5764 square kilometres (km) of land area will be lost, along with 4200 km of roads.

The coastal states of Maharashtra, Goa and Gujarat face a grave risk from sea level rise, which could flood land (including agricultural land), and cause damage to coastal infrastructure and other property. Goa will be the worst hit, losing a large percentage of its total land area, including many of its famous beaches and tourist infrastructure. A one metre rise in sea level will adversely affect 7 per cent of the population in Goa, and cause damages to the tune of Rs 8,100 crore.

In the state of Maharashtra, over 13 lakh people are at risk. The cost of damages for Mumbai, the business capital of India, is estimated to be Rs 2,28,700 crore. Mumbai's northern suburbs like Versova Beach and other populated areas along tidal mud flats and creeks are vulnerable to land loss and increased flooding due to sea level rise.

Beyond actual inundation, rising sea levels will also put millions of people at greater risk of flooding and displace a large number of people. Increased seawater percolation may further reduce freshwater supplies. Coastal erosion will increase substantially. Loss of coastal mangroves will have an impact on fisheries and coastal fishing communities will be severely affected.

The Andaman and Nicobar Islands and the coral reef of the Lakshadweep archipelago are most vulnerable. Orissa, West Bengal and Maharashtra face real danger, as also the Lakshadweep group of islands where the entire population is at risk. Most of the areas likely to be lost in West Bengal include the Sunderban mangrove swamps, already variously degraded, and reserved forests. Andhra Pradesh & Tamil Nadu, two coastal states with long and heavily populated coastlines will also face the risk of coastal erosion and displacement. Mangroves in the Krishna - Godavari & Kaveri deltas will be gravely affected, as will Important Bird Areas such as Pulicat, Point Calimere & Neelapattu wetlands. Intensive food grain production practiced in these states will be negatively affected by salt water intrusion.

Climate Change in India: A Case Study of Orissa

Orissa's fluctuating weather conditions suggest that it is reeling under climatic chaos. For more than a decade now, the state has experienced contrasting extreme weather conditions claiming many lives: from heat waves to cyclones, from droughts to floods. They have not only become more frequent, but have hit areas that were never considered vulnerable. As a result, Orissa's economy has been ripped apart. Agriculture, which is considered as the state's backbone has been worst hit due to such changes in the microclimate and natural calamities.

- A heat wave in 1998 killed around 1500 people in the state, mostly in coastal Orissa, a region otherwise known for its moderate temperature. The mean daily maximum and minimum temperature of the state is gradually increasing. The Titilagarh and Koraput belt comprising entire south and western Orissa has witnessed an exceptional rise in daily maximum and minimum temperature. Earlier western Orissa was a known calamity hotspot, but now the coastal areas are also experiencing heat waves. Bhubaneshwar now has a mean maximum temperature above 40°C which is comparable to Sambalpur located in the interior.

- The frequency of cyclones has increased on the Orissa coast, the worst ever being the cyclones of 1999, when two cyclones hit the state in quick succession. The second one lasted three days and ravaged 14 coastal districts. Around 15 million people were affected. Two million tonnes of rice crop was lost and 17,000 square kilometre of agricultural land was devastated. Official estimates put the loss at Rs.10,000 crore. Around 200,000 trees were uprooted in about 25,000 hectare (ha) of reserved forest. In the districts of Jagatsinghpur and Kendrapada, the forest cover has now been reduced by 50 per cent. The microclimate of the region has changed after this loss in vegetation. Temperature data of the coastal region in the last three years shows wide fluctuations and average temperatures have risen. Change in climate following the super cyclone possibly caused the state's mango and mahua trees to flower unusually early.

- Floods have become an annual affair in Orissa. The worst ever flood in 2001 inundated 25 out of the 30 districts of the state. Areas with no history of floods such as districts in western Orissa were also submerged.

- Ironically, Orissa suffered one of its worst droughts in 2001. It affected the lives of 11 million people in more than two-thirds of the state's districts, engulfing earlier drought free districts like Sundergarh and Kendrapada.

Since Orissa is placed at the head of the Bay of Bengal where weather changes are formed, even a slight change in the sea's behaviour can have an immediate impact on the coast. The Bay becomes the centre of low pressures causing heavy rains and cyclones in the sub-continent, especially in Orissa. Scientists are of the opinion that increasing temperature and rainfall, triggered by global warming and climate change may cause the climate to worsen in Orissa.

Apart from more frequent extreme weather events like floods and droughts, large-scale impact of climate change is also expected to cause an increase in sea level causing economic loss and disruption of life. In a case study of the Orissa and West Bengal region, an international body of scientists estimated that in the absence of protection, a one metre sea level rise will inundate an area of 170,000 ha predominantly prime agricultural land and displace 0.7 million people. An additional 4000 kilometres of dykes and sea walls will be required to protect the area.

With sea level rise, many coastal systems will experience increased levels of inundation and storm flooding, accelerated coastal erosion, seawater intrusion into fresh groundwater and encroachment of tidal waters into river systems. Big cities situated on coasts, flood plains and river deltas, supporting a large number of people and industries can expect increased flood damage causing loss of structures and property. Disappearing shorelines also mean loss of social amenities and infrastructure.

Coastal erosion will increase substantially, endangering natural protective features such as mangroves and barrier islands, and exacerbating flood risk. Consequently, many coastal communities dependent on these and fisheries will suffer. Deltas and low lying coastal areas will be inundated by sea level rise. Increased rainfall during the monsoons will increase the frequency of floods. Areas already prone to floods will suffer more. Both religious and resort-based coastal tourism will suffer.

It is important to note that all this climate chaos implies displacement of large numbers of people leading to rapid urbanization, straining resources and putting more pressure on civic amenities.

Agriculturally fertile coastal regions with paddy fields are vulnerable to inundation and salinisation. Orissa normally produces around five million tones of rice each year. The rice crop on the coast contributes about 40 per cent to the total rice grown in the state.

With rising temperatures, pest population will significantly increase because generally warmer and moist conditions are highly conducive to them. Higher temperatures also speed up the life cycle of both the mosquito and the disease organisms they harbour and make adult mosquitoes bite more often. The state accounts for 15-22 per cent of malaria cases in the country and 40-50 per cent malaria related deaths. At 20°C, mosquitoes take 26 days to breed. This period reduces to 13 days when the temperature rises to 25°C, which is also the average temperature of Orissa now.

A possible increase in cyclone intensity of 10-20 per cent against a rise in sea surface temperature of 2 to 4°C is very likely to happen. Climate change has already intensified the Asian monsoon and increased river flows. Experts say Orissa should brace itself for more severe flooding in years to come because of deforestation, faulty flood control planning and global climate changes.

Disasters have a long-term impact, as people are forced to spend more of their earnings on basics like building homes and agriculture. The already stressed ecosystem is made even more fragile with each disaster. And the poor living on the margins of subsistence are forced into greater penury. With each disaster their capacity to rebuild is reduced.

Climate Change in India: A Case Study of Sundarbans

The Sunderbans is the world's largest mangrove ecosystem spread across Bangladesh and India, covering an area of 6,000 Sq.km. The Sunderbans is the point where the Ganges, Brahmaputra and Meghna rivers converge and flow into the Bay of Bengal a 20,000 square km network of creeks and canals, tidal rivers and estuaries, with about one hundred islands on the Indian side alone, supporting rich biodiversity.

The Sunderbans is the only mangrove tiger habitat in the world and supports the largest tiger population in the wild. Bengal tigers *(Panthera tigris tigris)* are strong, solitary animals which use a large territory. These coastal mangrove forests also provide habitat for species such as Indian otters, spotted deer, wild boars, estuarine crocodiles, fiddler crabs, mud crabs, three marine lizard species and five marine turtle species.

These ecosystems are highly vulnerable to sea-level rise induced by climate change, which will change the salinity distribution and inundate mangroves. In the Sunderbans, for example, rainstorms are quite common during the monsoon season. The islands and its ecosystems including the community are severely stressed on availability of natural resources and are extremely vulnerable to change in climate. Communities have already begun to perceive drastic changes in weather conditions and monsoon patterns, along with frequent extreme climatic events like cyclones. Sea level rise is another major threat. Some of the low-lying islands have already got partially submerged, resulting in displacement of a large number of people and rendering them helpless as ecological refugees.

The IPCC forecasts that the already extreme weather, with its frequent severe storm surges, droughts and floods will further worsen and as the sea level rises, eventually the entire Sunderbans would get submerged. It is estimated that a 45cm rise in sea level could inundate 75% of the area while a 1m rise will completely inundate and submerge the Sunderbans, will destroy productive lands, wipe out species, and devastate ecosystem goods and services. Scientists estimate that by 2020, 15% of 12 islands identified as the most vulnerable in the Sunderbans will have disappeared. More than a million people will be directly affected in India and Bangladesh by 2050.

In last few years the region has seen significant rise in sea level (more than 2.5 cm/year), also the monsoon has been shifted for a period of 15 20 days, increases the vulnerability of the community and the ecosystem.

About 65% of the people in Sunderbans depend upon agriculture and they strongly suspect climate change to be responsible for causing rise in sea level, delayed monsoon seasons, lengthier summers, and a dramatic increase in rainfall over the past 15 years. The key threats to agriculture in Sunderbans include crop vulnerability to changing weather patterns, increased exposure to pests and salinization of freshwater supplies. Communities in Sunderbans are already responding by adjusting the timing of cropping, changing crop types, and increasing rainwater harvesting and building island mud barrages.

Climate Change Witnesses

DARJEELING

“When I migrated from Nepal in 1926, the thick forests of Darjeeling were covered with snow for more than three months. Now it just gets blown by the winds like bits of paper.” Phul Bahadur, 97, Resident of Darjeeling.

“Anthurium, a plant comfortable below 1,220 metres, is now thriving around our school, which is at about 2,285 metres.” Umesh Dwivedi, Botany Teacher, St. Paul's School

“Pine is the indigenous tree of this region. Its growth is no longer luxuriant. Evergreen and deciduous trees of subtropical climate are flourishing.” Micheal Dutta

SIKKIM

“Barely 5-6 years ago, I used to wear a suit and tie to office even in summer. Not now. It's too hot.” P.K.Shresta, Chief Conservator of Forests, Sikkim.

“(The disappearance of butterflies) has been disastrous for cardamom and orange plantations, which are declining rapidly”. Sikkim produces 60% of India's cardamom, which is a major source of revenue for the state. - Bimal Rasaily, Horticulture Inspector, Sikkim.

SRINAGAR

An entire season, called sonth, has disappeared in Kashmir.

“During my childhood, the Srinagar valley used to be snowbound and the courtyards had almost seven feet of snow till May, not to speak of the mountains buried under 35 feet of snow. Now it becomes warm in February.” Saifuddin Soz, Former Minister for Environment and Forests.

“When I was young and strong, I needed two layers of sweaters and a jacket on top of my kurta, below which were two vests. It was impossible for me to row my boat without two pairs of gloves and socks.” Abdul Salaam Bhat, owns a houseboat on Dal Lake, who now rows his boat dressed in a single jacket.

WEST BENGAL

"I lost everything to the sea... I never thought I would have to beg to feed my family. I never thought my grandsons would be deprived of a school education because of the lack of money. My only son now suffers from tuberculosis," - cries Rohima Bibi (58), a climatic refugee of Sagar Para Colony, Sunderbans. (Once a resident of Lohachara, Rohima Bibi's five 'bighas' of paddy fields lie beneath the Bay of Bengal).

"The government has told us to move, but where should we go? We don't have money. We lost everything to the rising seas. Even now, we live in terror: the Hooghly River, with its strong undercurrent, erodes a bit of the riverbank everyday and come the monsoons, we will spend sleepless nights. We have no choice because we are penniless," - weeps Bani Das, Ghoramara, Sundarban. (Her family, which once tilled its own plot with great pride, now works on someone else's land)

"I have shifted homes at least five times before arriving here (Ghoramara). We had agricultural land on Lohachara and never knew the rigours of poverty. Now we find it difficult to afford even a meal a day," says Kalpana Mondal (35), Ghoramara, Sundarban. (Her husband owned seven 'bighas' of agricultural land, which got consumed by the swelling seas. Now her husband is a fisherman, while she works as a daily labourer)

4.4 Activity

Judicious use of Fossil Fuels

a. **Duration of the Activity -**30 minutes each for 1 week after school hours and 60 minutes in classroom.

b. **Overview** - Students calculate the amount of fuel consumed by different modes of transport to cover a particular distance.

c. **Objectives** - Sensitize students towards the Judicious Use of Fossil Fuels.

d. **Background Information -** India is the world's 5th largest emitter of CO_2 with its present share in global emissions estimated at 4.5 percent. Rapid industrialization and urbanization, along with an ever increasing fleet of automobiles together are responsible for several environmental problems across the globe. Industries and factories need a constant power supply for maintaining their production levels, and for this they need fossil fuels. Similarly, vehicles are also fuelled by fossil fuels like petrol and diesel. Burning of fossil fuels emits carbon dioxide, which is a green house gas and its increased concentration in the atmosphere leads to global warming. Not only this, but such excessive use of fossil fuels is also leading to their rapid depletion.

e. **Curriculum Links -** Social Science

f. **Intended Learning Outcomes -** Through this activity, students will learn which mode of transport uses what kind of fuel. They will learn to identify less fuel consuming and more fuel consuming vehicles. This activity sharpens the observation and analytical skills of students. Students will voluntarily try to use less fuel consuming and less polluting vehicles during their lifetime.

g. **Class/Grade** - Class 8

h. **Materials Required -** Pen/Pencil and Observation Sheets.

i. **Procedure -** The teacher must devote 30 minutes prior to the commencement of this exercise, explaining how to proceed with this activity. Ask the students to draw a table as shown below and calculate the total amount of fuel consumed per student per trip when they cover the same distance from home to the school using different modes of transport (walking, cycling, using two-wheelers, cars, buses, or even local trains). Students can either take this up as a group activity or as an individual activity. Ask the students to use the chart provided below to calculate the total amount of fuel consumed by different modes of transport.

CHART : Amount of Fuel Consumed by Different Modes of Transport

Mode of Transport	Type of Fossil Fuel used (if any)	Total amount of fossil fuel consumed per trip (one way)	Number of students sharing the transport facility	Fuel consumed per student per trip

j. Observation - Each mode of transport consumes a definite amount of fuel. However, activities like walking and cycling do not require any fossil fuel; two-wheelers, cars and buses, which are fuelled by petrol/diesel, are major factors in causing emission of greenhouse gases.

4.5 Discussion

After the completion of this activity, the teacher must devote 30 minutes in class to explain about the dearth of fossil fuels available in the world and the importance of judicious use of fossil fuels.

4.6 Extensions/Modifications

The results of the class activity could be shared with the rest of the school during the school assembly or written up as an article for the school or local newspaper. Students can use their results to campaign against the excessive use of fossil fuels.

The teacher could invite a local employee from the Pollution Control Board to speak about vehicular pollution and explain the various ways in which climate is influenced due to vehicular emissions.

4.7 Take a Message Home

Around 15 million people were affected during the super cyclone in Orissa in 1999.

The 2001 Gujarat earthquake took claimed almost 20,000 lives.

The Tsunami which shook the southern coast of India on December 26, 2004 played havoc with about 300,000 lives.

The 2005 Kashmir Earthquake claimed almost 100,000 lives.

On the 26th June, 2006, 960 mm of rainfall inundated the city of Mumbai, the highest rainfall ever recorded on a single day.

Heat waves, frequent cyclones and floods, prolonged periods of drought, food scarcity.... the list is long. Climate Change is indeed sounding the death knell in India - India has been ranked 26th in terms of countries likely to be worst affected by climate change.

4.8 References

Impacts of Climate change Western and Central India, Centre for Science and Environment, Climate Change Fact sheet

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Climate Change: A Challenge To India's Economy

http://www.cseindia.org/html/eyou/climate/pdf/cse_briefing.pdf

Climate Change & its possible Impact on India, Greenpeace, India.

http://www.greenpeace.org/india/campaigns/choose-positive-energy/what-is-climate-change/climate-change-its-possible

Classroom Activity 4.1: TRAVELLING CARBON

a. **Duration of the Activity** - 20 - 30 Minutes.

b. **Overview** - Students calculate and compare the amount of CO_2 emitted by different modes of transport when covering a particular distance.

c. **Objectives** - To calculate the amount of CO_2 emitted by different modes of transport. Sensitize students to use cleaner modes of transportation.

d. **Background Information** - Burning of fossil fuels emit carbon dioxide. The increase in the atmospheric concentrations of CO_2 increases the greenhouse effect, which leads to global warming. Each mode of travelling (whether it is walking, cycling, using two-wheelers, cars, buses, trains or aeroplanes) releases a certain amount of CO_2 into the atmosphere.

e. **Curriculum Links** - Social Science

f. **Intended Learning Outcomes** - Through this activity, students will learn to calculate and compare the CO_2 emissions from various mode of transport. Students will try to use less polluting vehicles during their lifetime.

g. **Class/Grade** - Class 7 - 8

h. **Materials Required** - Pen/Pencil and Observation Sheets.

i. **Procedure -** The teacher must devote 10 minutes prior to the commencement of this exercise, explaining about how to proceed with this activity. Ask the students to draw a table as shown below and calculate the amount of CO_2 emitted from different modes of transport when they cover the same distance from home to the school (walking, cycling, using two-wheelers, cars, buses, or even local trains). Students can use the chart provided below to calculate the amount of CO_2 emitted by different modes of transport.

CHART: CARBON DIOXIDE EMISSIONS FROM DIFFERENT MODES OF TRANSPORT

Mode of Transport	Quantity of CO_2 Emissions per Km	Distance Travelled	Total CO_2 Emitted
Walking	3gm	X .....Km	=
Cycling	3gm	X .....Km	=
Two-wheelers	30 gm	X .....Km	=
Car (Diesel)	210 gm	X .....Km	=
Car (Petrol)	225 gm	X .....Km	=
Bus	515 gm	X .....Km	=
Train (Diesel)	50 gm	X .....Km	=

j. **Observation** - Each mode of transport emits a definite amount of carbon compounds. Even when we walk or perform cycling, we emit carbon dioxide which is produced in our body as a result of respiration. However, cars and buses are the maximum contributors of CO_2 gas.

k. **Discussion** - What is the most energy efficient way to get to school? How can you make riding the school bus to school more efficient? (Change of route, fewer stops, more kids, new busses, busses that run on alternative fuels, etc.)How can you make riding in a personal vehicle to school more efficient? (Change of route, more kids, etc) How can we encourage more students to get to school without using a fuel-powered vehicle (riding bike, walking).

l. **Extention** - Have your transportation department manager speak to the students on how routes are chosen. Have the students show him or her the routes they choose and have them explain the thinking behind this.

Classroom Activity 4.2: FARMING IN THE FUTURE WORD PUZZLE

SOLVE THESE CLUES TO FIND THE WORDS IN THE PUZZLE.

Check up and down, sideways and diagonally!

F	N	S	Q	L	T	R	X	S	G
W	I	U	O	T	M	L	G	P	1
N	T	A	Q	I	A	Z	B	R	O
B	R	F	C	E	L	U	V	I	X
B	O	C	A	R	B	O	N	N	Y
P	G	H	S	R	J	J	W	K	Y
G	E	O	A	I	M	M	I	L	K
N	N	U	A	C	L	E	A	E	E
O	B	Y	B	E	Z	H	R	R	O
W	A	T	E	R	H	T	A	S	A

CLUES

1. _ _ _ _ _ _ _ [1] are especially interested in what happens to our climate.
2. Crops such as _ _ _ _ [2] may grown well in places that were once too dry.
3. Coal, oil and wood are sources of _ _ _ _ _ _ [3].
4. Plants need nutrients such as _ _ _ _ _ _ _ _ [4] from the soil to grow.
5. Faster-growing crops could make _ _ _ _ _ [5] and _ _ _ _ [6] quality problems even worse.
6. As cows get warmer, they make less _ _ _ _ [7].
7. Farmers may have to keep their animals cool with _ _ _ _ _ _ _ _ _ _ _ _ [8].

(Solutions on next page...)

a. **Duration of the Activity -** 15 minutes.

b. **Curriculum Links** - English Language, Social Studies

c. **Class/Grade** - Class 6-7

d. **Discussion -** Just before commencement of this activity, explain the information provided in the fact sheet to the class.

FACT SHEET : FARMING IN THE FUTURE

Global warming is impacting planet Earth, causing changes to our climate that are going to affect every part of our lives. Amongst other things, global warming will change temperatures and rainfall - two things that are very important to anyone growing crops or raising farm animals - so one group of people who will be especially interested in what happens to our climate over the next 50 years is farmers.

As the name 'global warming' suggests, in many areas, temperatures will become warmer. This can have good and bad effects. Warmer temperatures and more rainfall in some areas will allow crops such as rice to grow well in places that were once too dry or too cold.

Another piece of good news for crops is the gas carbon dioxide. Carbon dioxide, which is released when sources of carbon such as coal, oil and wood are burned, is one of the main causes of global warming. However, carbon dioxide is also very important for plant growth - the more carbon dioxide in the air, the faster and bigger plants grow. So despite being one of the main causes of global warming, carbon dioxide could actually be a big boost for crops.

But there's a problem with this. Plants also need nutrients such as nitrogen from the soil, so if they are growing faster, they will need more of these nutrients. Farmers would need to add extra fertiliser which could then have bad effects on other important soil processes and on nearby water supplies. While faster-growing crops might be a good thing for the people who sell and buy them, it can be bad news for the environment, making current problems with salinity, water quality and soil quality even worse.

Just as we have problems when we get too hot, livestock (cows and sheep) also get overheated. Scientists from CSIRO have discovered that as cows get warmer, they make less milk. Even if they are kept in shaded sheds and kept cool with sprinklers, scientists say that by the year 2030, cows will probably be making 60-90 litres less milk than they are now.

Other farm animals such as chickens and pigs could also suffer from the heat. If chickens get overheated, they can actually fall off their perches. To prevent animals from overheating, farmers may have to keep animals in sheds with sprinklers and fans instead of letting them roam outdoors in the heat.

As with all the other possible effects of global warming, the best thing we can do is try and keep our land in as good condition as possible, and to prepare for whatever changes may come.

- Crops such as wheat and rice may grow better with global warming but this could in turn have a bad effect on soil quality.
- Animals such as pigs, chickens and cows can all suffer from overheating. When chickens overheat they sometimes just drop off their perches, while CSIRO scientists have discovered that hot cows make less milk.

Solution to Classroom Activity 4.2:

1. FARMERS	3. CARBON	5. WATER	7. MILK
2. RICE	4. NITROGEN	6. SOIL	8. SPRINKLERS

Source: http://www.greenhouse.gov.au/education/factsheets/pubs/farming_future.pdf

Classroom Activity 4.3: FARMING ECOLOGICAL FOOTPRINT QUIZ

1. How did I get to school today...

a. I walked or rode my bike

b. I took the bus

c. I was driven in a car

2. How much water did I use this morning...

a. I did not shower

b. I had a short shower

c. I bathed in a full tub

3. I am wearing...

a. Almost all second-hand or hand-me-down clothing

b. Some second-hand or hand-me-down clothing

c. Only brand new clothes

4. When I eat a meal there is this much food left on my plate...

a. I clean my plate

b. A little bit of food

c. Half of the food that was there to begin with

5. In my lunch, this much food is wrapped in disposable paper or plastic...

a. None of it

b. Some of it

c. All of it

6. When I leave a room I turn off the lights...

a. Always

b. Sometimes

c. Never

7. At my house we recycle...

a. All of the things that our depot will accept

b. Some of the things that our depot will accept

c. Nothing

8. When I go shopping with my family we buy products that contain recycled materials...

a. Always

b. Sometimes

c. Never

9. If I put all of the garbage that I threw away today into a container I would need...

a. I produced no garbage today

b. A shoebox

c. A crate

10. Each week, my family fills this many garbage bags...

a. 1

b. 2

c. 3 or more

Give yourself 1 point for each "a" answer, 2 points for each "b" answer and 3 points for each "c" answer. Now add up your score to see how big your footprint is!

Score: 0 10 Congratulations on having such a small footprint! You obviously walk very lightly on the earth to conserve resources and reduce waste.

Score: 11 20 You have a medium-sized footprint. Although you are doing some things to reduce your impact on the environment, you could make a few changes that will help you to walk a little lighter.

Score: 21 30 Your footprint could be smaller. Read the quiz again and ask yourself if you can make changes to help decrease the size of your footprint. Even small changes can have a big effect! What are you waiting for?

a. **Duration of the Activity -** 15 minutes

b. **Curriculum Links** - Social Studies

c. **Class/Grade** - Class 6 7

Source: http://www.earthcarecanada.com/Library/Get_In_The_Loop_Teacher_Gui.pdf

CHAPTER - V
Finding solutions to Climate Change

5.1 Objectives

- Understanding the global initiatives to minimize climate change.
- Undertake efforts at an individual level to combat climate change

5.2 Keywords

Carbon 'sinks', Emission trading, Energy efficiency, Recycle, Reduce, Renewable energy, Reuse, The Kyoto Protocol, UNFCCC.

5.3 Content

Since climate change is a worldwide problem, it is imperative to have binding international agreements between the key contributors to this problem. The phenomenon of human induced climate change was formally recognized as a global concern by the United Nations at the UN Conference on Environment and Development (UNCED), Rio De Janeiro, in 1992.

The United Nations Framework Convention on Climate Change (UNFCCC), the climate change arm of United Nations, emerged as a consequence of the Earth Summit in 1992. It was the first agreement between countries across the world to tackle the climate change problem. However, the UNFCCC was only a framework convention, signifying that members were not committed to any substantial reduction of GHG emissions. To achieve quantifiable emission reductions, the signatory countries of the UNFCCC, adopted the Kyoto Protocol in 1997 at Kyoto, Japan. The Protocol finally entered into force in Montreal, on 16th February 2005, with the ratification of Russia accounting for 55% of GHG emissions. Secondary to the Kyoto and UNFCCC process, are G8 and other initiatives.

While the UNFCCC and its Kyoto Protocol are responsible for administration and implementation of GHG emission reduction processes, the United Nations also evaluates the risk of climate change, attempts to ascertain its impacts and explores mechanisms for mitigation and adaptation through its Intergovernmental Panel on Climate Change (IPCC), established in 1988.

The IPCC is a collection of 2,500 leading scientists and scholars that operates under the UNEP and WMO and bases its assessment mainly on peer reviewed scientific research. Its chief role is to support the UNFCCC in its decision making with accurate information on the process and impacts of climate change.

The IPCC produces technical and special reports that are considered the most influential and accurate literature on climate. The First Assessment Report of the IPCC in 1991 was significant in establishing the UNFCCC in 1992. Since then, the IPCC has been publishing an assessment report every 5-6 years, the latest published in April 2007. These reports, along with other reports of IPCC, have become the most trusted and quoted reports on climate change.

UNFCCC

In recognition of the global nature of the problem, the United Nations Framework Convention on Climate Change (UNFCCC) was agreed at the Earth Summit in Rio de Janeiro in 1992. 189 countries, including all major developed and developing countries, have ratified the UNFCCC, which has become the international environmental agreement with the highest number of parties. The UNFCCC sets the overarching objective for multilateral action: to stabilize greenhouse gas (GHG) concentrations in the atmosphere at a level that avoids dangerous anthropogenic climate change.

It also establishes key principles to guide the international response, in particular stating that countries should act consistently with their responsibility for climate change as well as their capacity to do so, and that developed countries should take the lead, given their historical contribution to greenhouse gas emissions. The Convention places a commitment to act on all Annex B countries of the Kyoto Protocol. Whereas for developing countries this commitment is unquantified and linked to assistance from developed countries from Annex II of UNFCCC, the developed countries have agreed to return greenhouse gas emissions to 1990 levels by 2000.

Kyoto Protocol

The Kyoto Protocol, adopted under the UNFCCC in 1997, laid down a timetable for industrialized countries to reduce their GHG emissions. This Protocol is a legally binding agreement under which industrialized OECD countries will reduce their collective emissions of GHGs by 5.2% compared to the year 1990 between 2008 and 2012. These countries are defined as Annex B parties to the Kyoto Protocol. The Kyoto Protocol defines four categories of parties

Annex 1 parties - Developed and industrialized countries responsible for a majority of GHG emissions, and are committed under the Kyoto Protocol to reduce their emissions by an average of 5.2% below 1990 levels by 2012 through enhancing their carbon sinks through land use activities, or by trading in carbon credits. Various mechanisms are available for Annex 1 parties to assist them in realizing this target. There are currently 40 Annex 1 parties consisting of OECD countries and economies in transition.

Annex 2 parties - Developed and industrialized countries that provide development assistance to developing countries. There are currently 23 countries under this category, including all OECD countries.

Developing countries - Developing countries, including India, are not committed under the Kyoto Protocol to reduce their GHG emissions even after ratification of the protocol, as they are not responsible for historic GHG emissions causing climate change.

Economies in Transition - Developed counties with economies transitioning from regulated markets to capitalist markets, which are allowed to vary their emission reduction targets.

By now, over 160 nations including 37 developed nations have signed and ratified the Kyoto Protocol. Notable exceptions include the United States and Australia. India signed and ratified this treaty in August 2002. However, India being a developing nation, is exempted from the framework of the treaty and therefore stands to gain from it in terms of transfer of technology and related foreign investments.

At the G-8 meeting in June 2005, Indian Prime Minister Mr.Manmohan Singh pointed out that the per-capita emission rates of the developing countries are a tiny fraction of those in the developed world. Following the principle of common but differentiated responsibility, India maintains that the major responsibility of curbing emission rests with the developed countries, which have accumulated emissions over a long period of time.

The current first commitment period of the Kyoto Protocol ends in 2012 when the Protocol expires. Negotiations for a second period started at the first Meeting of the Parties to the Kyoto Protocol in December 2005 in Montreal.

The Kyoto Protocol strives to mitigate climate change through its core commitment of reducing GHG emissions from Annex 1 countries. In order to achieve this, the Kyoto Protocol assigns an allowable level of emissions for each Annex 1 country, equivalent to an average of 5.2% below its 1990 emissions by 2012, called the 'Assigned Amount'. This amount is denominated in individual units called Assigned Amount Units (AAU), which represent an allowance to emit one metric ton of carbon dioxide equivalent of GHGs. The country must achieve this amount to meet its target.

Parties have instruments available to help them meet their emissions targets. These activities generate further emission allowances, or credits, which the party can use to achieve its assigned amount. If an Annex 1 country has already achieved its assigned amount and has excess allowances, it may trade them with other countries that have not yet satisfied their assigned amount. These transferred allowances are called Kyoto Protocol Units.

The instruments available for parties to assist them in offsetting their carbon emissions include:

Emission Trading

Forests have an enormous capacity to sequester carbon, and growing trees can capture and store massive quantities of carbon. Annex 1 countries can undertake activities such as afforestation, reforestation, cropland management, grazing land management, etc which would increase the vegetative cover and capture carbon, thereby compensating for the carbon emitted from the country through various sectors. Allowances issued for carbon emissions offset through this instrument, are called Removal Units (RMUs). These may also be traded with other parties as Kyoto Protocol Units.

Clean Development Mechanism (CDM)

Annex 1 countries may undertake carbon capture projects in developing countries by financing them and furnishing them with technology, and can claim credits equivalent to the amount of carbon sequestered. Projects may include raising forests, implementing low carbon technology, harnessing renewable energy, and undertaking such other activities, the absence of which would give rise to an evident increase in emissions. Credits issued through these activities are called Certified Emission Reductions (CERs).

Joint Implementation

Annex 1 countries may alternatively undertake emission reduction activities in other developed countries, for which they may claim credits equivalent to carbon sequestered. However, as the cost of reducing emissions in developed countries is higher, the Clean Development Mechanism is the more preferred option. Carbon credits issued through these activities are called Emission Reduction Units (ERUs)

Emissions Trading Annex 1 countries can also buy credits from other Annex 1 countries in order to meet their Kyoto Protocol targets. This scheme has created a rapidly growing market for carbon, with the European Emissions Trading System being the largest.

The world's first fledgling stock exchange dedicated to carbon trading, the Chicago Climate Exchange (CCX) was opened in 2005. This year, Brazil has also opened a carbon exchange where it intends to sell carbon credits issued from its various small scale CDM projects.

Although it might appear very complicated, the entire process is quite simple. Joint Implementation (JI) and Emissions Trading allow for emissions trading programmes between only industrialized countries. But the Clean Development Mechanism, or CDM, is a form of collaborative implementation between industrialized and developing countries. Under this mechanism, industrialized countries pay the extra cost of upgrading technology in developing countries. In turn, they get credits for the amount of GHG emissions mitigated by the technology upgrade.

The primary purpose of CDM mechanism is to allow industrialized countries to buy cheap reductions from developing countries. Let us say that India decided to invest in a new power station, and has decided on a particular technology at the cost of X crore. An entity from an industrialized country (which could even be a company) offers to provide India with slightly better technology, which costs more (say Y crore), but will

result in lower emissions. The industrialized country will only pay the incremental cost of the project viz. Y minus X. In return, the 'investing' country will get 'certified emission reductions' (CERs), or credits, which it can use to meet its Kyoto commitments.

There are several key multi-sectoral climate change mitigation strategies and approaches currently available commercially and in the experimental phase. A few of these are listed in the following chart:

Sector	Mitigation strategies currently available commercially	Mitigation strategies expected to be commercialized by 2030
Energy supply	Improved distribution efficiency; in thermal power, switching from coal to gas based, coal gasification, application of carbon capture and storage (CCS) technology; nuclear energy, renewable energy like solar, wind, geothermal, tidal, and biofuels)	CCS for natural gas, biomass and coal-fired electricity generating facilities; advanced nuclear power; advanced renewable energy, including, and solar photovoltaics.
Transport	More fuel efficient vehicles; hybrid vehicles; cleaner diesel vehicles; biofuels; shifting to rail and public transport systems; fuel efficient aircraft (B 787); non-motorized transport like cycling; transport planning	Second generation biofuels; higher efficiency aircraft; advanced electric and hybrid vehicles with more powerful and reliable batteries
Buildings	Efficient lighting & utilization of CFL lamps; more efficient electrical appliances and cooling devices; improved cook stoves consuming less LPG, improved insulation; solar design for heating and cooling; recovery and recycle of fluorinated gases	Integrated design of commercial buildings including technologies, such as meters that provide feedback and control; rooftop solar photovoltaics integrated buildings
Industry	More efficient end-use electrical equipment; heat & power recovery; recycling & substitution; control of non-CO_2 gas emissions; and a wide array of process-specific technologies	Advanced energy efficiency; CCS for cement, ammonia, and iron manufacture.
Agriculture	Improved crop and grazing land management to increase soil carbon storage; restoration of cultivated peaty soils and degraded lands; improved rice cultivation and livestock and manure management to reduce CH_4 emissions; improved fertilizer application to reduce N_2O emissions; dedicated biofuels crops to replace petroleum use; improved energy efficiency	Further improvements in fuel use in agriculture.
Forestry	Afforestation, reforestation and forest management, reduce deforestation; harvested wood product management; use of forestry products for bio-energy to replace fossil fuel use	Increased biomass productivity,carbon sequestration,improved remote sensing technologies for analysis of vegetation /soil carbon sequestration potential
Waste	Methane recovery from landfills; waste incineration with energy recovery; composting of organic waste; controlled waste water treatment; recycling	Filters to optimize CH_4 oxidation

Source: IPCC, 2007: Summary for Policymakers. In: Climate Change 2007: Mitigation. Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change (B. Metz, O.R.Davidson, P.R.Bosch , R,Dave, L.A.Meyer (eds)), Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

Finding Solutions to Climate Change

Known sustainable energy sources and proven technologies could be harnessed between now and 2050 to meet a projected doubling of global demand for energy services, while achieving the significant 60%-80% reductions in greenhouse gas emissions. However, the economic policies and measures, as well as the inter-governmental actions, needed to drive this transition are not yet in place and may well be years away based on current progress rate. Time is the most important factor now. In five years it may be too late to initiate a sustainable transition which could avert a breach of the two-degree threshold for avoiding dangerous climate change. In that event, dangerously unsustainable options may be forced upon us or we will face more severe interventions which will have significant impacts on the global economy.

a. Decoupling energy services demand from energy production

Energy efficiency (getting more energy services per unit of energy used) is a priority, especially in developed countries which have a very inefficient capital stock. Investment in energy efficiency, at all levels from generation to actual use, is by far the most immediate, effective, and economically beneficial way to reduce emissions, to “buy time” while other technologies are developed, and to decouple rising demand for energy services from actual energy production. The model shows that by 2020-2025, energy efficiencies will make it possible to meet increasing demand for energy services within a stable net demand for primary energy production, reducing projected demand by 39% annually & avoiding emissions of 9.4Gt carbon per year, by 2050 through industrial energy efficiency, plus a similar amount from building efficiency & from a combination of reduced vehicle use and higher-efficiency engines. India is progressing towards increasing energy efficiency in power generation. All the Ultra Mega Power Projects (UMPPs), installed with a generating capacity of 5,000 MW, are equipped with 'super critical' technology, which means that each ton of coal ignited yields more power than in a conventional thermal power plant.

b. Replacing High-Carbon Coal with Low-Carbon Gas

In the short term, an increase in the use of natural gas as a “transition fuel” can play a significant role in avoiding the locking in of higher emissions from coal, thereby buying more development time for other energy solutions to grow. While this is more applicable in some countries than others, gas should be scaled up in the short term (where it can avoid coal use), without bringing about harmful biodiversity impacts. The even lower carbon emissions for gas used with carbon capture and storage technology are also taken into account.

c. Concurrent growth of Low-Emissions Technologies

The rapid and parallel pursuit of the full range of technologies, such as wind, hydro, solar PV & thermal, and bio-energy is crucial, but within a set of environmental and social constraints to ensure their sustainability. By 2050, these technologies could meet 70% of the remaining demand after efficiencies have been applied, avoiding a further 10.2Gt carbon emissions annually. In the next 50 years, expansion of sustainable wind, hydro, and bioenergy will be particularly important. Bioenergy for heat and transport holds vast potential but could go terribly wrong if implemented unsustainably e.g., by clearing biodiverse habitats to plant energy crops. Large hydro dams need also to be deployed with restraint. Although nuclear energy produces virtually no greenhouse gases, but public concern over safety, and the transport and disposal of radioactive wastes limit the employment of this alternative.

d. Developing alternative fuels, energy storage & new infrastructure

Deep cuts in fossil-fuel use cannot be achieved without large volumes of energy from intermittent sources, like wind and solar, being stored and transformed into transportable fuels and into fuels to meet the thermal needs of industry. New fuels, such as hydrogen, that meet these requirements will require major new infrastructure for their production and distribution.

e. Stopping Forest Loss

Stopping and reversing loss and degradation of forests, particularly in the tropics, is a crucial element of any positive climate-energy scenario. Priority must be placed on reducing emissions rather than on pursuing sequestration. Oceans and growing vegetation are the two main natural CO2 sinks. Growing more trees and not cutting down any more forests is as important as cutting back on fossil fuels. On one hand cutting forests reduces the number of trees available to absorb atmospheric CO2, and on the other, the trees that have been cut down decompose naturally (or used as fuel wood), contributing either way to GHG emissions. However, an important fact here is that the capacity of a plant to act as a 'carbon sink' decreases with the age of the plant. Young forests absorb much more carbon dioxide than mature forests. This is the principle used in sustainable forest management, wherein plants which are more than 30 years old are harvested and an equal number of new saplings are planted in that area.

f. Carbon Capture and Storage (CCS)

CCS technologies basically involve decarbonising the vented gases from power plants and storing the captured carbon, thereby preventing their emission into the atmosphere. A number of technologies are available for both capturing and storing carbon dioxide from power plants, many of which have the potential to greatly control emissions. In order to stay within the carbon emissions budget, it is essential that fossil-fuel plants are equipped with carbon capture and storage technology as soon as possible all by 2050. This requirement has major and immediate implications for the design, planning and location of new plants, since transport of carbon dioxide to distant storage sites would be very costly. Overall, fossil fuels with CCS could account for 26% of supply in 2050, avoiding emissions of 3.8GtC/yr.

How can we contribute to combating climate change?

Individuals, students, community groups and schools can greatly contribute to reducing greenhouse gas emissions from effecting a moderate change in their lifestyle, to make it less carbon intensive and more environmentally friendly. A list of things you can do in your everyday life to help improve the situation are provided below:

1. EFFICIENT TRANSPORTATION - Transportation is a leading energy consumer. Switching to public transportation, or resorting to carpooling, walking, or using a bicycle when you can, will definitely reduce the stress on environment due to transportation. Vehicular pollution is a significant contributor to green house gases therefore, replacing your diesel or petrol with cleaner fuels such as CNG offers a great solution. Another important suggestion is to try and use lesser number of vehicles for transportation of goods and finished products or to opt for other less polluting modes of transportation.

2. BETTER APPLIANCES & EFFICIENT ENERGY USE - Purchase energy efficient household appliances. For instance, replacing your top-loading washing machine with a front-loader will greatly reduce your annual expenditure on energy, water and detergent. Even a little thoughtful and planned placement and positioning of household appliances in your home can make a great difference in your

energy consumption. For instance, installing the dishwasher away from your refrigerator reduces your refrigerator's power consumption by 20% because the dishwasher's heat and moisture make your refrigerator work harder.

3. COLD WATER WASH AND LINE DRY - Washing clothes in cold water instead of hot water and drying them outside in the fresh air and sunlight instead of drying them in the washing machine reduces your machine's energy usage by 75% and also reduces the CO2 emissions to a great extent. Another useful tip to conserve energy is to always do full loads when using your dishwasher and washing machine.

4. REFRIGERATION TIPS - Maintain your refrigerator and freezer at the right temperature. Even if you maintain them at 10 degrees F colder than necessary, your energy consumption will shoot up by 25 percent. Keeping the refrigerator door open for longer duration than necessary or improper shutting of the refrigerator door will also raise the energy consumption, therefore, you must ensure that you shut the door tightly each time after you use the refrigerator.

5. AIR CONDITIONING - Avoid the unnecessary use of air conditioning systems in your homes since they are one of the largest contributors of carbon dioxide. If ceiling fans can cool the room significantly, avoid using an air conditioning system in that particular room. Sealing and insulating cooling ducts is also a very good option to cut on your electricity consumption. Although “green homes” are a bit expensive when building, they provide ample natural ventilation and lighting and greatly reduce our energy costs on air-conditioning. An attic "whole house" fan, commonly used in “green homes” is an effective way of cooling your home without using the air conditioner. It forces hot air out of your home and draws cooler air in through attic vents. Pulling down curtains and shades during daytime can also help screen the excessive light and heat from entering the home and also prevents cold air from escaping.

6. UNPLUG APPLIANCES WHEN NOT IN USE - Unplug appliances like microwaves, stereos, VCRs and printers that do not have to be on all the time, since they consume energy when plugged in. Simply unplugging these appliances can save a lot of energy. Unplug electronic devices and chargers that have a transformer on their plug when they are not in use.

7. LIGHTING - Switch over to energy saver bulbs wherein you will obtain the same amount of light but save on energy bills as well as cut a lot of CO2 emissions. Keep bulbs dust-free since dust on a light bulb or dirt on a glass fixture can reduce the light emitted. When building a new home, include natural lighting features (such as skylights, sun tubes, larger south-facing windows, etc.) to reduce the need for artificial lights. Adjust your daily schedule in such a manner that you complete most of your work during daytime when there is ample daylight and switch on minimum number of lights at home during nights. Turn off all unneeded lights, and save a lot of energy and simultaneously keep the CO2 emissions from your home to a minimum.

8. HOME HEATING - There are a large variety of home heating appliances available in the market. Switch from an oil based or electric heating system to natural gas, which is more efficient. A little market research will help a lot in selecting the right kind of heating appliance. For instance, you can opt for an appliance with a smart programmable thermostat, instead of a simple dial-type thermostat since this allows you to set the desired heating and also switches off automatically while you are out. However, it is always advisable to wear warm winter clothing and minimize the use of home heating appliances to keep the CO2 emissions from your home to a minimum. Avoid using kitchen, bathroom and other ventilating fans in excess, as these can eject a significant amount of heated air in a very short period of time. Sealing and insulating heating ducts is also a very good option to cut on your electricity consumption.

9. COOKING SMARTLY - Use vessels of suitable size while cooking instead of using large sized vessels for cooking even small quantities of food. It saves a lot of fuel as well as caps the CO2 emissions from your home. If using a microwave for cooking/heating food, minimize the number of times you open the oven door since you lose 25 to 50 degrees each time you open and shut it. Do not preheat the oven longer than it is necessary. Careful handling of your oven greatly reduces the energy consumption of your oven & even saves on your energy costs.

10. SMART LANDSCAPING - Shading your east & west windows with overhangs or trellises or by planting shade trees are also effective ways to reduce unwanted heat gain on hot, sunny days. Planting trees or shrubs to shade air-conditioning units (but not to block the airflow) greatly reduces the energy consumption by the air-conditioning unit. A unit operating in the shade uses as much as 10% less electricity than the same one that is directly exposed to sunlight.

11. HOT WATER EFFICIENCY - Reduce the hot water consumption in your home by installing efficient showerheads, faucets and other fixtures. Insulating the water heater with an insulating blanket, especially in the case of older water heaters with little internal insulation can be immensely helpful. The best option is to install a solar water heater, which apart from being emission free, also cuts on your monthly water heating bills.

12. SAVE ENERGY AT SCHOOL/WORKPLACE - Reduce the energy consumption in your school or workplace by setting computers, monitors & copiers to sleepmode, or simply turn them off if you are not going to use them for an extended period of time. Encourage your fellow students & co-workers also to do the same.

13. RECYCLE TRASH - Most people do not realize that solid waste reduction and recycling help address global climate change. The manufacture, distribution and use of products as well as management of the resulting waste, all result in greenhouse gas emissions. Waste prevention and recycling reduce greenhouse gases associated with these activities by reducing methane emissions, saving energy, and increasing forest carbon sequestration. An effective system of waste management involves the use of the "3 Rs" Reduce, Reuse and Recycle. While 'reduce' means to use less, 'reuse' means to put the article back to use without changing and 'recycle' means to put back into service after changing the article slightly or completely. As far as possible, we must try to recycle used aluminium cans, glass bottles, plastic bags and newspapers, which we use in our everyday life.

14. GROW MORE TREES - Green plants & vegetation can effectively absorb large quantities of carbon dioxide, and therefore help to combat climate change and global warming. Therefore, start planting trees and resort to celebrating any significant occasion in your life with planting of samplings in your garden or a nearby park. This will be more helpful if undertaken at a community level.

How is India working to Mitigate Climate Change?

India, being a developing country, is not obligated by the UNFCCC to commit to reduce its emissions by any level. The per capita carbon emission in India is as low as 1.1 tonnes per year, as opposed to 19.6 tons per capita in the USA. Even by developing country standards, Indian emissions are still lower than China at 4 tons and Brazil at 2.5 tonnes.

However, India's commitment to combating climate change has been demonstrated by its willing ratification of the Kyoto Protocol, and in its acknowledged leadership in the Asia Pacific Climate Partnership, a coalition of six countries in the Asia Pacific region (India, China, South Korea, Japan, Australia, US) looking for alternative emission reductions beyond the Kyoto Protocol. There are several initiatives in India striving for reducing carbon emissions, mainstreaming renewable energy technologies and funding carbon sequestration initiatives.

Numerous electricity generation and regulation utilities across India are starting to rely more on hydropower and renewable energy. Renewable energy sources together contribute 7.6% of India's energy supply with 10,175 MW of installed capacity. Hydel power generation is comparatively less polluting than thermal power generation, and is also economical as operational expenses are virtually eliminated, and can operate at near maximum installed capacity.

Our national energy policy also lays emphasis on the need for increasing the utilization of clean and renewable energy, with the Ministry of New and Renewable Energy (formerly the Ministry of Non conventional Energy Sources), actively exploring renewable energy options. IREDA, the Indian Renewable Energy Development Agency, is charged with the responsibility of providing loans for new and renewable energies. IREDA has played a key role in the development of renewable energy in India by assisting in the up gradation of available technologies and by extending financial support to energy efficiency and conservation projects. The Bureau of Energy Efficiency (BEE) has also embarked on an ambitious scheme of labeling products with stars on the basis of their level of energy efficiency. This scheme is expected to serve as an incentive for manufacturers.

India emerged as one of the five largest wind power-generating countries in the world, with nearly 7,000 MW of installed capacity. Wind energy is currently the fastest growing renewable energy sector in India.

Nuclear power, which has the potential to meet our energy requirements and the advantage of being non-polluting, is also progressing fast in India. Nuclear power now accounts for 3.1% of our energy supply, with 4,120 MW of installed capacity. The private sector is actively participating in developing and diversifying wind energy in India, along with other renewable energies. Private entities are now responsible for generating around 13% of total electricity generation in India, with 18,418 MW of installed power generation.

In transportation, CNG and biofuels, which have low carbon content, have entered the mainstream in a few cities. The public transportation agencies in several cities have already shifted entirely to or are experimenting with CNG as a replacement for diesel. With suppliers expanding their network across the country, CNG has also become viable for taxis, autos, and private vehicles. Biofuels are also being experimented in varying stages, with biodiesel being introduced in proportions in buses and train locomotives.

The industrial sector is also beginning to reduce its emissions. There are strict emission and flue gas treatment standards for most categories of industries, especially those consuming coal as fuel. The NTPC has mandated the installation of Electrostatic Precipitators (ESPs) in most of their thermal power stations to contain fly ash from vented flue gases. Industries are encouraged to have their own captive power plants to satisfy their in-house energy requirements and offset the burden on national energy generation. Many cement and power generation industries are also in the process of switching to cleaner fuels and emission reduction mechanisms, which result in reduction of emissions and are therefore entitled to financing under the CDM scheme. The industrial sector in Andhra Pradesh is emerging as a pioneer in mainstreaming clean fuel technologies, especially for industrial power. Bagasse generated from sugarcane pulp and biomass are gaining popularity in the state for power generation up to 50 MW, satisfying local power requirements.

India is actively reforesting vast areas of wasteland and deforested forestland under the National Afforestation and Biodiversity Programme. An increased land area will lead to greater capture of carbon dioxide from vegetation. India is also entitled to apply for reforestation projects under the Clean Development Mechanism, where India gets financed to grow forests on wasteland and degraded forestland, and the financing country receives carbon credits from the Kyoto Protocol. Currently, a large number of CDM projects in India are allocated to the energy sector through mitigation processes such as efficiency, renewable energy, fuel switching etc, but practically none in the area of forestry. This is therefore a potentially large and feasible area where India can receive finances and technology for developing its forest areas, while mitigating emissions.

Environmentally safe and friendly waste management can substantially curtail emissions. Though landfills and open dumping of municipal waste is still prevalent in India, electric incinerators, which completely contain and burn waste and prevent emissions, are being installed in a phased manner in several states. Once this technology is fully adapted to Indian conditions, it will greatly minimize GHG emissions from municipal waste disposal and burning.

The World Wakes Up To Global Warming

People across the globe are realizing the seriousness and enormity of the Climate change problem. Climate change is among the most pervasive threats to the web of life, yet we have the power to address its root causes and limit its impact on the planet. Smart energy choices made by individuals and industries can dramatically reduce GHG emissions and slow global warming. Industries are known to contribute around 14% to global GHG emissions. Any reduction of GHG emission from industrial processes will greatly contribute to reduction in overall GHG emissions and eventually in mitigation of global warming. Several industries have realized their role in contributing to climate change through greenhouse gas emissions, and have accepted their social responsibility to control emissions.

One such company is Tetra Pak, a world-leading food processing and packaging company. Its products include paper cartons, which are used for storing and transporting perishable goods like milk, which can be stored under normal room temperatures for about one year and do not require any refrigeration.

Tetra Pak conducts its business in an environmentally sustainable manner and adheres to the principles of Renewability, Recycling and Energy Conservation. Being a signatory of the United Nations' Global Compact, a member of the Sustainable Packaging Coalition, and a founding member of the High Conservation Value Forest Resource Network, Tetra Pak is committed to running its business in an environmentally sound and sustainable manner.

Tetra Pak and WWF have started a partnership project in 2006, pertaining to the responsible use of forest products and the reduction of Tetra Pak's contribution to climate change. It would really help the planet if other manufacturing companies, institutions and corporate firms across the globe could follow the example of Tetra Pak and device their own strategies to protect the environment.

We have got everything that is required to get started to protect the earth, with the possible exception of the will to act. Let us all make a conscious attempt and a genuine effort to combat climate change crisis.

Climate Friendly Business Operations: A Case Study of TetraPak

The industrial sector is responsible for around 14% of global GHG emissions, and a reduction of GHG emission from industrial processes will greatly contribute to reduction in overall GHG emissions and eventually in mitigation of global warming. To their credit, several industries have realized their role in contributing to climate change through greenhouse gas emissions, and have accepted their social responsibility to control emissions while embracing the risks and opportunities to their corporate mandate presented by climate change. One such company is Tetra Pak, a beverage carton manufacturing company that supplies packaging material for beverage and liquid drinks to companies like Godrej and Amul.

Tetra Pak is committed to ensuring environmental sustainability, reduction of greenhouse gas emissions and generating zero waste in its sourcing, production, and distribution mechanisms. Tetra Pak has a unique story to narrate from its experiences in environmental protection and mitigation of greenhouse gas emissions, one that is worthy for emulation by institutions across the world. To ensure that all processes are environmentally friendly and that standards are maintained, Tetra Pak has globally partnered with WWF in two crucial areas to preserve the environment through sustainable management-climate change and forestry. Both of these issues are closely related to sustainable development as they are centered on the use of renewable energy and renewable resources. This partnership helps WWF in achieving its objectives of promoting sustainable development, and serves as a role model of environmental stewardship for other companies to emulate. Tetra Pak also works frequently with schools, most notably in Thailand, to undertake recycling of used Tetra Pak milk cartons. Following the same initiative, Tetra Pak has challenged itself to achieve zero waste dumping of beverage cartons, and complete recycling.

Environmental sustainability

Tetra Pak packages are made primarily from paper from wood sourced from certified forests in northern Sweden. These forests are harvested periodically and selectively for required timber yielding trees and are verifiably renewed. However, more trees are grown than are harvested, so that the forest is continuously growing. Through the partnership with WWF, Tetra Pak has also joined and supports the WWF Global Forest and Trade Network Further, which aims to eliminate illegal logging and protect valuable and threatened forests, and promotes good forest management and governance practices. This partnership also elicits support for the High Conservation Value Forest resource network. Tetra Pak incorporates paper extracted from recycled fibers into its raw material, assuring a lower percentage of raw paper extracted from forests. Factories are operated in strict compliance with environmental standards, meeting ISO 140001 standards. Beverage cartons are therefore sustainable by nature, and guarantee environmental preservation through sustainable forest management.

Climate Change

Tetra Pak has undertaken several initiatives targeted at reducing greenhouse gas emissions throughout its production and supply chain. Tetra Pak has partnered with WWF by joining its Climate Savers programme, and has set an emissions reductions target of 10% in absolute terms by 2010. Already, Tetra Pak has achieved 15% energy efficiency improvement compared to 2002 following its partnership with WWF, and 29% of the energy used in its converting plants comes from renewable resources. Tetra Pak uses mostly sea transport for overseas supply, which has significantly lower emissions than other forms of transport. Packages are also delivered in reels, occupying less space and requiring less number of trucks for transportation, thus reducing emissions. By virtue of their effective packing, cartons don't necessitate refrigeration during storage and transport, avoiding wasteful electricity consumption releasing emissions. Furthermore, Tetra Pak factories are switching to green energy that is independent of grid supplied electricity, thereby offsetting emissions. The cartons themselves contribute immensely to offsetting of emissions. They can be easily flattened and folded, thus occupying less space and facilitating transport of a greater number of cartons.

Waste management

Tetra Pak minimizes wasteful disposal of its beverage cartons in schools by encouraging recycling programmes at the school and community level. Tetra Pak in Thailand has set itself an ambitious target of completely minimizing roadside and landfill disposal of beverage cartons, by adopting effective recycling campaigns. Tetra Pak cartons are composed of 75% paper, 20% polyethylene and 5% aluminium foil, and are 100% recyclable. At the paper mills, the good long fiber is recovered and supplied to making paper rolls. The residuals of polyethylene and aluminium left from the process are collected separately, and are extruded into Poly-Alu, used in the plastic industry to make useful products. Thus, no part of the beverage carton is wasted, and can be circumvented from polluting landfill sites.

5.4 Activity

Preparation of Recycled Hand-Made Paper

a. Duration of the Activity - 2 hours

b. Overview - Saving paper means saving trees. So, students are taught to manually prepare rough recycled hand-made paper from waste papers.

c. Objectives - To help students learn how to prepare recycled paper using waste papers. This is a good example of transforming a waste matter into a usable material.

d. Background Information - To help conserve forests and to reduce the quantity of waste, it is imperative to reuse and recycle paper as much as possible. The technique to make paper varies depending on the quality of paper used. A simple technique is given here which the students can even practice at home.

e. Curriculum Links - Arts Class

f. Intended Learning Outcomes - Through this activity, students will understand the importance of waste paper as a precious source of raw material for making fresh recycled paper.

g. Class/Grade - Class 7-8

h. Materials Required

- Waste paper from old notebooks/old newspaper/old magazines.
- A little starch.
- A bucket or an old basin.
- A mortar and pestle or any other device to pound the paper.
- A wire mesh sieve or a perforated plate.

i. Procedure

- Tear the paper you are using into small pieces.
- Soak overnight in a bucket of warm water, with a little starch added to it.
- In the morning, take out of the wet soggy paper from water and make a paste using mortal and pestle until it becomes soft and pulpy. Add more starch to thicken it.
- Put this pulp over a wire mesh and allow the water to drip out. Press a little to squeeze out the excess water.
- Now turn the sieve slowly upside down over a smooth surface and put some weight over it.
- Once it dries up your hand made paper is ready for use.

j. Observation - You will notice that the paper is uneven and not smooth enough. Therefore, you will not be able to write on it but you can draw on it or use it for making articles like pen stand, folders or attractive greeting cards.

5.5 Discussion The teacher can discuss the importance of recycling and explain to the class how recycling reduces the amount of waste and helps in protecting the environment by reducing the need to cut large number of trees for manufacturing paper. Discussion can also be held on -

1. Review the origins of paper and discuss logging practices.
2. Where does paper go if we don't reuse it?
3. What happens if we all take our paper to the recycling center, but no one buys recycled paper products?
4. Talk about some of the problems of cutting down too many trees (e.g. increase global warming, loss of habitat, loss of scenic beauty).

5.6 Extensions/Modifications

These articles prepared by using the rough recycled hand-made paper can be displayed during an Art & craft exhibition in your school or can be put out for sale during a school fete Programme. Alternatively, the teacher can ask to students to -

1. Add leaves or other objects on the screen to make imprints on the paper.
2. Use the paper for an art or language arts assignment.
3. Make paper-planting cups and grow plants in the classroom for home or school grounds. Just shape the wet paper about 1/4" to 1/2" thick inside the desired container and let dry about three days. Discuss that the container is biodegradable and so can be planted in the ground with the plant.
4. Visit a paper mill or have a representative visit your classroom.

5.7 Take a Message Home

There are a lot of things that you can do to control global warming. Every little effort you make to prevent energy from being wasted in your home, school or at other places you visit, can help decrease the negative impacts of humans on the earth's climate. Each one of us can reduce our contribution to global warming by using less greenhouse-gas-producing energy sources: driving less, choosing fuel efficient vehicles and appliances (like refrigerators and water heaters), and using different forms of renewable energy (solar, wind thermal energy), which do not release carbon dioxide, wherever possible for our daily energy requirements like water and space heating.

5.8 References

www.teriin.org - homepage of The Energy and Resources Institute, a Delhi based NGO that undertakes research on energy and policy studies on climate change strategies and legislations

http://eia.doe.gov/kids/ - Energy Kids page full of information on Energy facts, fun games, and classroom activities.

http://www.explainthatstuff.com/globalwarmingforkids.html - A climate source resource

www.devalt.org - homepage of development alternatives, with information on renewable energies, especially on rural electrification

www.ireda.in - homepage of the Indian renewable energy development agency, with information on development of renewable energies

Classroom Activity 5.1: ENERGY AUDIT

a. **Duration of the Activity -** 60 minutes each for 1 week.

b. **Overview -** Student will conduct energy audits to become aware about the energy consumption by different appliances. This awareness will help students to take measures to keep a check on wastage of electricity during their lifetime.

c. **Objectives** - To sensitize students about the level of energy usage in their daily lives, make them realize how over-consumption of energy negatively affects the environment, expose them to a variety of ways to conserve energy by conducting an energy audit of their school and/or homes and finally make them learn about the various energy-saving measures.

d. **Background Information -** The demand for electricity continues to rise as the population grows. People use energy without thinking about it all day. They turn on appliances and walk through rooms every day without a thought to where the electricity comes from, or how much they are using. Although considered as a clean source of energy, electricity generation involves a lot of deleterious environmental impacts. Therefore, as environmentally conscious citizens, we must limit the amount of electricity we use in our daily life.

e. **Curriculum Links -** Social Studies

f. **Intended Learning Outcomes -** Through this activity, students will understand the importance of electricity in our lives and our growing dependence on the energy resources.

g. **Class/Grade** - Class 9

h. **Materials Required -** Pen/Pencil and Observation Chart.

i. **Procedure**

1. Identify the main electrical appliances in your home and their individual electricity consumption.
2. Find out the wattage of each appliance and the number of hours for which each appliance is used per day.
3. Calculate the overall energy consumption for each electrical appliance for the whole month and then compare it with your monthly electricity bill.
4. Then work out a plan to reduce your overall electricity consumption.
5. You can even determine the CO_2 emissions from each of your electrical appliance.
6. You can even work out the positive impacts this reduced electricity consumption will have on the environment and how it will help combat global warming.

   You can use the following chart that provides the total amount of wattage of different electrical appliances for your calculations:

CHART: ENERGY CONSUMED BY DIFFERENT TYPES OF ELECTRICAL APPLIANCES

Electrical Appliance	Electricity Consumption	Electrical Appliance	Electricity Consumption
60 Watt Bulb	1 unit in 16 hrs	**Television**	1 unit in 6.5 hrs
40 Watt Tube Light	1 unit in 25 hrs	**Ceiling Fan**	1 unit in 16 hrs
1 ton AC	2.5 units in 1 hr	**Room Heater**	1 unit in 1 hr
Geyser	2 units in 1 hr	**Electric Grinder**	1 unit in 5 hrs
Electric Iron	1 unit in 1 hr	**Compact Fluorescent Bulb**	1 unit in 55 hrs

Using the above table, calculate the total energy consumption in your home/ school/ place of work. Remember, 1 unit = 1 kilowatt hour (KWh), where 1 kilowatt = 1000 watts. 1 kilowatt hour is the amount of electricity consumed by a 1000 watt appliance in 1 hour. You can calculate the number of units an electrical appliance consumes using the following formula:

$$\frac{\text{Wattage of appliance}}{1000} \times \frac{\text{Time taken in mins}}{60} = \text{Number of units consumed}$$

Prepare an observation chart based on your finding, using the format provided below:

Electrical Appliance	Energy used/hr	No. of hrs	Total Energy Consumption	Per unit cost	Total Cost

j. Observation

1. Every kilo of coal burnt in a coal plant yields 3 - 4 units of electricity.
2. To generate 1 unit of electricity, a coal plant emits about 900 gms of CO_2, which is a greenhouse gas contributing to global warming.
3. A coal plant also emits SO_2, nitrous oxides, CO, degrades the land and fills your water sources with metal pollutants.
4. India satisfies 70% of its electricity requirements using coal. Other forms of electricity generation emit less CO_2.
5. A gas plant emits 400 gms/unit and the levels are as low as 50 gms/unit for nuclear, hydroelectric, biomass and wind plants.

k. Extension - Have students do the energy checklist in parts of your school building. Make a presentation to the Principal, energy manager and school board about what they found and ways they could make the building more energy efficient.

Classroom Activity 5.2: REDUCE, REUSE & RECYCLE PAPER

Unscramble the missing words to learn how reusing or recycling can help reduce greenhouse gases and prevent global climate change.

Are you habituated to use paper napkins and paper towels instead of handkerchiefs and cloth napkins? Do you tear off unused pages from your notebook and make aeroplanes and boats to play with? Well, remember that paper is made from wood fibre. (SRETE)_____[1] must be cut down, transported by truck, and processed into paper at paper mills. All these activities (ALEERES) _____[2] huge amounts of greenhouse gases, further aggravating the problem of climate change. By reducing the (NATMUO) _____[3] of paper you (EUS) _____[4] everyday or by recycling paper, you help reduce greenhouse gases from being released during the manufacture of paper. You can also help in preventing climate change by preserving trees, which naturally absorb a greenhouse gas called (RBAONC) _____[5] (DIEXIDO) _____[6] from the atmosphere.

a. Duration of the Activity 10 minutes.

b. Curriculum Links English Language, Social Studies

c. Class/Grade - Class 6-7

d. Discussion Explain the terms Reduce, Reuse and Recycle and their roles in reducing Greenhouse Gas emissions.

Solution to Classroom Activity 5.2:
1.Trees, 2.Release, 3.Amount,
4.Use, 5.Carbon, 6.Dioxide

Source: http://www.epa.gov/epaoswer/osw/k00-001.pdf

Classroom Activity 5.3: QUIZ ON RENEWABLE ENERGY

Q 1. Which among the following is most energy efficient?

A. Incandescent bulb

B. Fluorescent tube light

C. Compact fluorescent lamp

Q 2. In India and elsewhere, biomass can be obtained from

A. Groundnut shells

B. Sugarcane bagasse

C. Rice husk

D. All of the above

Q 3. Solar cells are simple photovoltaic devices that convert solar energy directly into electricity and are manufactured from the second-most abundant element in the earth's crust. Name it.

A. Bauxite

B. Silicon

C. Calcium

Q 4. Biogas is a methane-rich gas formed by fermentation of animal dung, human sewage and crop residue. The advantage(s) of biogas is/are:

A. A clean and smokeless fuel

B. Slurry left behind is used as fish feed

C. High potential in rural India

D. All of the above

Q 5. In rural areas, this gas can be generated and used for cooking and lighting.

A. Biogas

B. Oxygen

C. Ammonia

Q 6. Which is the most common non-commercial biological fuel in a large number of developing countries?

A. Animal dung

B. Crop residue

C. Coal

D. Fuel wood

Q 7. Hydro power, which is derived from water is one of the earliest sources of energy in the country. The first mini hydel plant was set up in 1897 at the following place.

A. Shimla

B. Dehra Doon

C. Kulu

D. Darjeeling

Q 8. Wind energy is the kinetic energy associated with atmospheric air. It has been used for centuries for the following operation.

A. Grinding grain

B. Generating electricity

C. Running cars

D. None of the above

Q 9. Wind energy is one of the fastest-growing renewable energy source with worldwide wind power installed capacity reaching about 14,000 MW. At the end of March 2000, India had 1080-MW capacity 'wind farms'. Name the state that leads in this sector.

A. Maharashtra

B. Punjab

C. Andhra Pradesh

D. Tamil Nadu

Q 10. Large amounts of solar energy is stored in the oceans and seas. The process of harnessing this energy is called

A. OTEC (ocean thermal energy conversion)

B. OTC (ocean thermal conversion)

C. OSTEC (ocean and sea thermal energy conversion)

Q 11. This energy is the heat generated by natural processes within the earth. The main energy sources are the hot rocks, magma, geysers, and hot-springs. This form of energy is known as

A. Solar energy

B. Geothermal energy

C. Ocean thermal

(Solutions provided on next page...)

a. **Duration of the Activity** 10 minutes.

b. **Curriculum Links** Social Studies

c. **Class/Grade** - Class 8-9

d. **Discussion** Explain the answers of each of the question as provided in the solution below.

Solution to Classroom Activity 5.3: QUIZ ON RENEWABLE ENERGY

Answer 1: (C)

Compact fluorescent lamps should be used instead of ordinary incandescent lamps. These lamps may be more expensive but they last longer than the ordinary bulbs and are very energy efficient as they consume much less power, and thereby are more environment-friendly.

Answer 2: (D)

It is renewable and free from net CO_2 (carbon dioxide) emissions and is abundantly available on earth in the form of agricultural residue, city garbage, cattle dung, firewood, etc. At present, biogas technology provides an alternative source of energy in the rural India for cooking and lighting. The Indian sugar mills are rapidly turning to bagasse to generate electricity. It is a residue of sugar cane and is the part that is left of the cane after it is crushed and the juice extracted.

Answer 3: (B)

Solar energy is the most readily available source of energy. It is also the most important of the non-conventional sources of energy because it is non-polluting and, therefore, helps in lessening the greenhouse effect. The energy of the sun is taken in through simple photovoltaic solar panels that concentrate the heat of the sun and save it in solar cells to produce energy for cooking and boiling water. Solar heaters and cookers are available in the market and are being used in homes and factories.

Answer 4: (D)

Biomass is one of the cleanest forms of energy today and is being popularized in the rural areas. At present, biogas technology provides an alternative source of energy in rural India for cooking. It is particularly useful for village households that have their own cattle. Through a simple process, cattle dung, human sewage, and crop residue are used to produce a gas, which serves as fuel for cooking. The residual dung is used as manure or feed for fish. Biogas plants have been set up in many areas and are becoming very popular.

Answer 5: (A)

Earlier fuel wood and crop residues were the main sources of energy used for cooking and lighting in the rural areas. This source of energy is not clean and causes a great deal of health problems. Biogas technology provides an alternative source of energy in the rural India for cooking and lighting. Through a simple process, cattle dung is used to produce a gas which serves as fuel for cooking. Biogas plants have been set up in many areas and are becoming very popular.

Answer 6: (D)

In the developing countries, it is the rural areas that face the greatest threat from indoor pollution, where some 3.5 billion people continue to rely on traditional fuels such as firewood, charcoal, and cow dung for cooking and heating. Burning such fuels produces large amounts of smoke and other air pollutants in the confined space of the home, resulting in high exposure. Burning of fuel wood also causes depletion of forest resources as these areas rely heavily on the forest for their fuel needs, which they fulfill by cutting down trees.

Answer 7: (D)

Hydro power is one of the earliest known renewable energy sources in the country (since the beginning of the 20th century). The 130 KW small hydropower plant in Darjeeling set up in 1897 was the first in India. Besides being free from the problem of pollution, such plants are also free from issues and controversies that are associated with the bigger projects, namely affecting the lives of thousands of people living along the banks of the rivers, destruction of large areas under forest, and seismological threats.

Answer 8: (B)

Wind energy is the kinetic energy associated with movement of atmospheric air. Wind energy systems convert this kinetic energy to more useful forms of power. Windmills for water pumping have been installed in many countries, particularly in the rural areas. Wind turbines transform the energy in the wind into mechanical power, which can then be used directly for grinding etc. or further converting to electric power to generate electricity. Wind turbines can be used singly or in clusters called 'wind farms'.

Answer 9: (D)

In India, the states of Tamil Nadu and Gujarat lead in the field of wind energy. At the end of March 2000, India had 1080 MW capacity wind farms, of which Tamil Nadu contributed 770 MW capacity. Gujarat has 167 MW followed by Andhra Pradesh, which has 88 MW installed wind farms. There are about a dozen wind pumps of various designs providing water for agriculture, afforestation, and domestic purposes, all scattered over the country.

Answer 10: (A)

Large amounts of solar energy is stored in the oceans and seas. On an average, the 60 million square kilometres of the tropical seas absorb solar radiation equivalent to the heat content of 245 billion barrels of oil. Scientists feel that if this energy can be tapped, a large source of energy will be available to the tropical countries and to other countries as well. The process of harnessing this energy is called OTEC (ocean thermal energy conversion). Energy is also obtained from waves and tides.

Answer 11: (B)

Geothermal areas are areas where there are volcanoes, hot springs, geysers, and also methane in the oceans and seas. The core of the earth is very hot and it is possible to make use of this geothermal energy. Utilization of geothermal energy for production of electricity dates back to the early part of the twentieth century.

Source: http://edugreen.teri.res.in/explore/quiz/quiz.htm

Classroom Activity 5.4: WORD PUZZLE

Match the energy efficiency actions on the right, to the household items on the left.

Household Items	Energy Efficiency Actions
Leaky taps	Use cold water
Food scraps	Switch off at the wall
Glass and plastic bottles	Compost
Lights	Recycle
TVs	Fix immediately
Washing clothes	Switch off when not needed
Drying clothes	Close on hot days
Blinds and curta	Use the clothes line

(Solutions on next page…)

a. Duration of the Activity 15 minutes

b. Curriculum Links Social Studies

c. Class/Grade - Class 7

d. Discussion Hold a discussion on the various energy efficiency actions that can be undertaken at home as well as at the school before commencement of this classroom activity

Solution to Classroom Activity 5.4

Household Items		Energy Efficiency Actions
Leaky taps	→	Fix immediately
Food scraps	→	Compost
Glass and plastic bottles	→	Recycle
Lights	→	Switch off when not needed
TVs	→	Switch off at the wall
Washing clothes	→	Use cold water
Drying clothes	→	Use the clothes line
Blinds and curtains	→	Close on hot days

Source: http://www.greenhouse.gov.au/gwci/gwci-puzzle1.html

Classroom Activity 5.5:
WORD PUZZLE : GLOBAL WARMING - COOL IT

CAN YOU SOLVE THE CLUES AND FIND THESE WORDS IN THE WORD GAME?

Check up and down, sideways and diagonally!

O	E	Y	T	S	E	L	L	I	S
U	L	H	C	G	R	E	Z	D	E
R	E	C	Y	C	L	E	D	J	E
H	C	D	R	Y	I	N	G	L	L
E	T	D	J	I	R	G	L	A	R
T	R	Q	U	M	E	Y	C	B	I
W	I	J	M	R	D	J	D	E	M
H	C	U	P	Q	U	O	G	L	V
M	X	W	E	H	C	T	R	A	I
C	A	F	R	E	E	Z	E	R	S

CLUES

1. Fridges and _ _ _ _ _ _ _ _ [1] are big guzzlers of energy.
2. The more stars on an energy _ _ _ _ _ [2], the more energy efficient the appliance is.
3. Putting on a _ _ _ _ _ _ [3] instead of the heater makes you warm without warming the planet.
4. Natural gas heaters and _ _ _ _ _ _ _ _ [4] reverse-cycle air conditioners use less energy.
5. _ _ _ _ _ _ [5] clothes in the sun makes no greenhouse gases.
6. _ _ _ _ _ _ [6] the waste you make.
7. Remember Refuse, Reduce, Re-use and _ _ _ _ _ _ _ [7].

(Solutions on next page...)

a. **Duration of the Activity -** 15 minutes

b. **Curriculum Links -** Social Studies

c. **Class/Grade** - Class 7

d. **Discussion -** Explain the information provided in the factsheet to the class before commencement of this classroom activity.

FACT SHEET : GLOBAL WARMING - COOL IT

Some of the things we use daily and the ways we produce energy have contributed to the greenhouse effect - an increasingly hotter and wetter world. Temperatures are likely to heat up an extra 1.4 to 5.8 degrees by 2100, and sea levels will be from 9 to 88 cm higher. The problem is so huge that it's global. What can we do?

There are lots of things we can do around our own homes and gardens to help. We can have a big impact on the amount of greenhouse gases being released into the atmosphere by saving energy at home . . .and it saves money too.

Ever walked around the house and found every light was on? Turning off a few of these can make a difference. Energy efficient lights, such as fluorescent tubes or compact fluorescent lamps, add less greenhouse gas than ordinary lights; they also last longer and cost less in electricity. Make the most of daylight in your house and turn off extra lights at night. Computers, televisions, video recorders and stereos all use electricity, adding to greenhouse gases. Switch them off when they are not in use.

Fridges and freezers are big guzzlers of energy, and produce the most greenhouse gases of all household appliances apart from heaters. If your family is buying a new fridge, an energy efficient model is a good idea - check for lots of stars on the sticker of new fridges. The sticker is an energy label - the more stars the more energy-efficient the appliance is. You can make the most of your existing fridge too - get your parents to put it in a cool spot, and leave a gap so that air can move around the back of the refrigerator. This can save up to 250 kilograms of greenhouse gases entering the atmosphere each year. Making sure the fridge door is closed properly; and putting food and drinks back in the fridge straight away will also save on energy.

Washing and drying clothes is another big energy user. This doesn't mean we should all run around dirty and smelly; using the washing machine efficiently saves money and helps the planet. Save your washing until you have a full machine load rather than a small load - both make the same amount of greenhouse gases. Washing clothes in cold water generates less than one-fifth the greenhouse gases of washing in hot water. Detergent is another big problem for the Earth - just a few tablespoons of detergent is responsible for more than ten times that amount of greenhouse gas! Drying clothes in the sun makes no greenhouse gases, but if you use a dryer it helps to clean the lint filter and spin-dry clothes first.

Fuel or electricity to heat water produces a huge two tonnes of greenhouse gases a year. Energy efficient water heaters and solar hot water systems can reduce bills and produce less greenhouse gases, too. Use cold water when you can, and use a water-efficient showerhead or take shorter showers. And watch out for dripping taps - fixing these can prevent 100 kg of greenhouse gases from entering the atmosphere.

Putting on a jumper instead of the heater makes you warm without warming the planet. Open wood fires, electric fan heaters, oil heaters and radiators all use lots of energy. Natural gas heaters and electric reverse-cycle air conditioners use less energy.

Electricity produces greenhouse gases because it is made from burning coal and other fossil fuels. Making electricity with wind, the sun and water is called 'green' electricity and it produces little or no greenhouse gases. Investigate the different types of electricity available in your state - green electricity may cost a bit more, but it is a huge saving for the planet.

One family's car can produce 6 tonnes of greenhouse gases a year. Imagine how much greenhouse gas all the cars put together releases! Better cars are being built, but until then, a car in good condition with good tyres can reduce the impact your family car makes on the environment. Plan to avoid unnecessary trips. Combine several activities in one trip, or share the trip with a friend. Where possible walk or ride to school, or use public transport.

Remember; Refuse, Reduce, Re-use and Recycle - refuse extra packaging, reduce the waste you make, re-use what you can and recycle!

- Reverse cycle air conditioners are energy efficient, but the best way to warm up is to put on a jumper instead.
- Washing clothes in cold water uses twenty times less energy than washing in hot water.
- Energy labels tell you how much energy an appliance uses. More stars mean the appliance is cheaper to run and it makes less greenhouse gases, too!
- Most electricity is made from burning fossil fuels. Solar water heaters make energy from sunlight instead.

Solutions to Classroom Activity 5.5:

1. FARMERS	3. JUMPER	5. DRYING	7. RECYCLE
2. LABEL	4. ELECTRIC	6. REDUCE	

Source: http://www.greenhouse.gov.au/education/factsheets/coolit.html

Classroom Activity 5.6: REDUCE, REUSE & RECYCLE

Fill in the blanks with the correct key words. Remember that each word in the Answer Bank can only be used once.

Reduce, Reuse, and Recycle are the most important ways of preventing our wastes from harming the Earth. When we reuse our trash or when we collect it in the recycle bin instead of throwing it in the garbage dump, we are actually helping to keep our _____[1] (including air, water & soil) healthy. When we recycle, less garbage will pile up in those big holes in the ground, called _____[2]. In addition, when we reuse old things instead of buying new products, factories will need to produce fewer products, which will save energy and reduce the amount of _____[3] that is released into the atmosphere.

Answer Bank: Pollution, Environment, Landfills, Air Molecules, Land

a. **Duration of the Activity -** 10 minutes.

b. **Curriculum Links -** English Language, Social Studies

c. **Class/Grade** - Class 6

d. **Discussion -** Explain the terms Reduce, Reuse and Recycle and their roles in reducing Greenhouse Gas emissions

Classroom Activity 5.7: RECYCLE PLASTIC, METAL & GLASS

Unscramble the missing words to learn about how reusing or recycling these products can help reduce greenhouse gases and prevent global climate change.

Do you drink water from a plastic water bottle, eat your food on a steel plate or eat your ice-cream from a small glass bowl? These containers are all made from natural (SEROUCSER) _____[1], which are mined, transported, and then made into plastic, metal, or glass at a (ORTACYF) _____[2]. This entire (RUNTGAFNICAMU) _____[3] process releases greenhouse gases and causes climate change. By recycling or reusing plastic, (LEMAT) _____[4], or glass items, you can reduce the need to mine, transport, and manufacture natural resources to make new products. In other words, you reduce the amount of (SHOUERNEEG) _____[5] gas released and help prevent climate change.

(Solutions on page 118)

a. **Duration of the Activity -** 10 minutes.

b. **Curriculum Links -** English Language, Social Studies

c. **Class/Grade** - Class 6-7

d. **Discussion -** Explain the importance of reusing/recycling plastic, metals and glass and the role of recycling in reducing Greenhouse Gas emissions.

Solutions to Classroom Activity 5.6:

1. ENVIRONMENT	2. LANDFILLS	3. POLLUTION

Source: http://www.epa.gov/epaoswer/osw/k00-001.pdf

Solutions to Classroom Activity 5.7:

1. RESOURCES	3. MANUFACTURING	5. GREENHOUSE
2. FACTORY	4. METAL	

Source: http://www.epa.gov/epaoswer/osw/k00-001.pdf

GLOSSARY

Abiotic - An object, substance or process that doesn't involve living organisms.

Adaptations- Special traits that help living organisms survive in a particular environment. These adaptations may be structural (size and shape or body temperatures, or needs for minerals), or behavioural (differing ways of reacting to the environment).

Aerosols- Solid or liquid particles dispersed in the air, including dust, soot, sea salt crystals, spores, bacteria, viruses and other microscopic particles. Aerosols are often regarded as air pollution, but many aerosols have a natural origin.

Air - A mixture of gases and aerosols that composes the atmosphere surrounding Earth. The primary gases of dry air are nitrogen (78%) and oxygen (21%). Trace gases and aerosols make up the remaining 1%. The trace gases include argon, neon, helium, krypton and xenon; hydrogen; and the greenhouse gases. The water vapour content of air can also be significant, but is highly variable with time and from one region to the next. In some locations it can be virtually absent, while in others it can represent a few percent of air volume. Most air is found in the lowest 10 kilometres of the atmosphere.

Albedo - The fraction of solar energy (shortwave radiation) reflected from the earth's surface back into space. When you look at the globe, you see that the clouds are mostly white but the ocean is a dark blue. The clouds have a higher albedo than the surface of the ocean.

Arctic circle - This is the parallel of latitude that runs approximately 66.5° north of the Equator. Within the Arctic Circle, the arctic sun is above the horizon for, at least, 24 continuous hours per year at the time of the summer solstice , and at winter solstice, the arctic sun is below the horizon for at least 24 continuous hours.

Atmosphere - The mixture of gases and aerosols the air that surrounds the earth in layers-, protecting us from dangerous cosmic rays, powerful ultraviolet (UV) radiation from the sun, and even meteors on collision course with earth. Although traces of atmospheric gases have been detected well out into space, 99% of the mass of the atmosphere lies below about 25 to 30 km in altitude, while 50% is concentrated in the lowest 5 km (less than the height of Mount Everest).

Biodiesel - A biofuel in which organically-derived oils (soybean or canola oils, animal fats, waste vegetable oils, or microalgae oils) are combined with alcohol and blended with conventional diesel fuel or used by itself (see also “Biomass power”)

Biofuel - See “Biomass power”

Biogas - Gas, rich in methane, which is produced by the fermentation of animal dung, human sewage or crop residues in an airtight container. It is used as a fuel for stoves and lamps, to run small machines and to generate electricity. Biogas fuels do not usually cause pollution to the atmosphere, and because they come from renewable energy resources they have great potential for future use.

Biomass - The total quantity or mass of living material within a specified area at a given time.

Biomass power - Biomass power is energy produced by the burning of biofuels plant material and animal waste, and specifically grown crops. Biomass material may include tree and grass crops, and forestry, agricultural and urban waste. It includes biogas (see “Biogas”), and other fuels such as wood, ethanol (an alcohol fuel made partly from corn), and agricultural waste. Unlike other renewable fuels, biofuel energy does release carbon dioxide into the atmosphere, but it only returns to the atmosphere as much as the plant removed through photosynthesis during its lifetime.

Biome - A very large ecosystem. There are six main biomes in the world: tundra, taiga (boreal forest); desert; tropical rainforest, savannah (grasslands); and marine. The climate in a region, along with the soil, terrain and elevation, helps to define what biome category it fits into.

Biotic - Refers to something in the environment that is alive, such as animals, plants, or bacteria

Boreal forest - See "Taiga."

Carbon cycle - The combined processes including photosynthesis, decomposition, and respiration by which carbon moves between the atmosphere, oceans, and living organisms. For example, carbon (in the form of CO_2 in plant sugar molecules) could be trapped in a plant. When that plant eventually dies and decays or burns, the carbon is once again released to the atmosphere. Living plants absorb carbon from the atmosphere, through photosynthesis, starting the cycle again.

Over very long periods of time (millions of years) the biomass from plants is buried under sediment and placed under extreme pressure that allows it to eventually form coal. This carbon is then removed from the active carbon cycle. Coal can be extracted from the earth and burned, thus releasing CO_2 into the atmosphere and returning it to the active cycle.

Carbon Dioxide (CO_2) - A heavy colourless gas that is formed especially in animal respiration and in the decay or combustion of animal and vegetable matter. CO_2 is absorbed from the air by plants in photosynthesis. It is one of the greenhouse gases.

Carbon sink - Carbon sinks are areas that absorb and hold onto lots of carbon dioxide oceans, soil and forests. A carbon "sink" can become a carbon "source." For example, a growing forest is a carbon sink as it absorbs more carbon than it releases. But when it burns, it becomes a carbon "source" as it releases lots of carbon into the atmosphere. (See "Carbon cycle.")

Climate - The average weather for a particular region and time period. In other words, climate is the weather you would expect to have in a particular region.

Climate change - Climate change is a change in the "average weather" that a given region experiences. When we speak of climate change on a global scale, we are referring to changes in the climate of the Earth as a whole, including temperature increases (global warming) or decreases, and shifts in wind patterns and precipitation.

CO_2 - See "carbon dioxide"

Convection - The transfer of heat by the movement of heated liquid or gas. Vertical rising of heat energy (heat convection) in the atmosphere occurs when a shallow layer of air in contact with a hot surface warms up, becomes more buoyant (warmer air is less dense than colder air), and rises, taking with it the energy that it has stored.

Crude oil - Crude oil is the mixture of petroleum liquids and gases (including impurities such as sulphur) that is pumped out of the ground by oil wells.

Diesel - Diesel is a fuel, which like gasoline, is refined from oil. It is heavier and oilier than gasoline, and has a higher energy density. It is generally cheaper, too, because it needs less refining than gasoline. The diesel engine is a high-efficiency engine that uses higher compression than gasoline engines. The efficiency of the engine and the energy density of the fuel, means that diesel engines generally get better mileage than equivalent gasoline engines.

Deforestation - Deforestation is the removal of trees from an area because of changes in land use. Trees absorb carbon dioxide from the atmosphere by photosynthesis, helping to control the greenhouse effect. Deforestation releases significant amounts of CO_2 into the atmosphere because of soil disturbance, burning, and removal of above ground biomass from the ecosystem.

Desertification - Long-term damage to dry lands caused by drought and by human activities such as over cultivation, deforestation, and poor irrigation practices that turn the land into a desert, unable to grow anything. Existing dry lands, which cover over 40% of the total land area of the world, mainly in Africa and Asia, are most at risk for desertification resulting from drought caused by climate change.

Drought - Long periods without any rain.

Ecosystem - The community of all of the living things in an area. It includes surroundings, plus all the ways in which the living things interact with each other and their surroundings.

Energy - Energy comes in different forms heat (thermal), light (radiant), mechanical, electrical, chemical, and nuclear. There are two types of energy stored (potential) energy and working (kinetic) energy. For example, the energy from the food that you eat is stored in your body as chemical energy until you use it. Much of the energy we use comes from non-renewable sources such as fossil fuels (coal, oil and gas). Renewable energy sources include solar power, wind power and hydroelectric power.

Energy audit - An assessment of how much energy your home consumes, combined with suggestions on how you can make your home more energy-efficient. An audit shows you where your house is losing energy, and how your insulation, heating and cooling systems could be made more efficient. You can perform a simple energy audit yourself, or have a professional energy auditor carry out a more thorough audit.

El Nino - Southern Oscillation - a decadal phenomenon which occurs in the southern Pacific ocean, which rises the average temperature of the oceans by at least 1 degree.

Evaporation - The process of turning water to vapour (from a liquid to a gas). At 100ºC, the boiling point, all water will rapidly be turned to vapour, because the energy supplied to heat the water is enough to break apart all the molecular bonds. At temperatures between 0ºC and 100ºC, only some of the molecules in the water have enough energy to escape to the atmosphere and the rate at which water is converted to vapour is much slower. The rate of evaporation depends on temperature of the air (an increase of 10ºC will double the rate of evaporation) and the dryness or humidity of the air will (drier air has a greater "thirst" for water vapour than moist air). Evaporation is an important part of the water cycle.

Feedback loops - (positive and negative) In the climate system a "feedback loop" refers to a pattern of interacting processes where a change in one variable, through interaction with other variables in the system, either reinforces the original process (positive feedback) or suppresses the process (negative feedback). For example, increased global warming will cause increased evaporation, leading to increased cloud cover. This increased cloud cover could have a positive feedback effect on global warming, because it will insulate the earth, keeping more heat in. But it could also have a negative feedback effect, because clouds have a lot of reflectivity, and could reflect more solar energy into space.

Food chain - A food chain is a sequence of organisms, each of which uses the next lower member of the sequence as a food source. Algae, for instance, are at the bottom of the marine food chain. Plankton eat algae and are in turn eaten by fish, which are then eaten by seals. These different layers are sometimes called links in the food chain.

Fossil fuels - Fossil fuels are fuels containing carbon coal, oil and gas that were formed over millions of years through the decay, burial and compaction of rotting vegetation on land, and of marine organisms on the sea floor. Burning fossil fuels is the major way in which humans add to the greenhouse gases in the atmosphere.

Geothermal energy - Power generated by the harnessing of heat from the interior of the earth when it comes to -or close to the earth's surface. The regions with highest underground temperatures are in areas with active or geologically young volcanoes. The term geothermal energy is also sometimes used to describe ground source heating (see "ground source heating")

GHGs - See "Greenhouse gases."

GHG emissions - The greenhouse gases we discharge into the air. The major emission adding to the greenhouse effect is carbon dioxide (CO_2), but other greenhouse gases, such as methane and nitrous oxide, trap heat more efficiently than CO_2 and thus have a higher impact per unit emitted.

Glacier - A very large body of ice moving slowly down a slope or valley or spreading outward on a land surface

Global warming - The earth has warmed up by about 0.6°C in the last 100 years. During this period, human emissions of greenhouse gases have increased, largely as a result of the burning of fossil fuels and deforestation. Scientists now think that these increased emissions, leading to the enhanced greenhouse effect, are the cause of global warming.

Greenhouse effect - The effect produced by greenhouse gases allowing incoming solar energy to pass through the Earth's atmosphere, but preventing most of the outgoing heat from the Earth from escaping into outer space. This effect, which is necessary to maintain life on earth, helps to keep the Earth 33°C warmer than it would be without the presence of an atmosphere. Unfortunately, because of excess GHG emissions, the GHGs are now trapping too much heat. This is sometimes called the enhanced greenhouse effect.

Greenhouse gases (GHGs) - Gases such as water vapour, carbon dioxide, methane and nitrous oxide, that allow incoming solar radiation to pass through the Earth's atmosphere, but prevent most of the outgoing infrared (heat) radiation from the surface and lower atmosphere from escaping into outer space. See also "GHG emissions."

Ground source heating - A system that captures the earth's underground warmth in pipes, and transfers it into a building using a heat-pump.

Habitat The natural environment of a plant or animal, including its food supply, climate, and shelter

Hydropower - Hydroelectric energy uses the force of moving water to create electricity. Generally, the water is dammed and released in controlled amounts through a system of turbines. Large-scale hydropower currently accounts for about 20% of the world's electricity supply.

Idling - The practice of keeping a vehicle engine running, without moving the vehicle. Excessive idling wastes an enormous amount of fuel and money and generates needless greenhouse gas emissions.

Intergovernmental Panel on Climate Change (IPCC) - A panel set up by the United Nations in 1988 to review scientific information on climate change. This panel involves over 2,000 of the world's climate experts. Many of the climate change facts and future predictions we read about come from information reviewed by the IPCC.

Kyoto Protocol - In December 1997 in Kyoto, Japan, industrial nations agreed to reduce their collective emissions of greenhouse gases by 5.2% from 1990 levels by the period 2008 to 2012. 160 countries have endorsed the Kyoto Protocol. In order for the Kyoto Protocol to come into force, 55 countries that produced 55% of the developed world's 1990 carbon dioxide emissions must now ratify it. The European Union ratified in May 2002, Japan in June 2002, and Canada in December 2002. However, those ratifying so far only collectively represent about 44% of developed country emissions. The United States has decided not to ratify the Protocol and Russia is still undecided about ratification. If Russia ratifies, the Protocol will come into force.

Methane - A colourless, odourless, non-toxic gas that is produced by organic matter decomposing in an environment without much oxygen a landfill or a swamp, for instance. Methane is one of the greenhouse gases, and is the main ingredient in natural gas. Methane is also a biogas fuel (see "Biogas") a renewable energy source, increasingly used as a source of power on large farms where there is lots of animal manure.

Model (climate) - A climate model is a method of simulating the behaviour of the climate, to give us a picture of past climates, and to predict future climate change. The basic laws and other relationships necessary to model the climate are expressed as a series of mathematical equations. The climate however, is a very complex system, and climate models require supercomputers to calculate the complicated interactions between landforms, atmosphere and emotions.

Nitrous Oxide - A colourless, non-flammable gas with a sweetish odour, commonly known as "laughing gas," and sometimes used as an anaesthetic. Oceans and rainforests naturally produce nitrous oxide. Nitrous oxide is produced by a range of human activities including: nylon and nitric acid production; the use of fertilizers in agriculture, use of catalytic converters in cars and the burning of organic matter. As are carbon dioxide and methane, nitrous oxide is a greenhouse gas.

Non-renewable energy - Energy that can be used only once. Most non-renewable sources of energy (oil, gas and coal) produce greenhouse gases when they are used.

Oil - Oil (sometimes called petroleum) is formed from the decayed remains of animals and plants. Under the influence of heat and pressure, the decayed matter breaks down first into liquids and into gases. Both the liquid (petroleum) and gas phases (natural gas) collect in pools under the earth's surface. After a drilling and pumping process to extract it, oil is refined and turned into a variety of petroleum-based products.

Permafrost - The layer of permanently frozen ground that underlies nearly half of Canada and much of Tibet, existing wherever ground temperatures remain below 0º C (on average) throughout the year, and where summer heat fails to reach it.

Petroleum products - Petroleum is another word for oil (see "Oil"). After being pumped up from the earth, petroleum is refined and turned into many products, including kerosene, benzene, gasoline, paraffin wax, and asphalt. Other materials that we use every day, like plastic and nylon, are also petroleum-based products.

Photosynthesis - The process by which green plants use light to synthesize organic compounds from carbon dioxide and water. In the process, oxygen and water are released. Plants create a very important reservoir (or "sink") for carbon dioxide. See "Carbon cycle" for more on this.

Photovoltaic cells - Cells, usually made of specially-treated silicon, that transfer solar energy from the sun to electrical energy.

Precipitation - Rain, hail, mist, sleet, snow or any other moisture that falls to the earth.

Radiative forcing - The measure of the influence that a factor has in altering the balance of incoming and outgoing solar, and is an index of the importance a gas has in causing global warming. A positive forcing causes global warming, while a negative forcing causes global cooling. It is measured in watts per sq. meter. The cumulative radiative forcing effect of all the GHGs combined is + 1.6 watt/mt^2.

Ratification - A procedure where a country formally accedes to and agrees to comply with an international treaty after completing its parliamentary approval.

Reflectivity - The fraction of solar energy reflected from a surface (as compared to the fraction that is absorbed by the surface). See also "albedo."

Renewable energy - Energy that comes from sources such as sun, wind and falling water sources available in an unlimited supply. (See "Solar power," "Wind power," "Hydro power," "Geothermal energy," and "Biomass power.")

Sequestration - the natural process of capturing carbon dioxide from the atmosphere and binding it permanently, occurring in trees, oceans and soils.

Small-scale hydro - Small hydro-electric power generating projects that vary in size from 5 kw to 30 MW, which either use a "run-of-the-river" turbine, or a small dam to generate power.

Solar power - Energy derived directly from the sun. Passive solar heating involves the design of homes and other buildings to make full use of direct sunlight for heating purposes. Houses can be designed with large windows in the south facing walls and small windows in the north facing walls, reducing the need for other heating sources such as electricity or fossil fuels. Active solar heating includes the use of solar panels to heat large tanks of water mainly for domestic hot water systems and swimming pools. Active solar radiation also includes the use of photovoltaic cells, where the solar energy is converted to electricity.

Sub arctic - Sub arctic regions lie just south of the Arctic Circle, characterized by very cold winters, and brief, often warm, summers. This kind of climate offers some of the most extreme seasonal temperature variations found on the planet. In winter, temperature can drop to -40º and in summer, the temperature may rise to 30º C above zero. Vegetation in sub arctic climates is usually sparse, as only hardy species can survive the long winter and make use of the short summer.

Taiga - One of the six biomes, taiga is another word for boreal forest. Taiga exists in northern areas that have 40-100 centimetres per year of precipitation, much of it snow. The forest contains conifer species (Abies, Picea, Larix, and Pinus), and some deciduous trees. Ground cover is mostly mosses and lichens.

Thermal power station - power stations that produce electricity by burning coal and its derivates, natural gas, oil etc for producing heat to drive electricity generating turbines

Tidal energy - Tidal changes in sea level can be used to generate electricity by constructing dams across coastal bays or estuaries which have large differences between low and high tides. The difference in water levels creates water pressure that can drive turbines, creating electricity.

Tundra - One of the six biomes, tundra is the open Arctic terrain between the treelike and the ice regions of the far north. Shrubs and small vegetation grow on the tundra that covers much of Nunavut, the Northwest Territories and northern Yukon.

Turbine - A mechanism that spins to create power. It is made up of a rotor with blades or cups. Moving water, air, steam or gases turn the blades or cups. This spinning action activates a generator to create electricity.

Water cycle - The water cycle is the movement of water from the surface of bodies of water, to the atmosphere, to precipitation. Water vapour enters the atmosphere by evaporation from surface bodies of water and from plants and trees. When the air becomes saturated, excess water vapour is released as condensation. This condensation is the source of all clouds and precipitation. The cycle of evaporation, condensation and precipitation is called the water cycle of the earth and atmosphere.

Weather - The specific condition of the atmosphere at a particular place and time. It is measured in terms of such things as wind, temperature, humidity, atmospheric pressure, cloudiness, and precipitation**.** In most places, weather can change from hour-to-hour, day-to-day, and season-to-season. (For more on long-term weather patterns, see "Climate.")

Wetlands - Areas that are neither fully terrestrial nor fully aquatic. In wetlands, the water table is at, near, or above the land surface, or the area is saturated for long periods. Currently, wetlands cover about 14% of Canada. Most of these wetlands are found in the Prairies and southern NWT, but there are also important ones in the northern Yukon. These wetlands provide important homes to rare or threatened species, particularly birds.

Wind power - Air moves around the earth because of the differences in temperature and atmospheric pressure that exist. Wind turbines harness the movement of air to produce energy. The wind turns the blades, which turn a rotor shaft. This produces mechanical power used to drive an electric generator.

Combating Climate Change Through School Level Activities

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