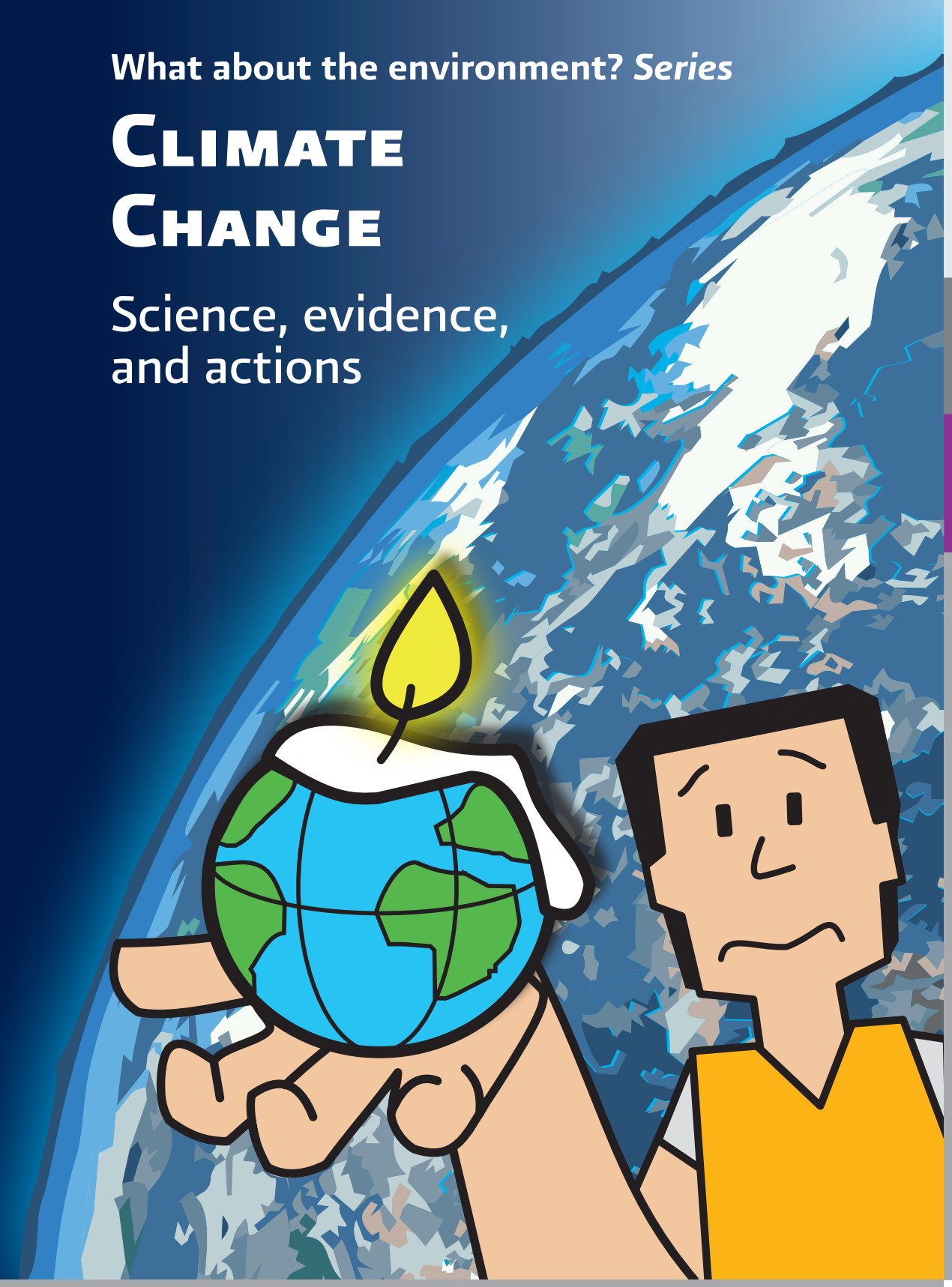
What about the environment? *Series*

Climate Change

Science, evidence, and actions



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For more information about this book please contact:

General Direction of Statistics and Environmental Information
Direction of Analysis and Environmental Indicators
Boulevard Adolfo Ruiz Cortines No. 4209
Jardines en la Montaña, CP 14210
Tlalpan, México D. F.

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Index boxes

Is climate change real? Is it the true cause of the high temperatures, strong hurricanes and droughts that we have experienced over the last years? Should we worry about it? Is anything being done on this regard?

If you already had doubts about climate change or if we raised your curiosity with these questions, this book is meant for you. Climate change -which, until a few decades ago, was only of the interest of scientists- has now become a common topic in television and radio shows, newspapers and common conversations. Upon enduring the hardships of a hot day, a pouring rain, gales or floods, most people would mention climate change as the likely cause. It seems that climate change has become the favourite villain to be blamed of every natural disaster occurring in the planet.

In this book you will find answers to many of your doubts about climate change and to others that will emerge as you proceed. In the end, you will have the bases to regard this problem in its true dimension and, if you choose to keep it as your favourite villain, to blame it only for what it is really responsible.

Being this a book about climate change, first we have to set common criteria and agree on what we understand for climate change and what the difference with global warming is, as these two terms are often confused.

What is climate change?

Scientists define climate change as "...any change in climate over time, whether due to natural variability or as a result of human activity." Global warming, on the other hand, is the most evident expression of climate change and it refers to the increase in the average temperature of Earth's near-surface air and oceans.

Although climate does change due to natural causes, experts point out that clear evidence does exist indicating that the planet warming recorded over the last 50 years can be attributed to the effects of human activities. Further details about natural variations in climate can be found in the ***Box Natural climate variability.***

The Earth: A huge greenhouse

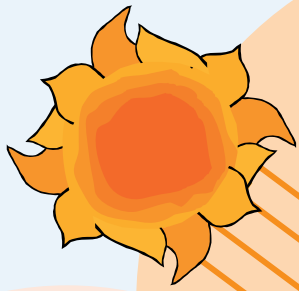
Life on Earth depends on, among other factors, a thin layer of gas, the atmosphere. The atmosphere is a mixture of gases in which nitrogen (78.1%) and oxygen (20.9%) predominate, along with small amounts of argon (0.93%). The tiny remaining amount is made up by water vapour, ozone, carbon dioxide, hydrogen, neon, helium and krypton. These gases are scattered, in varying amounts, among the five layers that scientists have divided the atmosphere into for study purposes (Figure 1). Among the most important functions of the atmosphere are its role as a filter for ultraviolet radiation reaching the Earth, its protective action destroying a large number of meteorites which, otherwise, would impact the Earth's surface and its role as a temperature control through the so-called greenhouse effect.

If you have entered into a greenhouse, you might have noticed the higher temperature inside than outside. This is mostly due to the structure's glass walls which let the Sun radiation go through but do not let it to escape easily, thus producing a heating effect. The Earth works very much like a huge greenhouse, with the effect of glass being produced by the gases in the atmosphere. The atmosphere gases affecting temperature are called greenhouse gases (GHG) and are mainly carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), ozone (O_3) and water vapour. These gases let the Sun radiation get through, then reaching the Earth's surface and oceans

Natural climate variability

Factors affecting regional climate

Climate is defined as the average state of atmospheric conditions (temperature, rainfall, pressure and humidity) in a given region. Climate varies from region to region and through time. In the following figures we describe the causal factors of such differences.

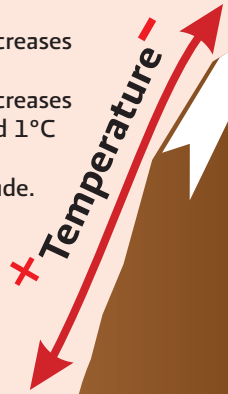


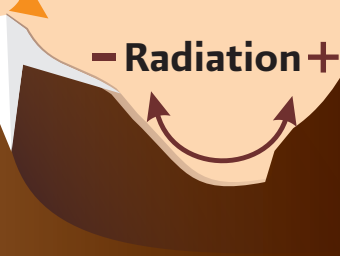
SLOPE ASPECT

A site directly facing the Sun will receive more radiation and its temperature will be therefore higher than another site that is less exposed to sunlight.

ALTITUDE

Temperature decreases with altitude. Temperature decreases between 0.5 and 1°C for every 100 m increase in altitude.



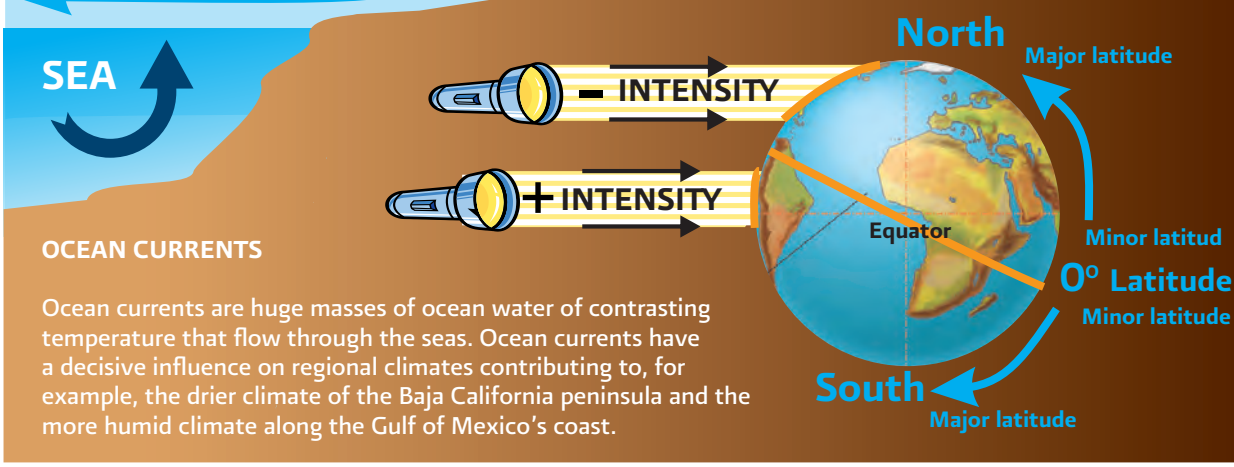


CONTINENTALITY

Distance to the sea affects humidity and temperature. Sea breezes blowing inland bring additional humidity in.

LATITUDE

Latitude is a measure of distance from the Equator. Latitude affects the angle at which sunlight strikes the Earth: closer to the Equator sunbeams strike the Earth with greater intensity all year long –leading to higher temperatures–, than near the Poles where sunlight shines on the earth at a lower angle, thus reducing its intensity and leading to lower temperatures–



OCEAN CURRENTS

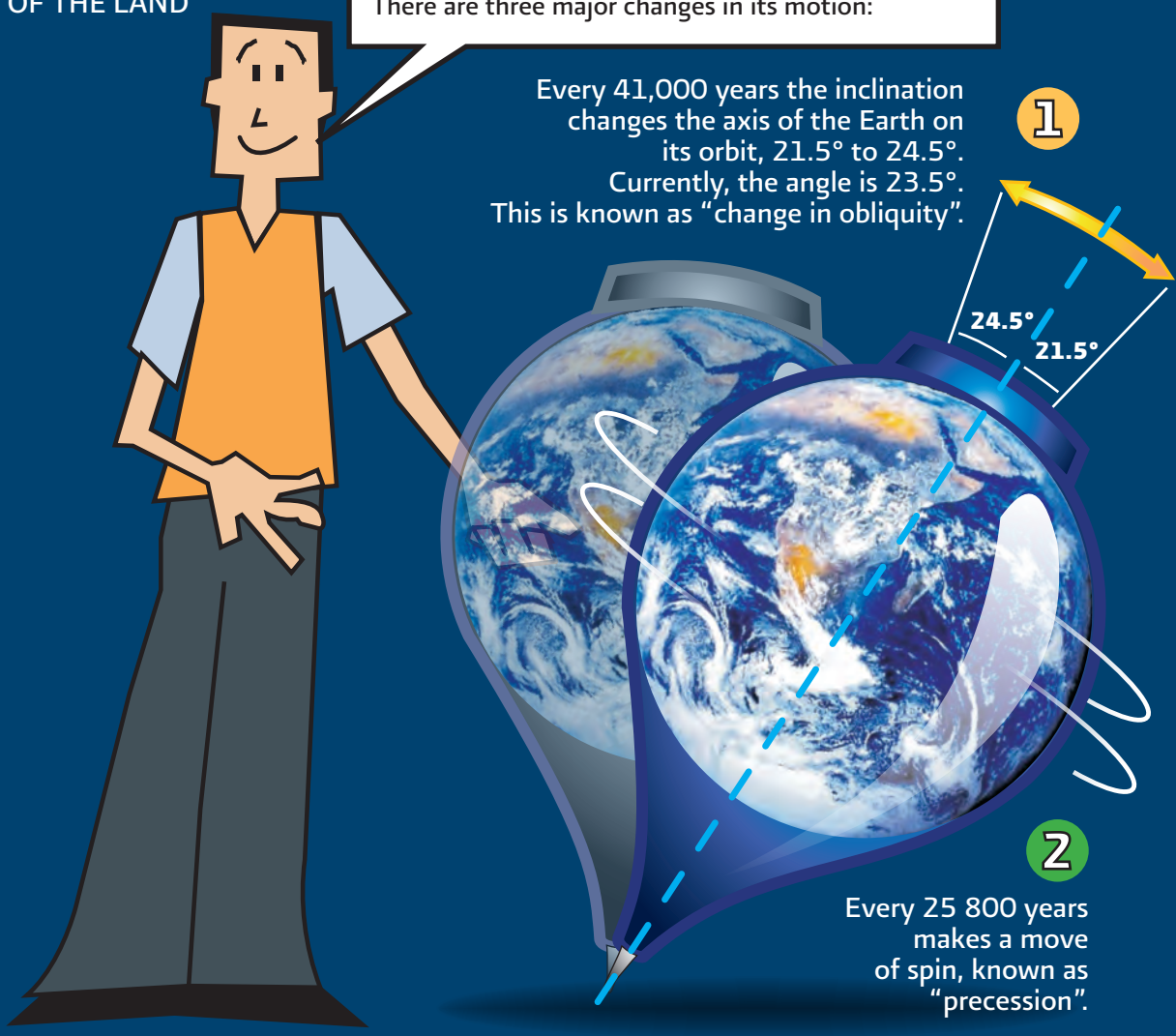
Ocean currents are huge masses of ocean water of contrasting temperature that flow through the seas. Ocean currents have a decisive influence on regional climates contributing to, for example, the drier climate of the Baja California peninsula and the more humid climate along the Gulf of Mexico's coast.

Factors that affect the climate temporarily

MOVEMENTS OF THE LAND

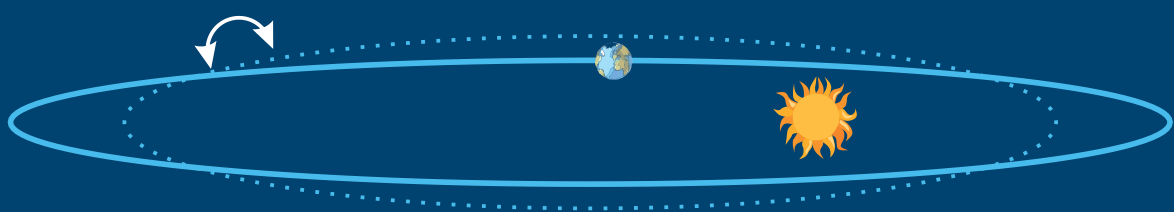
Earth's trip around the sun does not always the same. There are three major changes in its motion:

Every 41,000 years the inclination changes the axis of the Earth on its orbit, 21.5° to 24.5°. Currently, the angle is 23.5°. This is known as "change in obliquity".



Every 25 800 years makes a move of spin, known as "precession".

3 Every 100,000 years the Earth's orbit changes to more elliptical shape. This movement is called a "change in the eccentricity."



These changes produce a reduction in the sunlight that Earth receives, so that the ice that form in the winter does not melt and accumulate, resulting in the so-called ice ages.

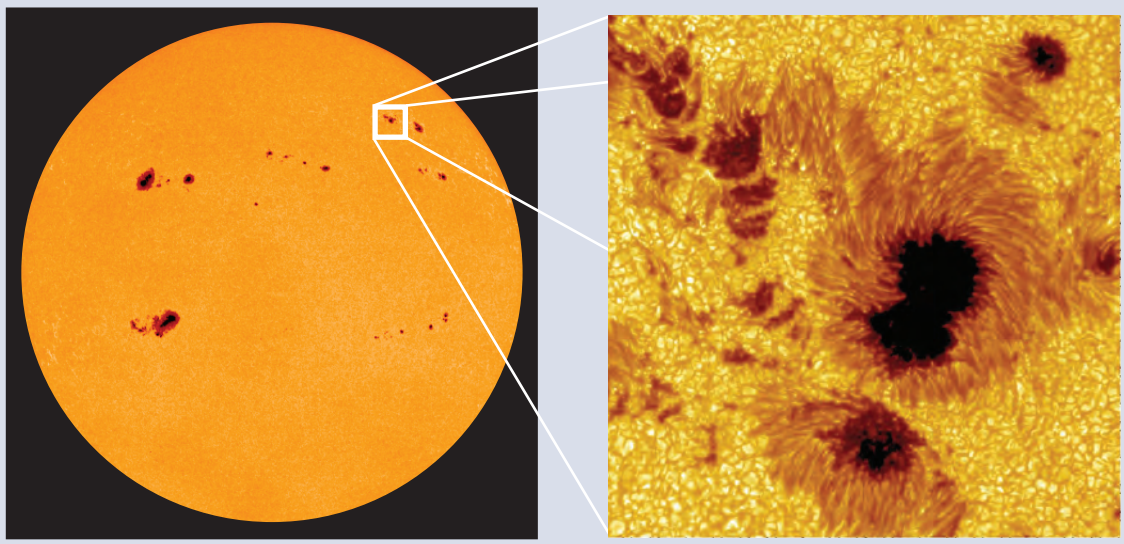
Natural climate variability (conclusion)

Box

SOLAR ACTIVITY

Sunspots are dark spots on the surface of the Sun which can only be seen with special filters. When the Sun bears a larger number of spots (approximately every 11 years), it radiates more energy and, consequently more energy reaches the Earth's surface too. Although solar activity does influence the Earth's climate, its effects are transient and short term.

Warning:
Do not attempt to watch sunspots directly or through undeveloped film, it might seriously damage your eyes!



where is transformed into heat, that is, infrared radiation. Part of that radiation remains in the oceans and continents but some other part is re-emitted to the atmosphere. It is then when the greenhouse gases stop part of that infrared radiation (Figure 2). Lacking this phenomenon, the Earth's temperature would be some 33°C colder, the planet's water would be frozen and life, as we know it today, might have not evolved.

As greenhouse gases are one of the major factors controlling the atmosphere temperature, it is easy to understand why an increase in the concentration of GHG can modify the natural flow of energy. Theory says that the greater the amount of GHG, the larger the amount of heat that will be trapped and the planet's surface will then reach a higher temperature. That is, the re-emission of energy towards the space becomes less efficient. Any process that alters this balance, through changes either in the incoming or the outgoing radiation or in its distribution on the Earth, will lead, sooner or later, to changes in climate.

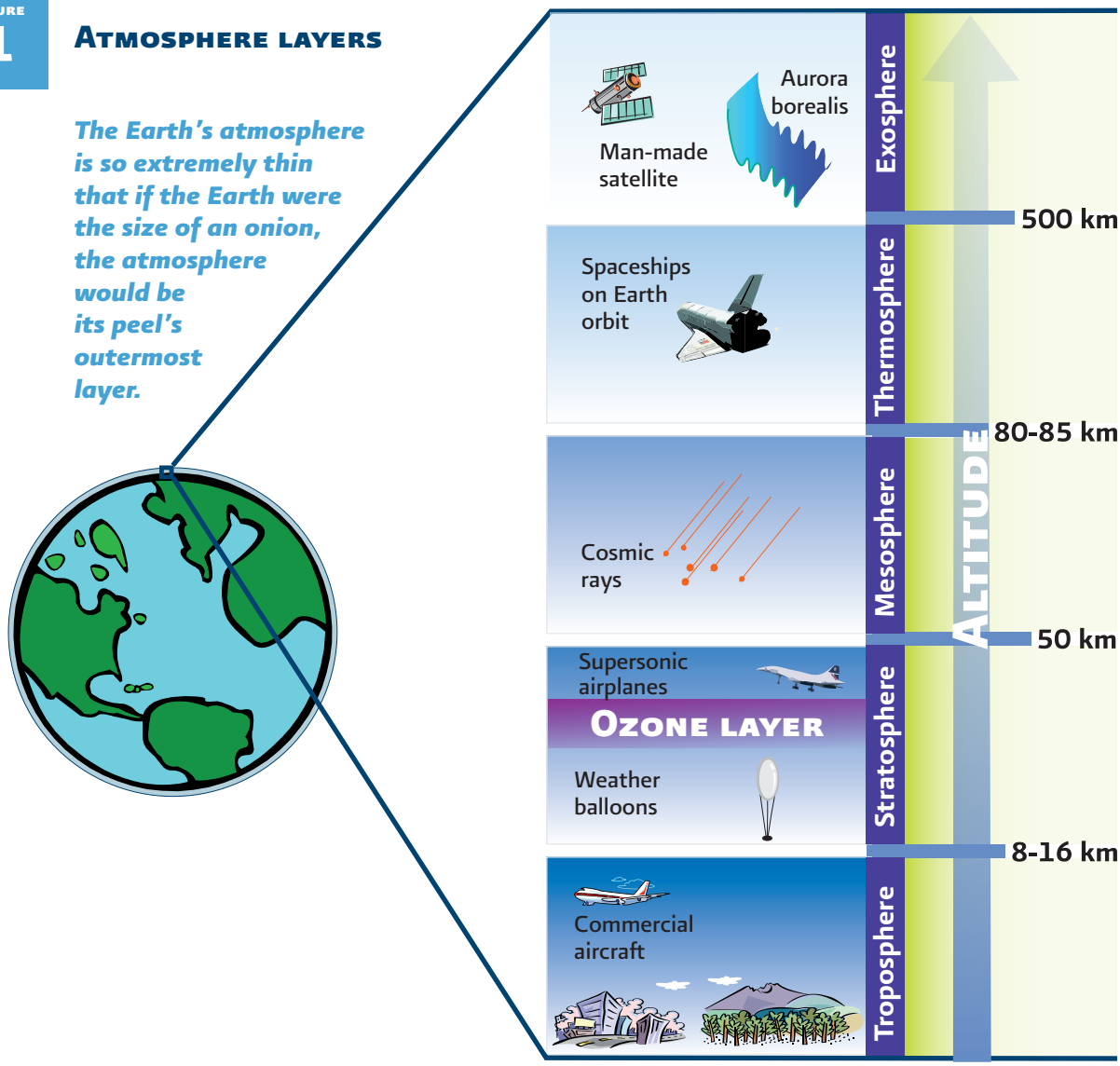
Where do greenhouse gases come from?

Greenhouse gases (GHG) are not a man-made invention; they have existed for billions of years,

Figure 1

Atmosphere layers

The Earth's atmosphere is so extremely thin that if the Earth were the size of an onion, the atmosphere would be its peel's outermost layer.

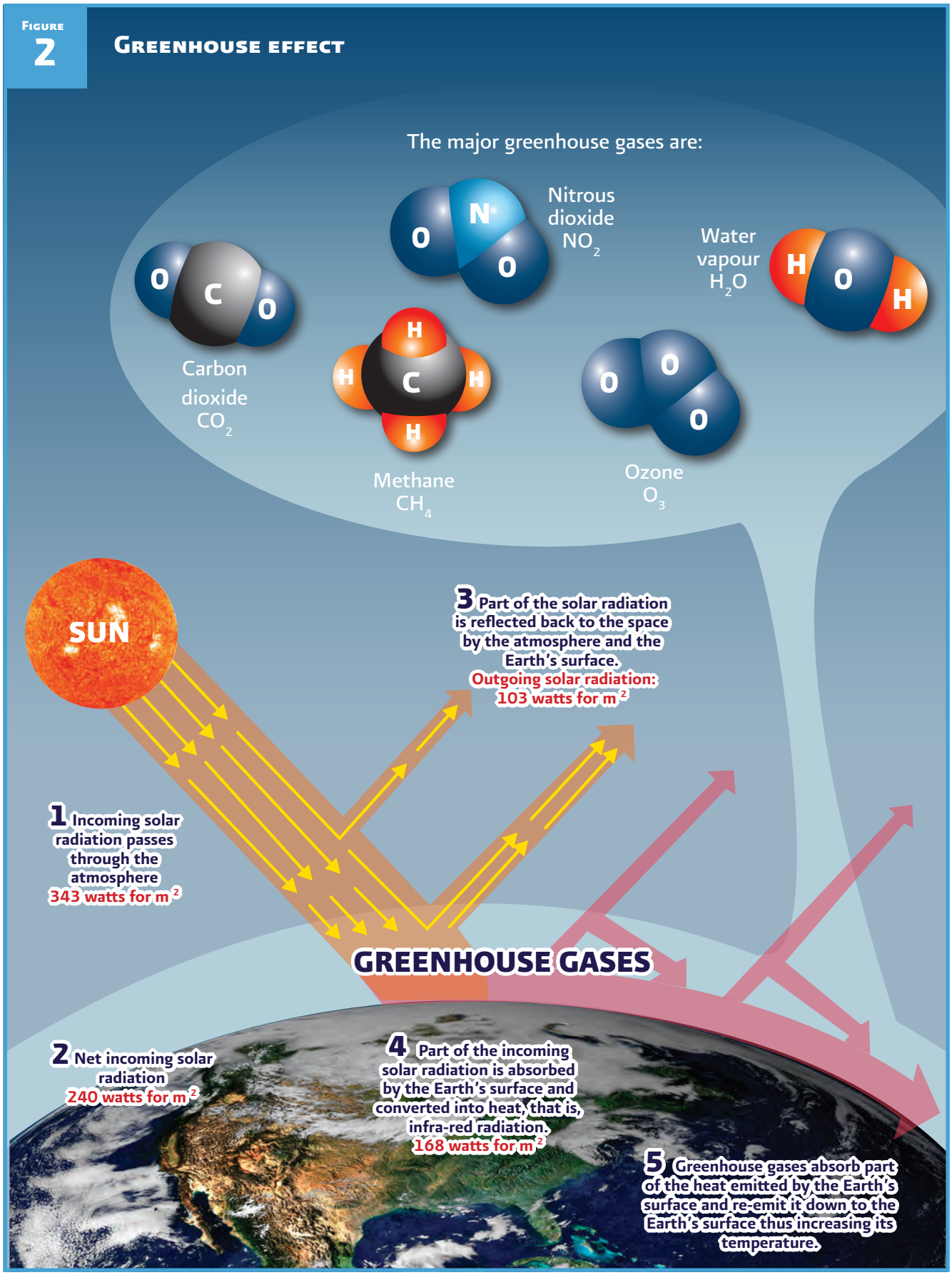


produced by natural sources such as volcanism, vegetation and the oceans. For example, during volcanic and hydrothermal eruptions, huge amounts of CO_2 and water vapour are generated. Biological processes such as the respiration by animals and plants and the microbial decomposition of organic matter all contribute to the natural generation of GHG.

However, human beings also contribute to the generation of GHG. Since the origins of industry and the use of fossil fuels such as oil, natural gas and coal (if you want to learn more about these fuels, look at the ***Box From methane to oil, fossil fuels***), humans have thrown huge amounts of GHG into the atmosphere and, by doing so, have contributed to increase their concentration in the atmosphere. In order to discriminate natural from human-related sources of GHG, the latter are called "anthropogenic sources". Through these sources, humans have modified the natural flow of GHG between natural sources and the atmosphere (see ***Box Carbon cycle***). It is precisely the GHG that humans have generated that are blamed for the recent warming of the planet.

Figure 2

Greenhouse effect



Who is to be held responsible for climate change?

When environmental problems are mentioned, we often think that it is other people who cause them and, therefore, their solution is not in our hands. Apparently this also happens with regard to the emission of the GHG causing climate change. We usually do not associate the emission of those gases with our daily activities and, even less so, think that these might contribute to climate change. Generation of electricity, the use of fossil fuels such as gasoline and diesel, cement production for construction works, the removal of vegetation –which is known as land-use change–, as well as the production of food and other goods and services for our everyday use, do generate a large amount of greenhouse gases. That is: We are also part of the problem.

If you add up your individual emissions to those from your family, neighbours and the rest of the Mexican population, as well as those produced by industries, schools, households and offices throughout the country, you will get the total amount of GHG that is generated by anthropogenic sources in Mexico. If you had the same data for all the countries of the world and add them up, then you could know the total amount of emissions worldwide. This information is already available but, before we go into it, it should be kept in mind that due to differences in data availability, in some sections we will deal with all the GHG whereas, in some others, we will refer only to CO_2, which is the major GHG. Let us first look at the worldwide and region-wide emissions and then look at Mexico's contributions to those.

Worldwide emissions

Worldwide, the emission of CO_2 has increased with fossil fuel consumption, and this increase has been significant: Between 1971 and 2005, worldwide emissions from fossil fuel consumption increased about 90%; in 2005 alone, 27 billion tonnes of CO_2 were emitted throughout the world (Figure 3). This huge amount of CO_2 is equivalent to about 4,500 times the weight of the Cheops pyramid, the largest pyramid in Egypt.

Although all countries contribute to GHG emissions, some of them have contributed far more than others. Map 1 looks vastly different from what we have learned in geography lessons. Africa and Europe have lost their original shape, the US looks almost like a balloon, Canada has practically disappeared and Japan is no longer a small island but has become a large country. There are no mistakes in this map, what really happens is that each country's outline has been drawn in such a way that its size is proportional to its contribution to the global GHG emissions. That is, regions or countries with larger emissions appear accordingly larger in this map, while those with lower emissions appear proportionally smaller. It can be noticed that Mexico looks severely distorted, and this is due to the fact that its emissions are close to the worldwide average. Put in numbers, those regions of the world that in 2002 had the largest emissions of GHG were, apart from North America (which contributed 26% to the total emissions in that year), East Asia (15%), Western Europe (14%) and the Middle East (13%)[1].

[1]These figures include three GHG: carbon dioxide, methane and nitrous oxide.

Carbon cycle

Box

For a long time, scientists have studied the pathways followed by some chemical elements and their molecules in nature. As a result, scientists have described the so-called biogeochemical cycles, that is, the movement and transformations that elements undergo as a result of biological activity and chemical reactions occurring in the atmosphere, rivers, lakes, oceans, soils, rocks and also in living organisms. The most important biogeochemical cycles include the carbon cycle, the nitrogen cycle, the phosphorus cycle and the sulphur cycle.

The carbon cycle is one of the most important ones as life on Earth is made up of carbon compounds. The carbon cycle involves the atmosphere, the Earth's crust, soils, water bodies (oceans, lakes, rivers, etc.) and living organisms. Before describing this cycle in detail, we should point out that it involves two phases: The geologic phase, which takes millions of years to be completed, and the biological phase, which is completed over rather short periods of time, ranging from a few days to thousands of years.

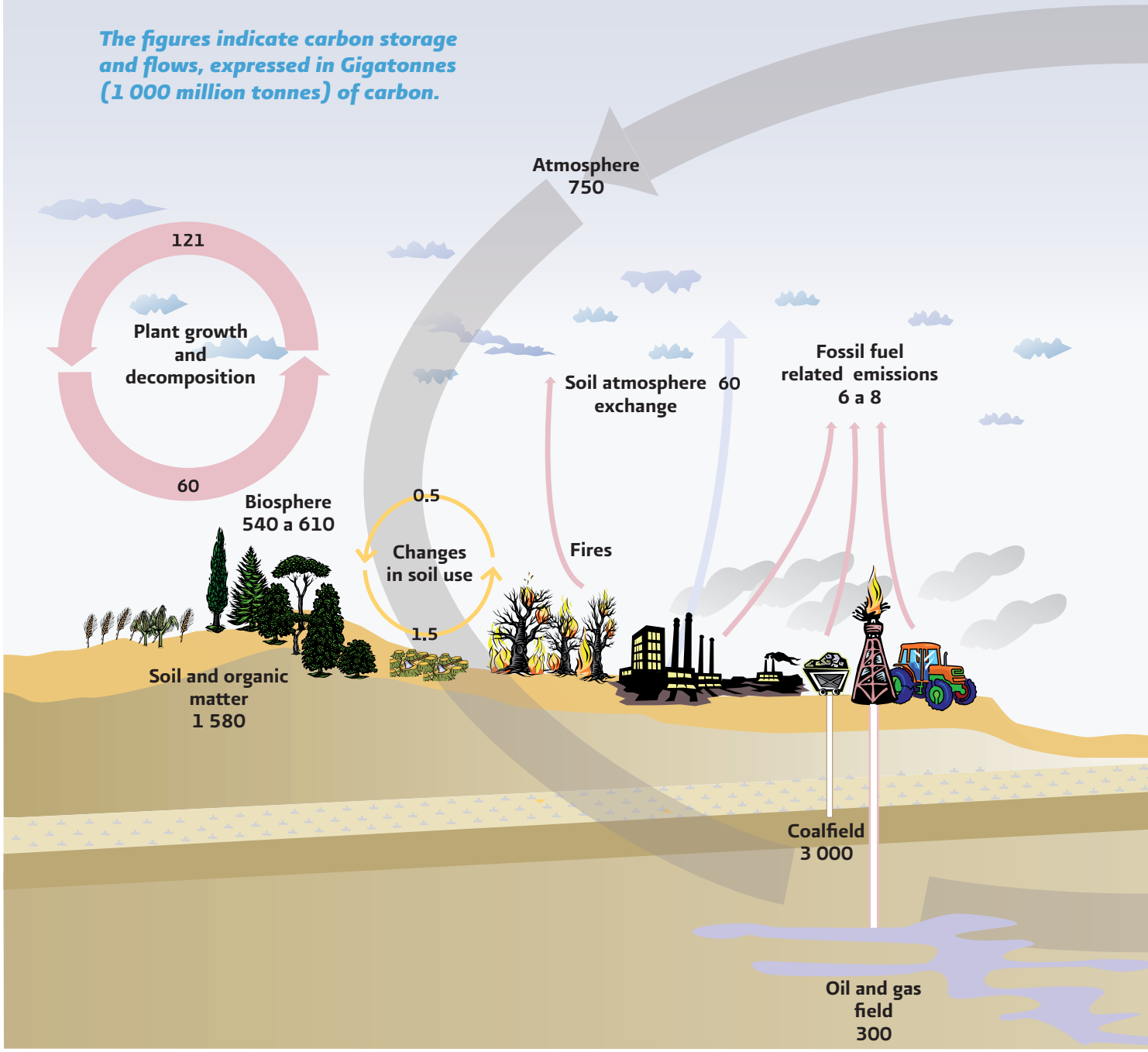
Let us start by describing the biological phase. Carbon is naturally found in the atmosphere –as carbon dioxide or methane- as a result of the decomposition of organic matter, wildfires, and emissions from volcanoes or from living organisms. Plants absorb CO_2 from the atmosphere and, through photosynthesis, use it for building up plant structures (stems, leaves, roots, flowers, fruits and seeds). Carbon can remain in plants and ecosystems for a long time either in the woody parts of trees or in the litter covering the soil. Nevertheless, it can also be used as food for herbivores. Carbon returns to the atmosphere through animal respiration and digestion and through the decomposition of animal waste, plant debris and litter. That way, carbon comes back to the starting point closing the cycle.

The second phase of the carbon cycle is the so-called geologic phase which is far slower. Carbon dioxide contained in the atmosphere can dissolve in the ocean water where it is transformed into bicarbonate and combined with calcium to build up huge accumulations of limestone. This way, carbon becomes integrated into the Earth's crust and becomes the largest reservoir of carbon in the cycle. You might then ask: How is then carbon released from limestone? This is precisely one of the slowest processes of the carbon cycle. After a very long time, through volcanic activity or through the dissolution of limestone (for example, produced by rainwater), carbon is returned to the atmosphere in gaseous form as carbon dioxide, thus closing the cycle again. As can be seen in the figure, the atmosphere lies at the intersection of both phases as it is this reservoir where both, vegetation and the oceans can absorb carbon from in the form of CO_2.

Carbon cycle (conclusion)

What does all this have to do with climate change? The answer is simple: Human beings have introduced more carbon into the natural cycle through activities such as the destruction of forests, jungles and grasslands, the burning of coal, oil and natural gas and the raising of livestock.

The figures indicate carbon storage and flows, expressed in Gigatonnes (1 000 million tonnes) of carbon.



You might think that the world's oceans and vegetation should be able to absorb all that carbon dioxide and thus we should not worry about it. However, although oceans and vegetation are in fact able to absorb large amounts of CO_2, they are not capable of absorbing all the excess, and this has led to the increase in the concentration of CO_2 and other GHG in the atmosphere.

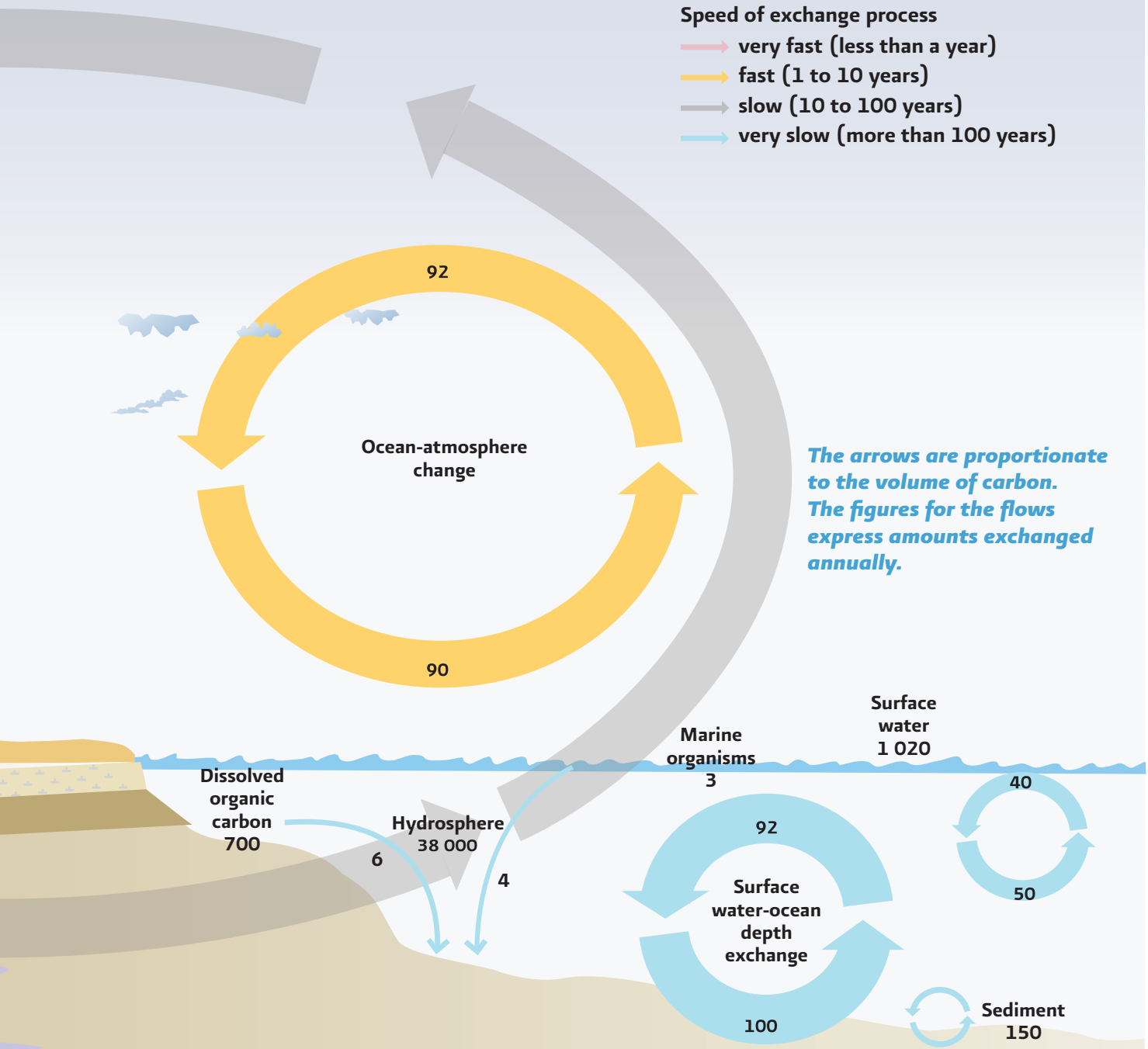
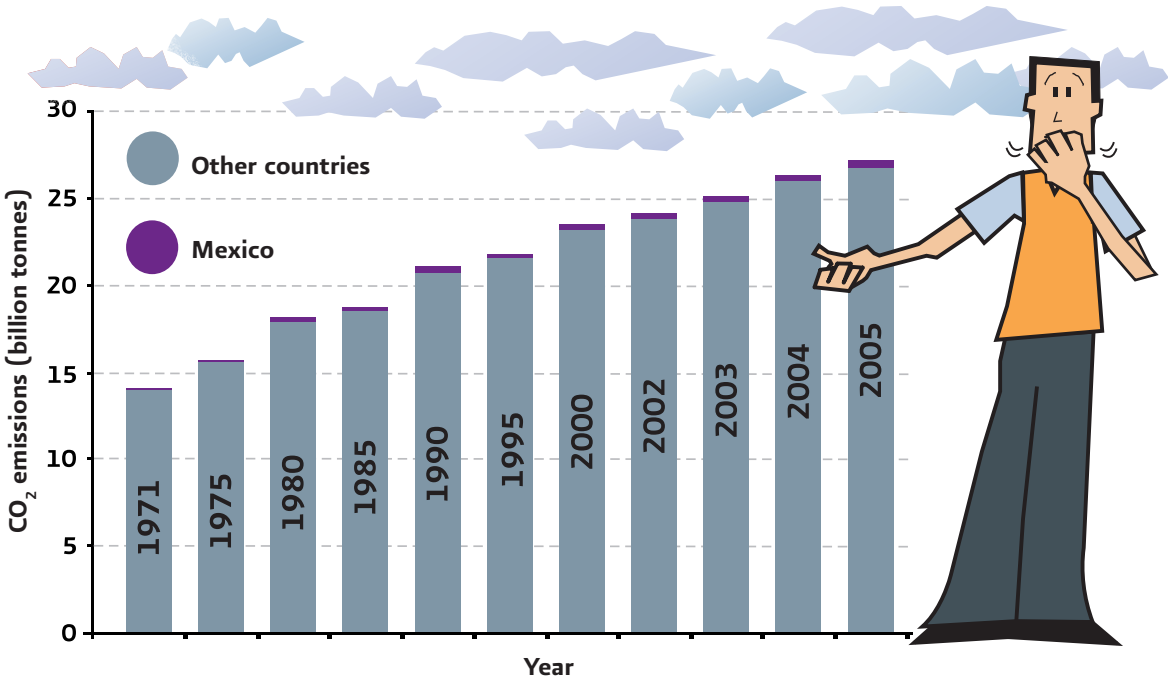


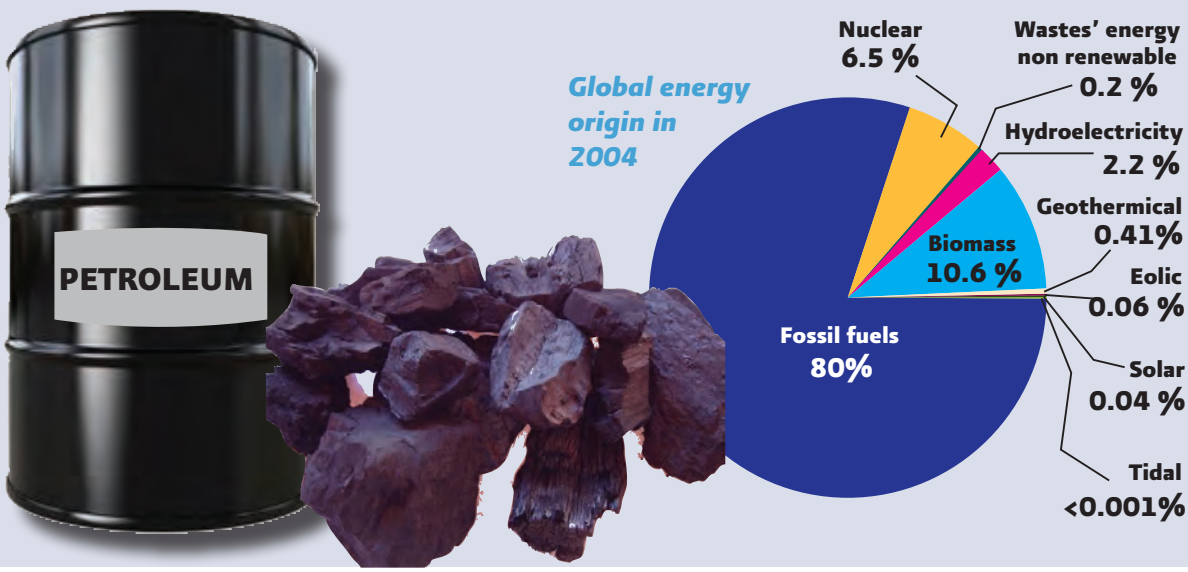
Figure 3

GLOBAL CO_2 EMISSIONS FROM FOSSIL FUEL CONSUMPTION BETWEEN 1971 AND 2005



From methane to oil: Fossil fuels

Fossil fuels are a diverse set of chemical compounds constituted mainly by carbon and hydrogen; these include from the highly volatile methane (CH_4) to the thick petroleum. Other important fossil fuels are coal and natural gas. Fossil fuels have formed over millions of years through slow processes in which the huge pressure and heat in the Earth's interior



Map 1

REGIONAL CONTRIBUTIONS TO GLOBAL GREENHOUSE GAS EMISSIONS IN 2002

In this map, the regions are depicted in such a way that their sizes are proportional to their greenhouse gas emissions. The inset in the left shows the original map with the regions' actual sizes.

Note:
The map denotes the accumulated emissions of carbon dioxide, methane and nitrous oxide, each weighted by its global warming potential.

Box

have transformed the organic remains of animals and plants. The importance of fossil fuels lies in the fact that they are the main source of energy used to power motor cars and buses, as well as many of the power plants that generate the electricity used in daily life. Fossil fuels have been the humankind's most important source of energy, more important than solar, wind, water and nuclear energy. However, fossil fuels have a downside: Their combustion releases large amounts of the greenhouse gases that are responsible for the climate changes that the planet is currently undergoing.

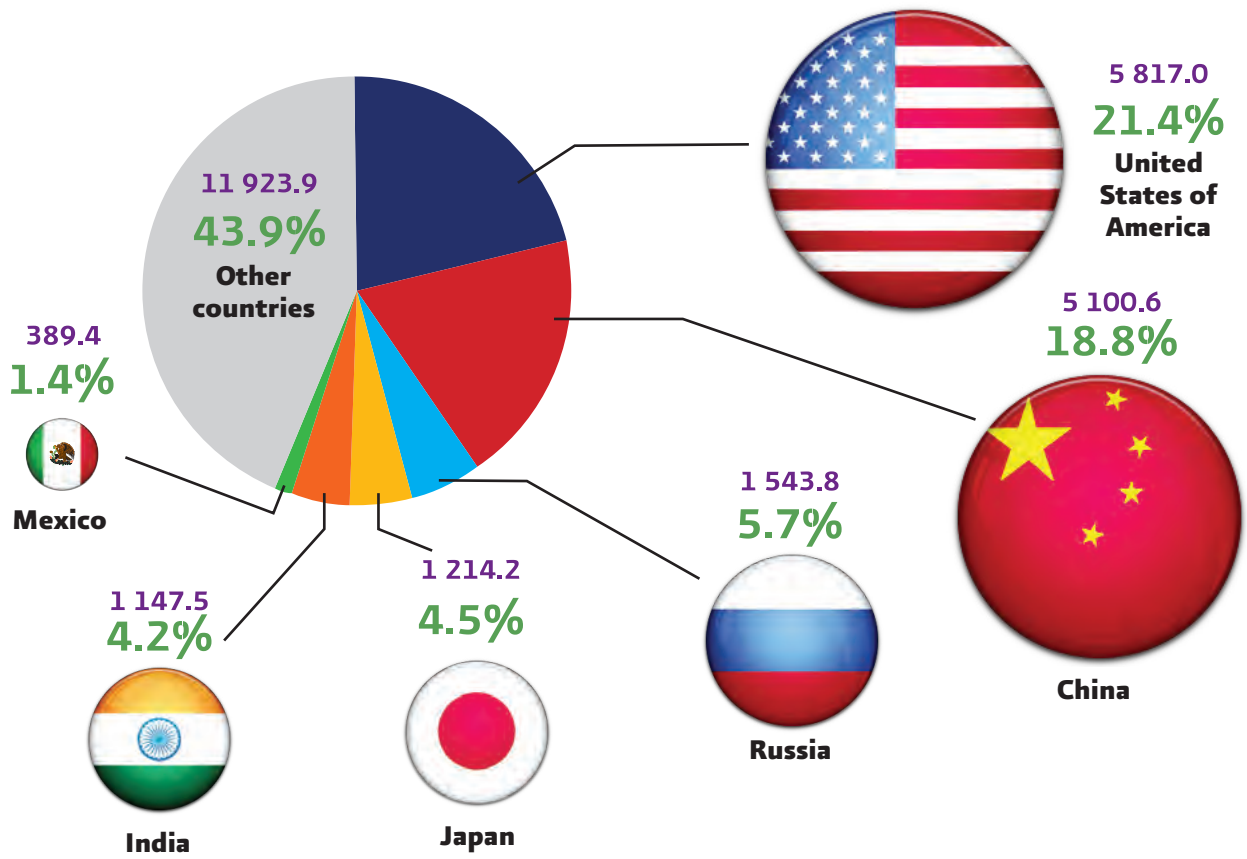
Let us now look at the country-level data for the year 2005. The US, China, Russia, Japan and India were the countries with the largest CO_2 emissions originating from fossil fuel consumption (Figure 4). In that year, those countries emitted a little over 54% of the world's total. At the same time, Mexico contributed with 1.4% of the total, ranking among the 15 largest emitters.

As GHG emissions are related to energy consumption, one would expect that those countries with the largest populations would have the largest emissions. However, this is not always the case. This is why it is important to also consider each person's emissions, as this would give us some idea of our individual responsibilities. The way to estimate this is by means of the average per capita emissions in each country[2]. For example, in

[2]This is easily calculated by dividing the country's total emissions by the number of inhabitants at a given time. Bear in mind that both figures should correspond to the same year.

Figure 4

Contribution of the major emitting countries and Mexico to global CO_2 emissions from consumption and flaring of fossil fuels in 2005. Million tonnes of CO_2 and percentage

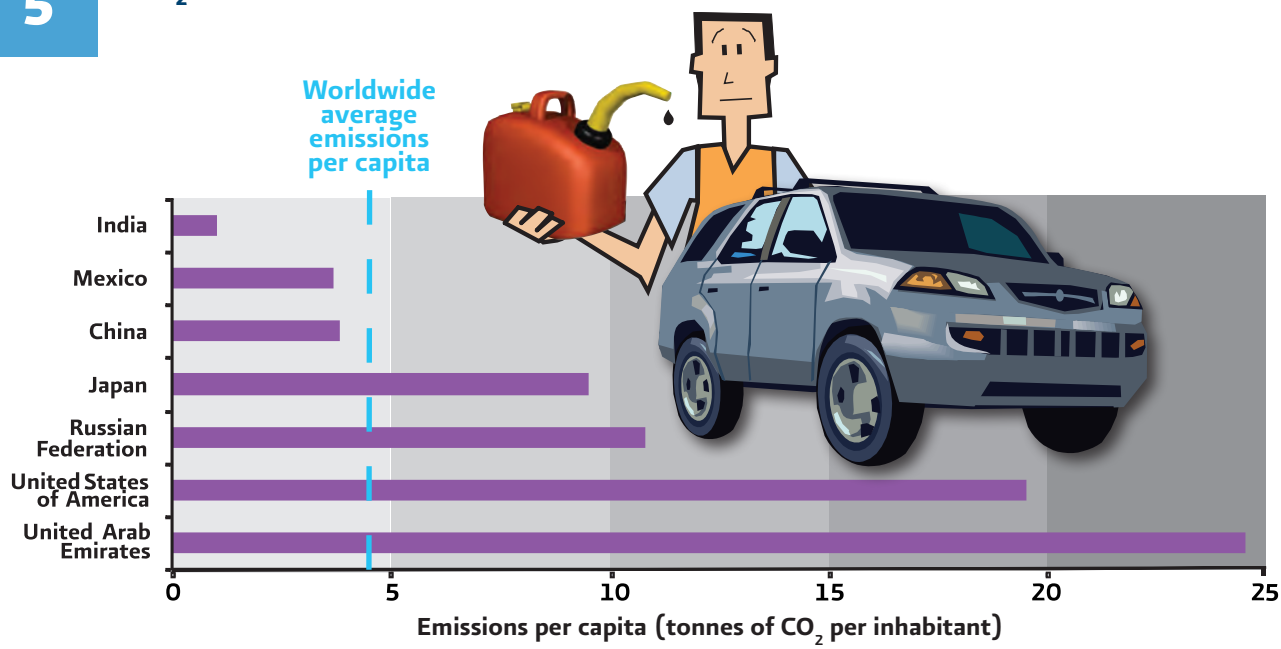


the United Arab Emirates, with a population of only 4.5 million people, each person emits some 24.5 tonnes of CO_2, whereas in China and India this figure amounts only to 3.85 and 1.04 tonnes of CO_2, respectively (Figure 5). This means that an Arabic person emits almost six times as much GHG as a Chinese and about 23 times as much as the average inhabitant of India. How can these differences be accounted for? The answer lies in the "life style" of each country's inhabitants. Emissions are related to the people daily activities, that is, to the way and the amount of things they purchase, the ways they use products, live in their households and use transportation, and other activities. For example, the more we depend on private cars, consume processed products and rely on electric appliances and electronics, the more we will be promoting, directly or indirectly, that industries use larger amounts of fossil fuels for their manufacturing and maintenance processes. All this will eventually lead to larger emissions of GHG to the atmosphere.

If you want to calculate the amount of CO_2 that is emitted from your daily activities, you can use the "Mexican CO_2 Calculator", available at the website www.calculatusemisiones.com

Figure 5

CO_2 Emissions per Capita in Selected Countries in 2005



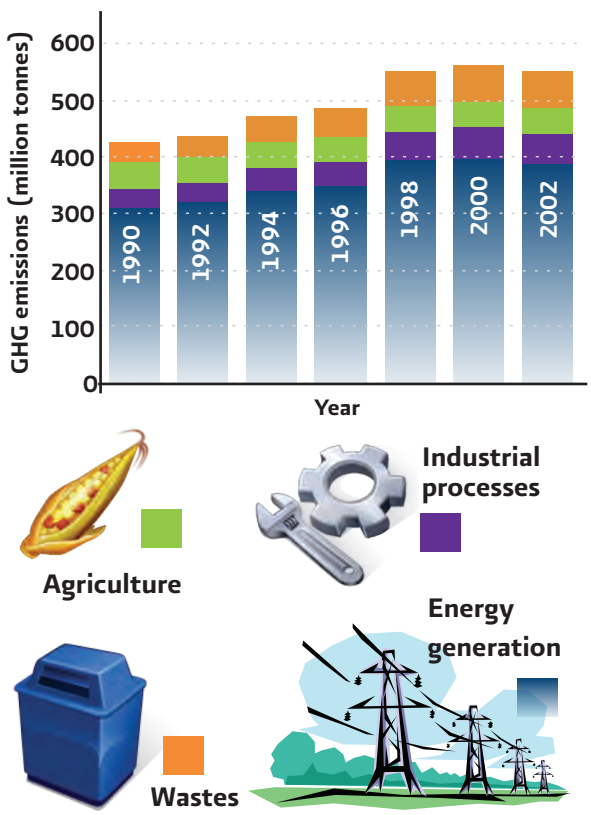
GHG Emissions in Mexico

Let us now look at the amount of GHG that are emitted in Mexico. According to the most recent National Inventory of GHG Emissions, a little over 553 million tonnes of GHG were emitted in the year 2002 (Figure 6). This seems to be a small amount when compared to the world total emissions but it is not that small when one considers that the amount of GHG emitted in Mexico every year is about 5,500 times the amount of concrete used to build the Azteca Stadium. The view is even more worrisome if we take into account the fact that the country emissions have increased over the last years: Emissions in 2002 were 30% higher than the amount estimated twelve years earlier, in 1990.

In the year 2002, the main source of GHG in Mexico was the energy sector, which contributed with nearly 70% of the country's emissions. This sector includes the use of fossil fuels to power automobiles and other motorcars and to generate electricity.

Figure 6

Mexico's Greenhouse Gas Emissions



Other industrial processes, such as the production of cement, glass, steel, paper, food and beverages, among others, contributed with about 9% of the total GHG emissions in the country. On the other hand, farming activities carried out to produce grains, fruits and meat, also generate two other GHG: methane (CH_4) and nitrous oxide (N_2O), which accounted for 8% of the country's GHG emissions. These gases are released during the fermentation of food in the livestock's guts, from manure and crops such as rice, as well as from some natural processes in the soil.

Finally, waste generated in households and industries also emit GHG. Municipal and industrial wastewater release methane and nitrous oxide from the decomposition of organic matter, whereas burning solid waste releases CO_2 and nitrous oxide into the atmosphere. Waste management and wastewater treatment, despite their undeniable benefits, also generate GHG: Emissions from these sources accounted for nearly 12% of the total country's emissions in 2002.

There is another important source of GHG that has not been mentioned yet. This is named "land use, land use change and forestry". This source basically includes those emissions generated from natural vegetation, activities leading to the conversion of natural ecosystems into farming or urban systems, and forest exploitation.

These sources will be further described in the following pages. Odd as it might sound, terrestrial ecosystems –such as forests and jungles- also release enormous amounts of GHG into the atmosphere. In fact, old forests naturally release as much carbon dioxide as the oxygen they produce through photosynthesis.

When natural vegetation is removed and burnt in order to convert the land into pastures, crop fields or even urban zones –a process known as "land use change"-, GHG are also released. For many farmers and owners of forests or shrublands, often the easiest way to clear them out is by means of fire, by which much of the Carbon that had been stored in the wood, leaves and litter, is rapidly transformed into CO_2 and released into the atmosphere. In some other cases, existing vegetation is cut down and left in the site to decompose, also releasing GHG. Due to the extensive deforestation that has occurred in Mexico over the last decades, terrestrial ecosystems also constitute a significant source of GHG.

Although results are still being reviewed, the latest inventory for Mexico shows that land use, land use change and forestry contribute with about 14% of the country's GHG emissions. This means that the total country's GHG emissions are about 643 million tonnes, almost 90 million tonnes higher than the previous estimate (553 million tonnes).

The most recent data available for Mexico date back to the year 2002. However, a new inventory is being currently completed, with data for the year 2006. Preliminary results show that, in 2006, GHG emissions were approximately 626 million tonnes –excluding land use, land use change and forestry. This constitutes an 11% increase over the previous inventory for the year 2002.

Once we have looked at the data available for Mexico and the world, we can compare the various sources of GHG and their contribution (Figure 7). As you can see, the emissions profile in Mexico is similar to the global profile: The major source is the energy sector, followed by land use, land use change and forestry.

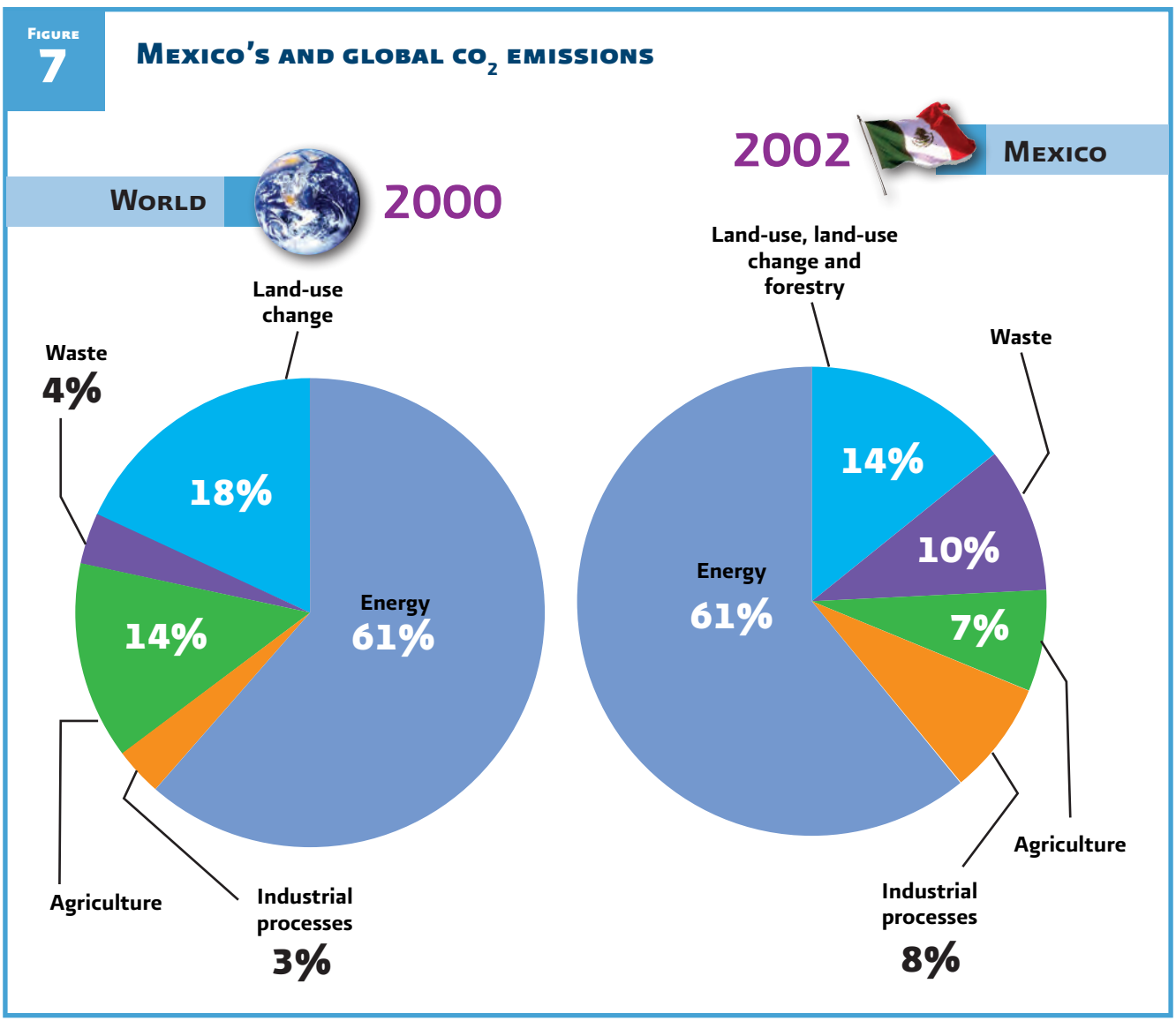
It is undeniable that human beings have released a huge amount of GHG into the atmosphere and that this process has been particularly intense since the Industrial Revolution in the 18th century. The accumulated amount of CO_2 released over only the last 50 years was about 898 billion tonnes[3].

Undoubtedly, the emission of GHG into the atmosphere is overly important but, is this process causing changes in climate? The answer is a sound yes, unfortunately.

What are the evidences of climate change?

Although global climate change is still the subject of heated debate, the major scientific bodies of the world, as well as the expert group named Intergovernmental Panel on Climate Change (IPCC; see ***Box: IPCC: The scientists behind climate change***) have concluded that there exists clear evidence that the warming recorded over the last 50 years can be attributed to the effect of human activities.

Figure 7 **Mexico's and global CO_2 emissions**



[3]This figure includes CO_2 emissions from fossil fuel consumption and cement production.

IPCC: The scientists behind climate change

Box

Representatives from the IPCC receive the Nobel Peace Prize

Who says that temperature is rising? Who has predicted future climate? All this is the result of research conducted by hundreds of scientists from all over the world who have been carefully studying the changes in the global climate for decades. Some of those scientists form part of the Intergovernmental Panel on Climate Change (IPCC).

The IPCC was established in 1988 by the World Meteorological Organization (WMO) and the United Nations Environment Programme (UNEP). Its main assignment is to analyze in an exhaustive, objective, open and transparent manner all the scientific, technical and socioeconomic information relevant to understand human-induced climate change, but also addressing the impacts of climate change and the options for adaptation and emissions reduction. One of the main activities of the IPCC is the periodic assessment of the scientific knowledge about climate change, based on which it publishes special reports and technical documents to support the implementation of the UN Framework Convention on Climate Change.

All this is meant to tell you that all the assessments published by the IPCC are not based on crystal ball predictions but are solidly based on the most up to date scientific and technical literature. Hundreds of experts from all over the world, including some Mexican scientists, contribute to the analysis and integration of information and in the preparation of reports and technical documents. It should also be pointed out that, in order to prevent misunderstandings, all the major reports are discussed, on a word by word basis, before being approved and released.

IPCC: The scientists behind climate change (conclusion)

Box

The IPCC encompasses three working groups: One in charge of addressing the scientific aspects of climate change (named Working Group I); the second group is in charge of examining the impacts, adaptation measures and vulnerability (Working Group II) and the third one addresses the reduction of emissions or mitigation (Working Group III). In addition, there is a special team that provides support to countries to elaborate their emission inventories. The diverse composition of the working groups ensures a wide range of opinions, areas of specialty and geographical representation. Thus, the IPCC includes experts in geography, biology, mathematics, climatology and economics to name just some of their main fields of expertise, who come from all the regions of the world. In recognition of its work, in 2007 the IPCC was awarded the Nobel Peace Prize for its efforts to disseminate the knowledge about man-made climate change, and for its contributions to define the measures that are needed to counteract such change.

But, since human activities date back to thousands of years, why then has planet warming not occurred before? This is because it was not until the start of the industrial era –when the use of fossil fuels became predominant- that the emission of GHG increased substantially. In the pre-industrial era (before the year 1750), when productive activities were dependant on human labour and not on machines that use vast amounts of fossil fuels, the concentration of CO_2 in the atmosphere was 38% lower than the current level (280 parts per million, as compared to 385 ppm in the year 2008; Figure 8). In fact, CO_2 concentrations recorded in samples 650 thousand years old, are also lower than current ones, and do not reach the 300 parts per million.

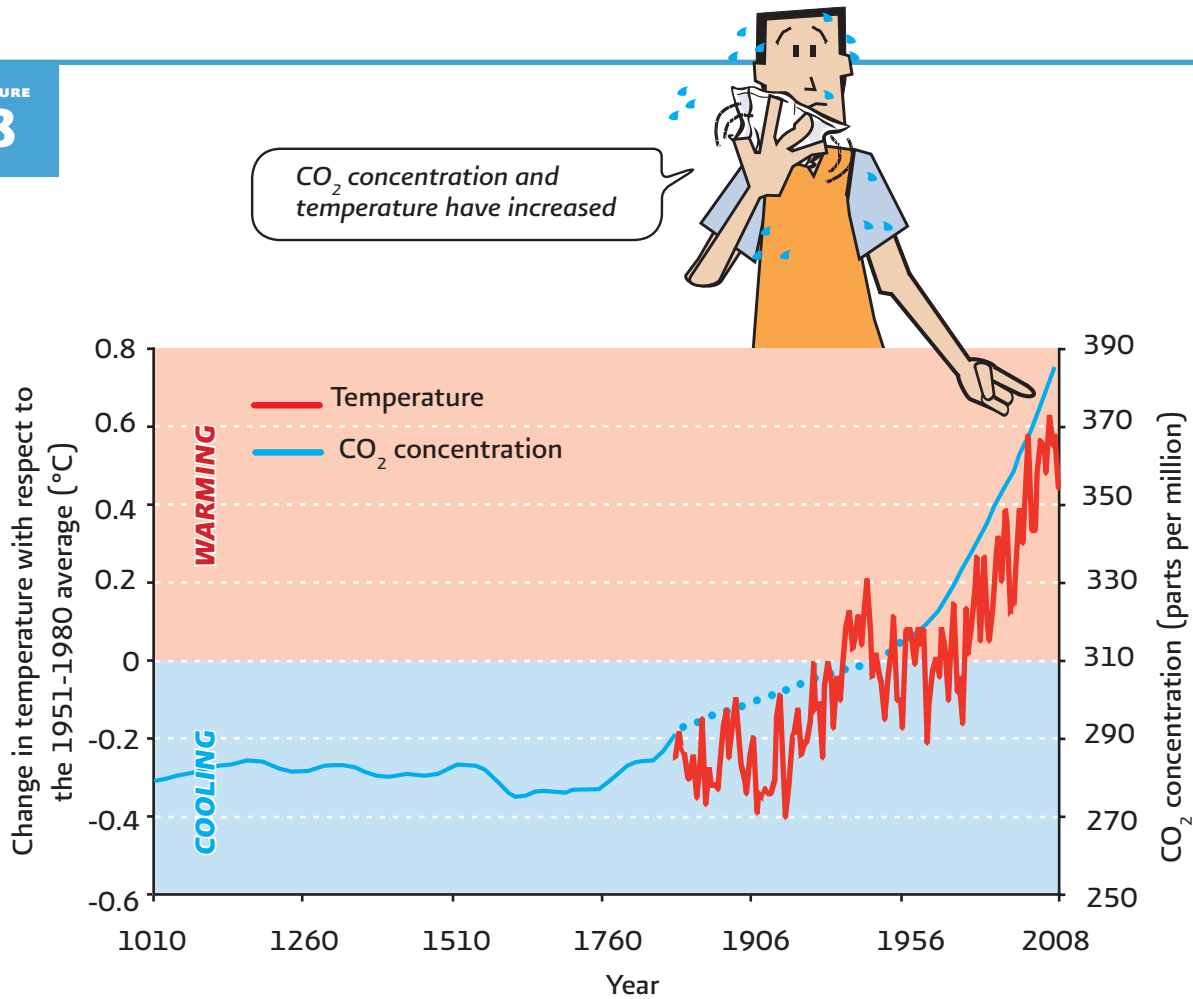
The most convincing evidence of the occurrence of climate change is the increase in temperature, although important alterations in other elements of climate, such as rainfall and humidity, have also been recorded. However, before you ask why we do not also include other pieces of evidence such as the often mentioned rise in sea level or glacier melting and hurricanes, let us point out that, out of convenience, those have been included in another section of this book, dealing with the consequences of climate change. Nevertheless, scientists do consider those phenomena as additional evidence of climate change, as their occurrence confirms their predictions.

Temperature

Figure 8 shows that the temperature increase over the last fifty years closely tracks the increase in CO_2 concentration in the atmosphere. The average increase in the temperature of the Earth's near-surface air and oceans was 0.74°C between 1906 and 2005.

The planet is quite definitely warming up: NASA reported that the five warmest years in history since 1890 have been, in descending order, 2005, 1998, 2002, 2003 and 2004. This heating has also been noticed in the occurrence of "record" temperatures and, hey! We have surely noticed that!

Figure 8



Let us go back further in time. Figure 9 shows that, over the last ten thousand years, humankind has developed within a narrow range of temperature variation. Were the planet to reach temperatures outside that range, the consequences for environment and society could be serious. Unfortunately, projections of the temperature increase over the following 100 years seem to point in that direction. It is worth noticing that the temperature increase currently observed has not been the same in all the regions of the world. The Arctic, for example, has warmed up more than the rest of the planet over the last 100 years. On the other hand, temperatures over terrestrial regions have increased faster than over the oceans, particularly so on North America, Europe and Asia (Map 2).

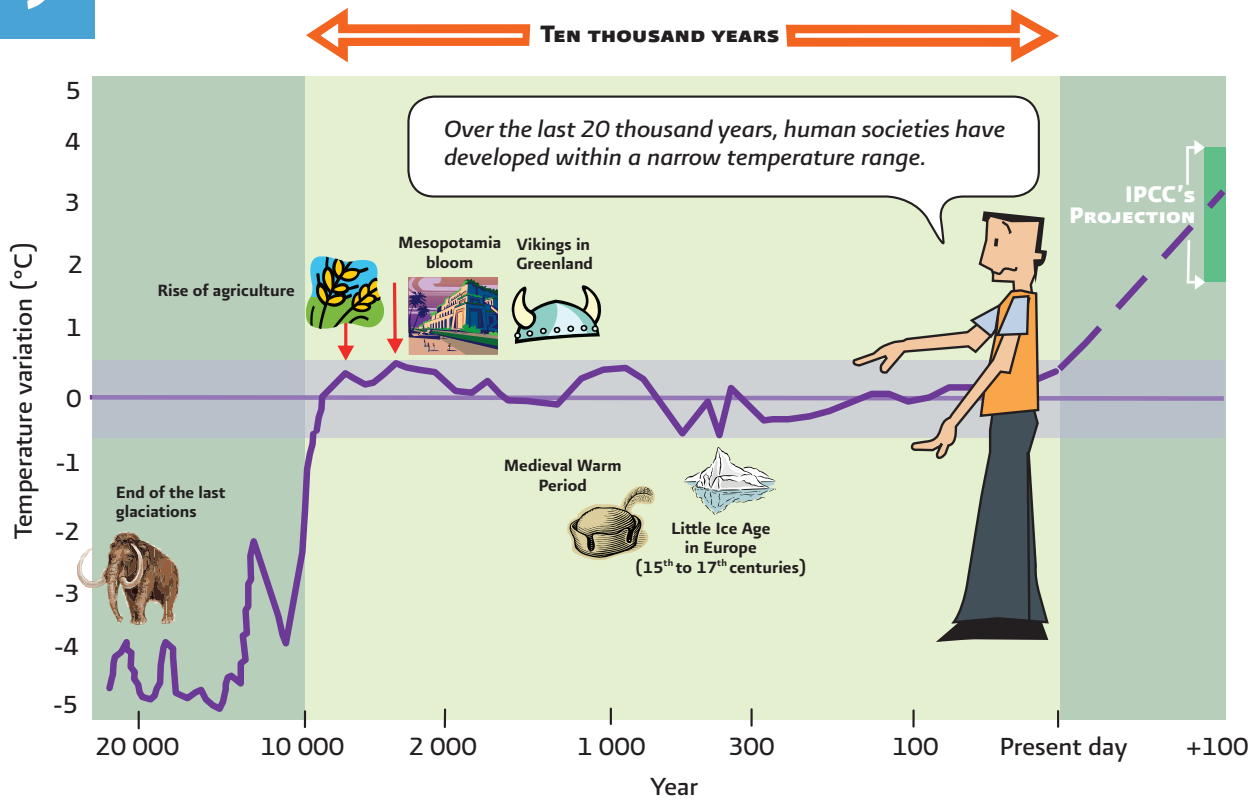
Humidity and rainfall

Everybody would think that a warm climate is more pleasant than a temperate one and that no problem should therefore exist were the temperature to increase. It is not quite so, however, as you should remember that changes in temperature are often accompanied by changes in humidity and, therefore, in the rainfall regime. Both changes, as we will see later on, have important effects on dramatic events such as hurricane formation and the occurrence of water floods.

Water vapour in the air upon the world's oceans has increased at a rate of 1.2% per decade, an increase that might already be affecting rainfall and snowfall patterns. Precipitation over the Eastern parts of North and South America, Southern

Figure 9

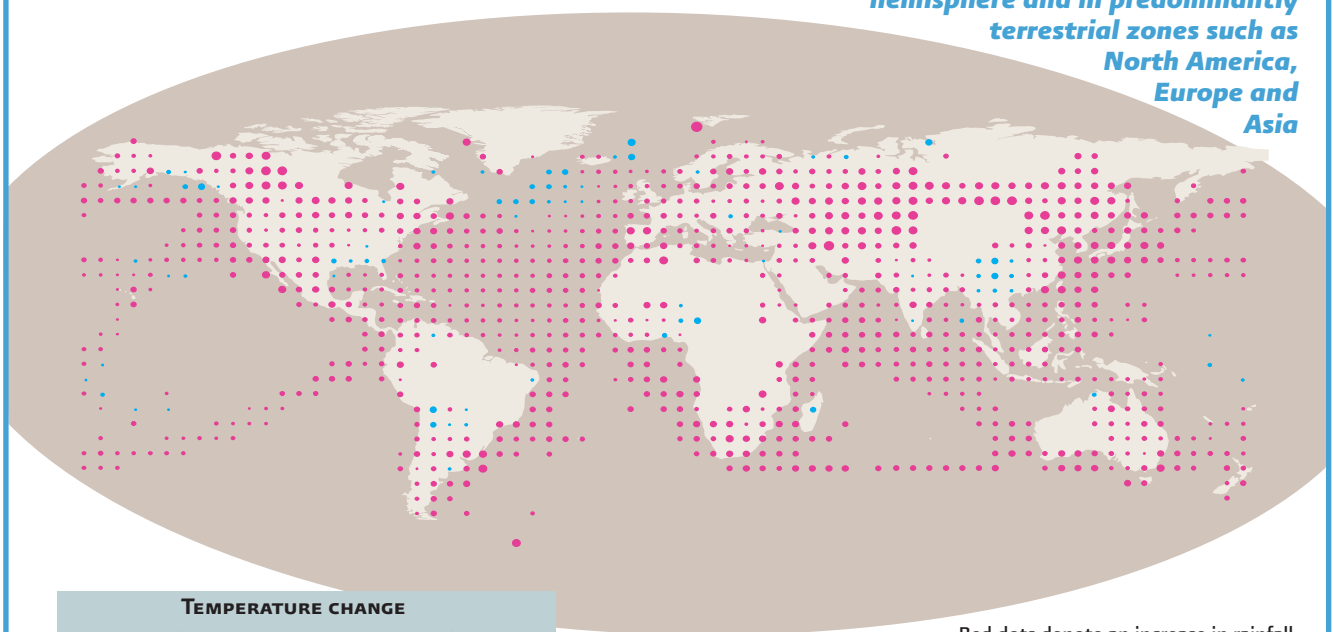
Variation in mean temperature over the last 20 thousand years



Map 2

Trends in annual temperatures over the period 1901-2000

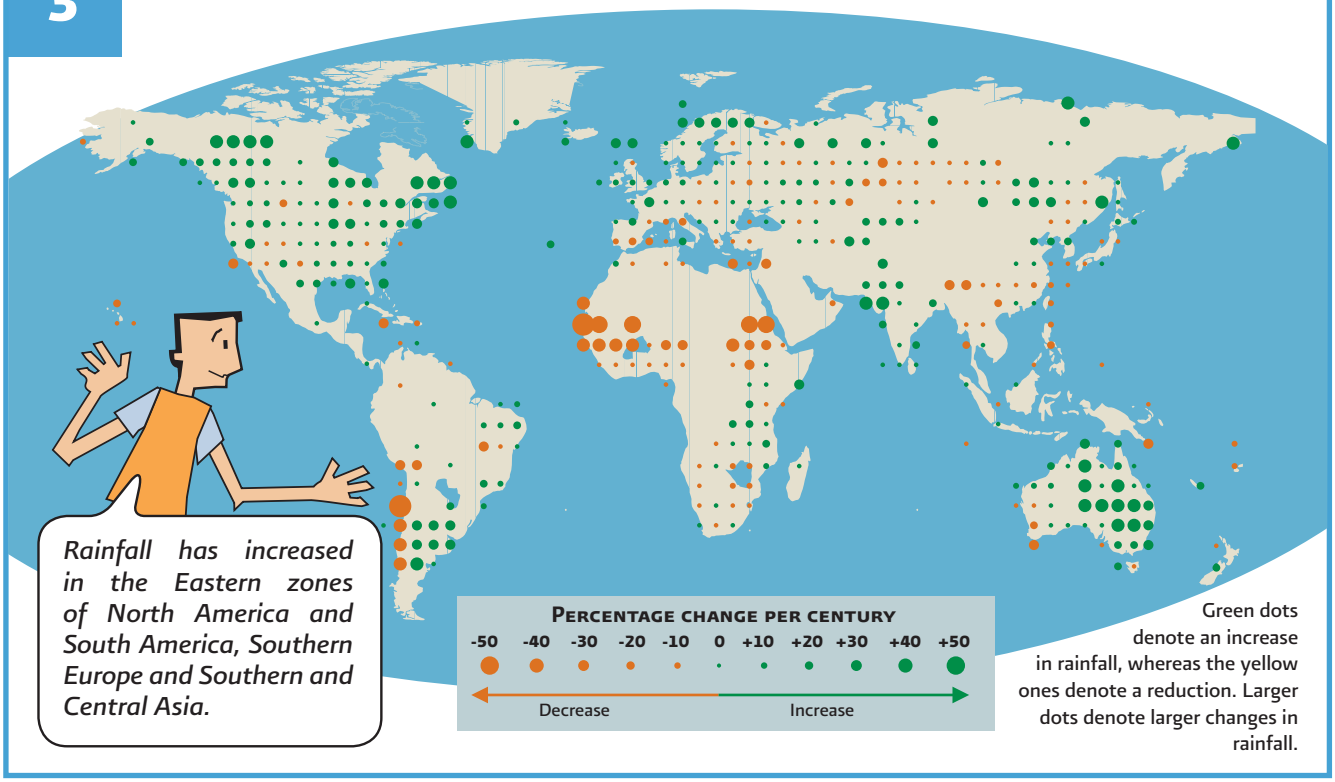
Temperature has increased more in the Northern hemisphere and in predominantly terrestrial zones such as North America, Europe and Asia



Red dots denote an increase in rainfall, whereas the blue ones denote a reduction. Larger dots denote larger changes in temperature.

Mapa 3

Trends in annual rainfall over the 1901 – 2000 period



Europe, Southern Asia and Eastern Australia has increased significantly over the last century (Map 3). The IPCC points out that the intensity of rainfall might also have increased in many regions of the world since 1950, even in those regions where the total amount of precipitation has decreased. By contrast, more intense, longer droughts have been recorded since 1970, mainly in the tropics and subtropics, and particularly so in the desert zones of Africa and South America.

What consequences we are facing by climate change?

As the elements of the environment are interrelated, modifying one of those leads to changes in the others. Sometimes, these are barely noticeable changes but, in some other times, those are evident. Through the planet history, changes in climate have been recorded a number of times but all of them took hundreds or even thousands of years to occur. According to the records available, no other change had been as fast as the one that we are currently witnessing. In the following pages we will describe the major consequences of climate change for some of the elements of the environment.

Ice melting

One of the most dramatic impacts of global warming is glacier melting. Glaciers are huge ice masses covering the top of the highest mountains and volcanoes or immense expanses –such as Greenland and the Antarctic- that have been built up by the gradual accumulation of snow through hundreds or thousands of years. Glaciers are so huge both, in extension and depth, that they constitute the largest reservoir of freshwater in the planet.

Let us look now at some examples of what is happening to glaciers as a consequence of global warming. In little over 30 years, the Arctic ice shelf lost some 950 thousand square kilometres, or

nearly 20% of its original extension -an extension equivalent to about half of the Mexican territory. On the other side of the world, in the Antarctica, part of the Larsen B ice shelf shattered and separated from the continent in the year 2002, by which a total of about 3,240 square kilometres of shelf area (a surface area over twice the size of the Mexico City) disintegrated. Unfortunately, these are not isolated examples; reports of large fractures in glaciers keep coming: In early 2009, the ice bridge connecting the Wilkins ice shelf with the Antartic Peninsula splintered, and some 25% of its total extent broke off (Figure 10).

Ice melting has not only affected the Arctic and Antarctica, but also the cold and the perpetual ice zones of the highest mountains and volcanoes of the world. The extent of mountain glaciers and snow fields has decreased in both hemispheres: In the Northern hemisphere, the maximum coverage of seasonal ice has decreased 7% since 1900. For example, the Swiss Alps glaciers lost one third of their surface area and, at least, half of their mass between 1850 and 1980. The loss has been so intense that, during the summer of 2003, 10% of the mass of the permanent glaciers was lost. If this is not worrisome enough, predictions say that things will not improve: Scientists estimate that, for the year 2050, some 75% of the glaciers in the Alps might have disappeared.

Usually, when we read or hear about glaciers, we think about the polar zones, overlooking the fact that tropical regions also harbour glaciers at the top of the highest volcanoes and mountain ranges. As one can easily imagine, these glaciers are also being affected by climate change. For example, it has been estimated that glaciers in Peru have lost between 20 and 30% of their surface area since early 1970 (Figure 11). The Chacaltaya glacier in Bolivia has lost 82% of its surface area, while other smaller glaciers have almost totally disappeared. If things keep going as they currently are, in a decade many of the Andean small glaciers will exist only in history books.

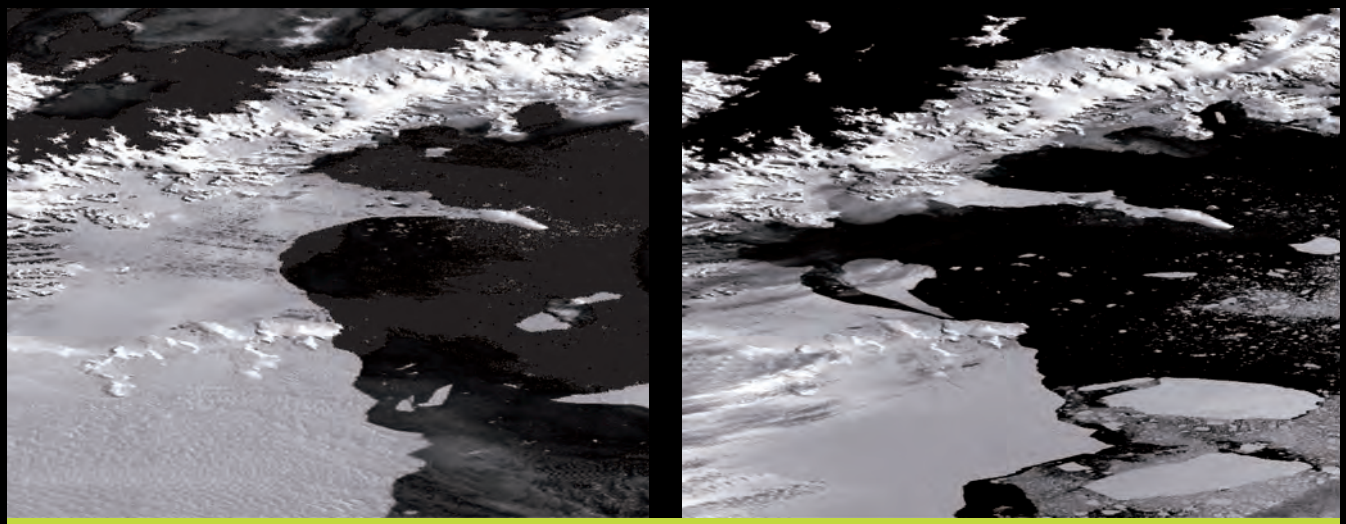
There are also glaciers in Mexico, at the top of the Iztaccihuatl, Popocatepetl and Pico de Orizaba volcanoes, and they have also been affected by climate change. Data available show that the Iztaccihuatl glaciers have experienced losses in both, their surface area (up to 40% over a 20 year period) and depth (70 metres in 1999, 40 metres in 2004). A similar trend has also occurred at the Pico de Orizaba and Popocatepetl volcanoes, the highest mountains in Mexico, but in the latter the loss has been exacerbated by its volcanic activity of the last years. Experts estimate that if the Iztaccihuatl and Pico de Orizaba glaciers keep melting at the same rate as observed lately, they will likely disappear completely in the following ten and 35 years, respectively.

Glacier melting has two major effects. On the one hand, freshwater sources that are vital for human populations are lost, as glaciers function as free reservoirs that store water during the wintertime, to gradually release it during the spring and summer. On the other hand, and odd as it might sound, glaciers help to prevent the planet from warming even more; this is not due to the ice itself but to its white colour which reflects much of the incoming radiation towards the space. When glaciers melt down, the underlying darker-coloured surfaces –such as sea water or soil- become exposed to absorb more of the incoming radiation, warm up and emit infrared radiation back to the atmosphere, thus contributing to warm the Earth even more. As a consequence of this additional heating, more ice is melted.

Figure 10

Colapse of the wilkins and larsen b ice shelves in antarctica

January, 2002 **March, 2002**

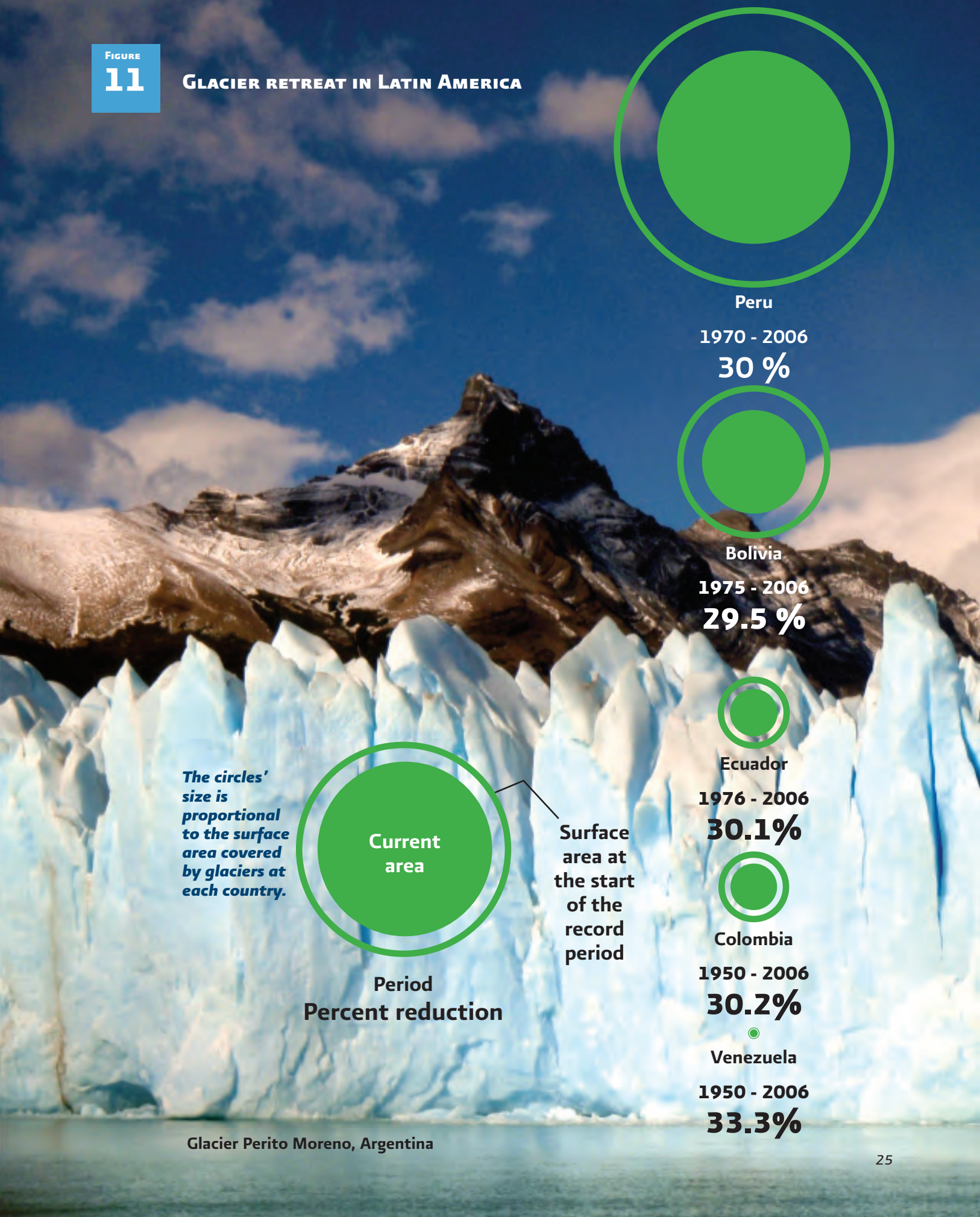


3,240 km^2 of the Larsen ice shelf disintegrated in Antarctica.

View of the breakup of the ice bridge connecting the Wilkins ice shelf on the Antarctic Peninsula.

Figure 11

Glacier retreat in Latin America



Glacier Perito Moreno, Argentina

Water derived from glacier melting does not stay standing there but goes somewhere else. Water from mountain glaciers can follow natural waterways such as the streams, creeks and rivers that traverse the continents and eventually discharge into the ocean or, as is the case in Greenland, water can run down directly into the sea. This is also worrisome for two reasons. First, because the huge volume of ice that might melt and eventually reach the oceans would dilute sea water to such an extent that the major ocean currents of the world might be affected, thus affecting further the global climate (the ***Box A conveyor belt through the oceans: The thermohaline circulation*** provides details on this). Secondly, because sea level would rise.

Sea level rise

The melting of ice masses in the polar zones and mountain tops has made the sea level to rise. To this effect, we should also add the water warming experienced over the last decades, which has made the oceans to undergo -as any other body that acquires heat- thermal expansion and, being confined within a limited volume, their level to rise. Long-time records of sea level are available for some sites of the world such as Amsterdam (The Netherlands), Brest (France) and Swinoujscie (Poland) and these confirm the rapid increase in sea level that has occurred over the 20th century (Figure 12). Although the rise of sea level is actually a consequence of climate change, it has also been used as an evidence of this global phenomenon.

Scientists have calculated that sea level has risen, on average, 1.8 millimetres per year over the period 1961-2003 and that the total rise over the 20th century was 17 centimetres. These figures might appear as insignificant but they are not. In fact, they are worrisome for many countries of the world that have cities in coastal zones, sometimes even at elevations below sea level, as is the case of Amsterdam, in The Netherlands, which is located a few metres below sea level. This means that, in the near future, many million people around the world would be condemned to suffer the consequences of seawater floods. An extreme example of today's effects of sea level rise is presented in the ***Box Tuvalu: A disappearing country.***

Extreme weather events

There is no exact definition for "extreme weather events" but what we are referring here to as "extreme events" are those very intense, but rare weather phenomena that have significant and adverse environmental and social impacts either at the local or the regional level. Examples of this are hurricanes, tornadoes, droughts, frosts or hail which make us feel climate change impacts closer (Figure 13).

Let us start by looking at intense thunderstorms that cause floods and loss of material property and human lives. A recent example occurred on July 2005 in Mumbai, India where 94 centimetres of rain fell in only 24 hours. This is equivalent to 940 litres of water having poured on each square metre of the territory in one single day: Nearly the full content of one standard-sized water tank! Such a large amount of water would come very useful for water supply but, lacking the proper infrastructure to catch and store it, causes huge damages.

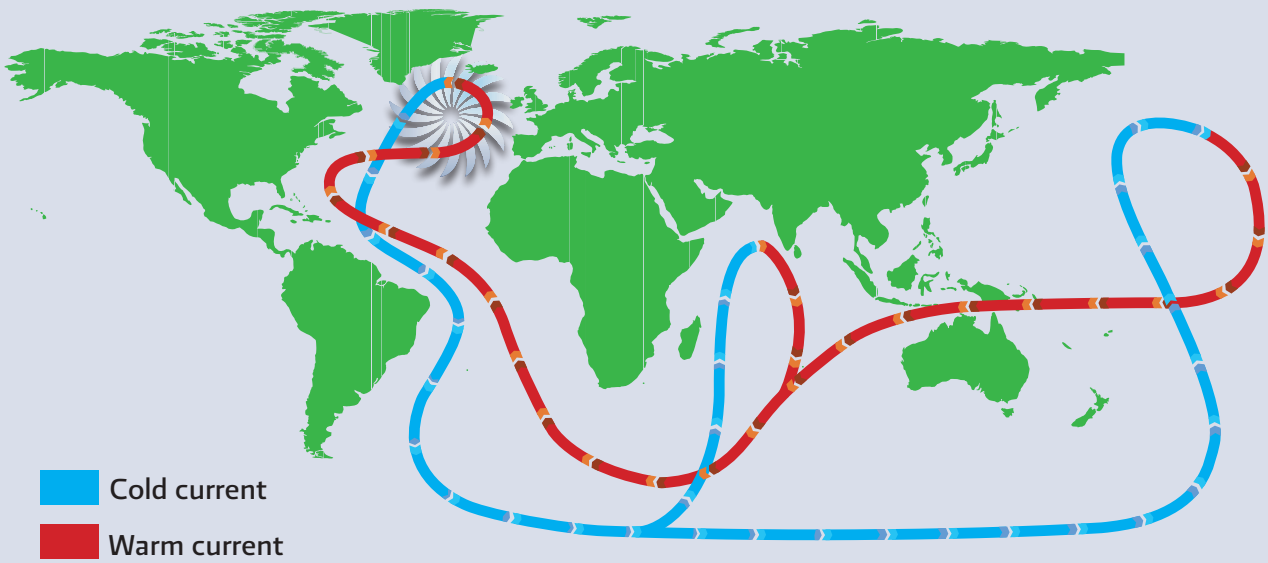
Similar situations have also occurred in Mexico: Serious floods were caused by thunderstorms in the states of Tabasco and Chiapas in 2007. These were the most serious floods in the last 50 years and, only in Tabasco State, left 500 thousand affected people and a 100% crop loss. At the same time, some parts of the world have received less rainfall than usual. Paradoxically, one of the sites of the world that we usually think of as constantly humid, the tropical forests in the Amazon basin in South America, experienced an unusually extensive drought in 2005 that left several of its tributaries dry.

A conveyor belt through the oceans: The thermohaline circulation

Box

If you have ever swum in the sea it is likely that, while you were enjoying the lukewarm water, suddenly you might have felt a surge of cold water by your feet. After the surprise, you might have then wondered where the cold water came from, within that vastness of apparently homogeneous, lukewarm water. As it happens, that weak current of cold water is a tiny-scale example of a phenomenon that also occurs in the open sea.

The oceans in our planet are never still. On the contrary, they are in constant movement due to the ocean currents that move huge amounts of water from one place to the other as a consequence of the Earth's rotation or of variations in temperature or salinity or even due to the Moon's influence, as it has been suggested recently. One of the most important ocean currents is the one known as the Global Conveyor Belt. The figure below depicts the way in which the warm (red arrows) and cold (blue arrows) waters in this current move along the planet's oceans.



Let us see how this current works at one of the major segments of its trajectory: the North Atlantic. To do this, we will carry out a mental exercise: Imagine that you have a glass of salty water and you sip a little bit of it. Then, what would happen if you taste this same solution but after having left it all day long in the sun and part of the water has evaporated? Besides the awful taste, the solution will be saltier and denser than originally. This is exactly what happens in the North Atlantic: As they move North, the warm surface waters of the Gulf Stream loss large amounts of water by evaporation, undergoing evaporative cooling in the process, and thus become saltier, colder and denser which makes them eventually sink down towards the seafloor and flow Southwards. This process is known as the thermohaline pump, as it is powered by both, temperature (thermo) and salinity (haline).

A conveyor belt through the oceans: The thermohaline circulation (conclusion)

Box

These movements of cold and warm waters through most of the world's oceans have a great influence on the climate of the entire planet. Thanks to those movements, masses of warm water from the tropical regions flow towards the poles making, for example, the climate of the coast of Western Europe to be milder than that in the coastal zones of Canada located at the same latitude, which is far colder.

As you can see, the thermohaline pump plays a crucial role in the flow of ocean currents. However, this is a fragile process, and even small changes in salinity may cause the waters moved by this pump to flow more slowly or, in an extreme case, to stop completely. This is not at all impossible. In fact, some ten thousand years ago, when the glacier blanket of North America melted down, part of the fresh water that had been trapped in the form of ice drained down into the North Atlantic and the thermohaline pump almost ceased to work. What happened then? Nothing less that Europe went through a glacial period for nearly one thousand years, as the warm waters that used to bathe its coasts and the water vapour that produced milder temperatures in the western part of Europe disappeared.

Nowadays, scientists fear that the rapid melting in Greenland would release large amounts of the freshwater that is currently stored in the form of ice and this would disrupt the flow of the world's ocean currents. Obviously, this would have major consequences for the life in the planet as, if the pump stops, ocean currents throughout the world would be affected and all the inhabitants would undergo the ensuing effects. The bad news is that scientists have already detected some variations in the salinity of the North Atlantic.

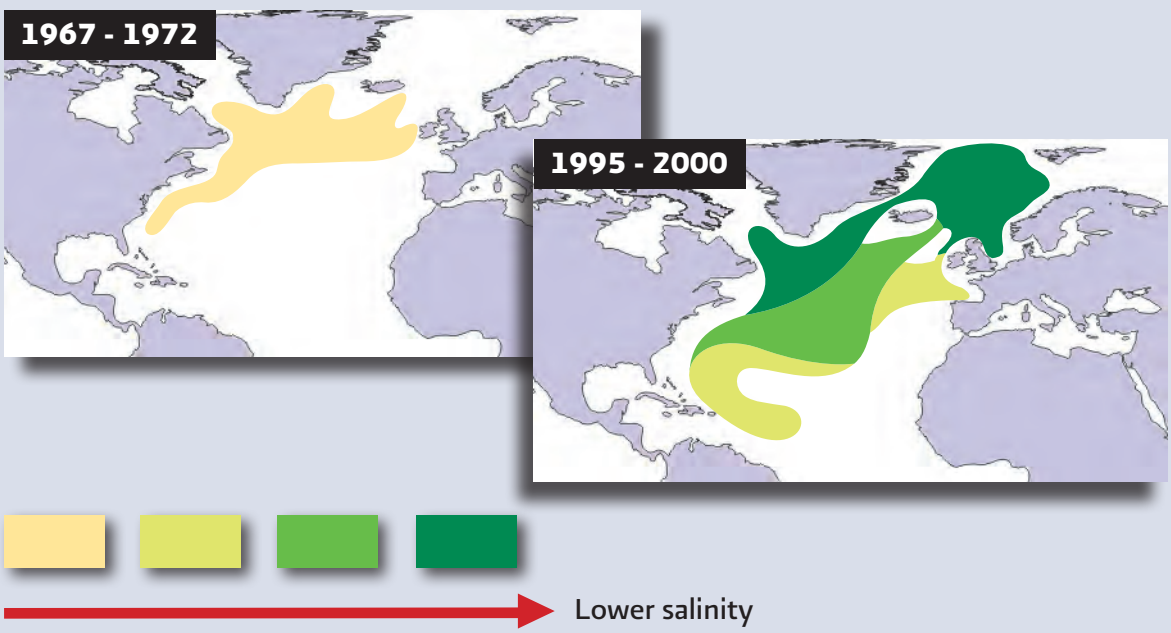
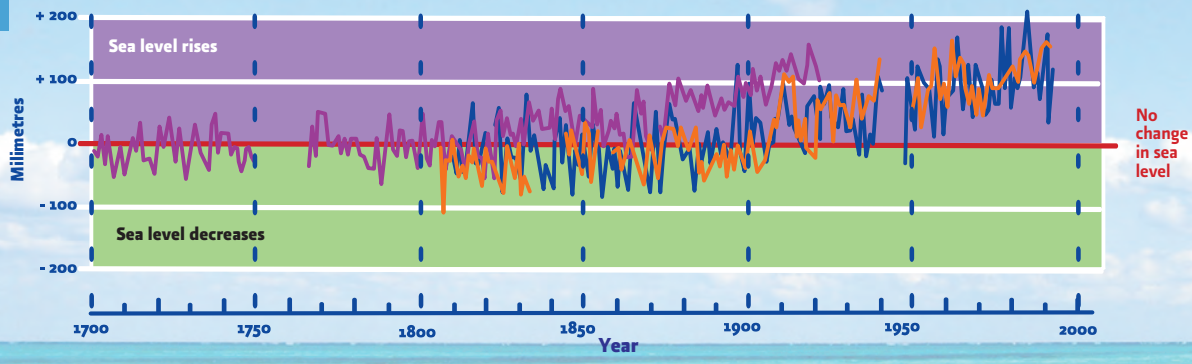


Figure 12

Sea level rise at some European cities



Amsterdam, Netherlands

Brest, France

Swinoujscie, Poland

Figure 13

Extreme weather events

Hurricane Katrina, New Orleans, United States, 2005

Hurricane Wilma, Cancun, Mexico, 2005

Drought, Zacatecas, Mexico, 2008

Intense rains, Villahermosa, Mexico, 2007

Tuvalu: A disappearing country

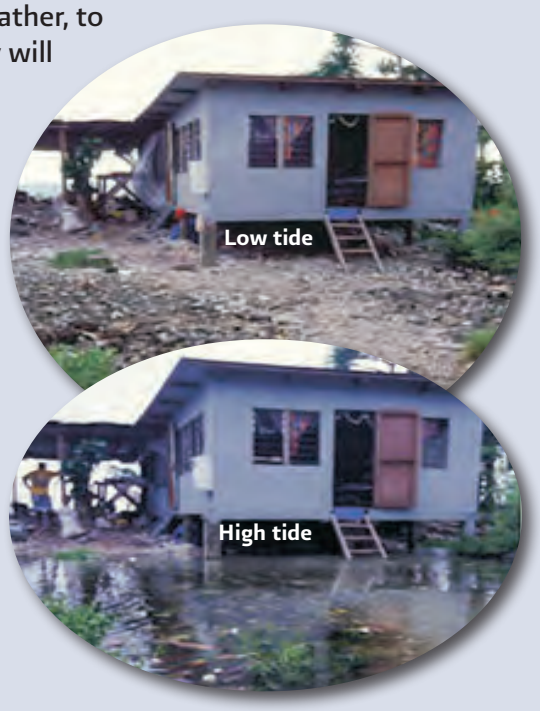
Box

Can you ever imagine a country getting ready to disappear? This is what is currently happening in Tuvalu and other island countries. Tuvalu is a small island nation located in the Pacific Ocean, midway between Australia and Hawaii; it comprises several small islands where the highest elevation barely reaches 5 metres above sea level. Due to the rise in sea level, its inhabitants have been suffering floods in the lowest lying lands. Some years ago, sea waves swept over the Tepuka Savilivili, one of the islands, which caused the destruction of all the vergetation there. This is not the only problem; the intrusion of sea water in the territory has also affected the aquifers and therefore, their potable water sources.

Food production has also been affected. Islanders usually consume a tuber called "pulaka", but their soils and plantations have been infiltered with sea water. Over the last years, three fourths of their crops have been lost, which has led the islanders to be dependent on imported food for their subsistence.

Over the last years, the possibility of evacuating the inhabitants of Tuvalu to some other countries has been suggested, as sea level rise will impose serious risks for their lives and health in the future, given that most households, infrastructure and commercial activity are located along the coast. Since 2002, New Zealand has been receiving some 75 people from Tuvalu every year. This assistance, however, has proved to be insufficient as the total population is about 11,000 people and, in order for them to be accepted as refugees, they should fulfil some strict requirements such as a minimum command of the English language, being 45 years or older and have secured a job offer in the country.
Nowadays, negotiations are under way to evacuate or, rather, to migrate the population to some other countries as they will not be able to return to their own.

Being faced with these circumstances, the inhabitants of Tuvalu wonder whether they will eventually be compensated for losing their country. This case reminds us of the "Ecological debt" that environmental impacts produce and of how important is that countries take serious measures to reduce their greenhouse gases emissions. Tuvalu is not the only country suffering the consequences of sea level rise; it is foreseen that low-lying island nations in the Pacific will be inundated and their aquifers intruded by sea water. Other island nations that are threatened are the Cook and the Marshall Islands. Over the last decade, the Majuro Island (one of the Marshall Islands) has lost some 20% of its beaches.

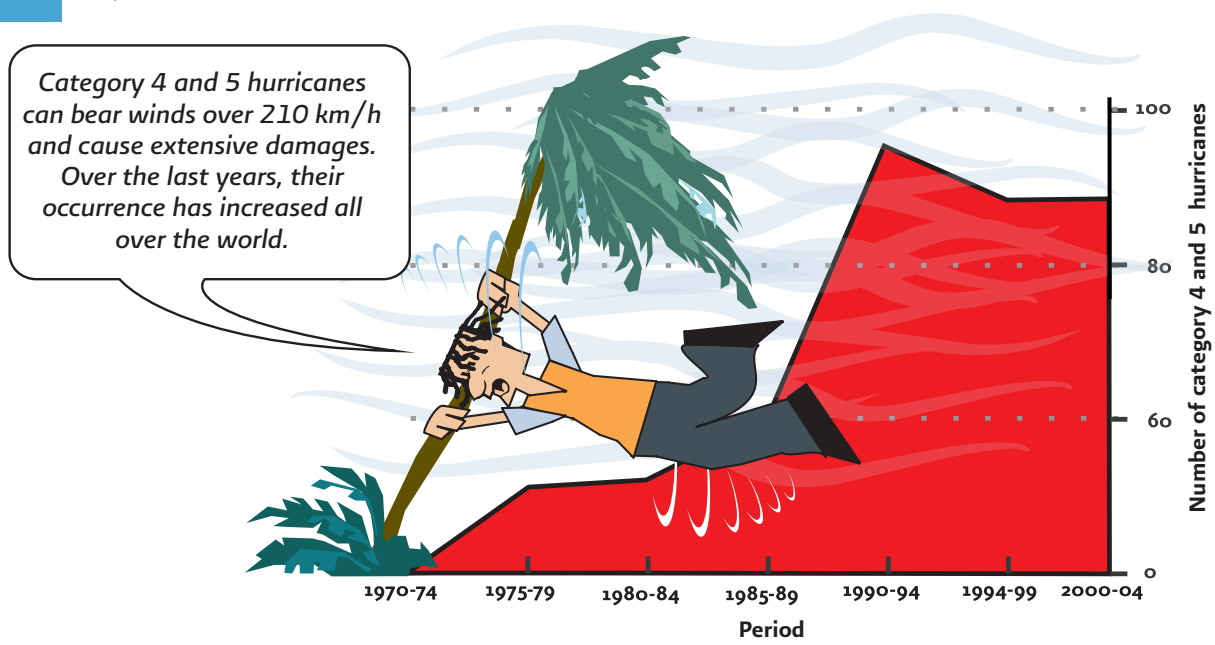


On the other hand, over the last years we have seen or heard of hurricanes that have caused not only extensive loss of property and human lives but also considerable damages to natural ecosystems: Hurricane Emily over the Yucatan Peninsula, Katrina over Southeast USA and Stan and Wilma over Southeast Mexico. It is reckoned that hurricane Stan caused losses for 1 934 million dollars in the States of Hidalgo, Puebla, Oaxaca and Veracruz in 2005, while hurricane Wilma caused losses for 1,724 million dollars and damaged 98% of the infrastructure in the Southern coast of the Yucatan peninsula in the same year. Hurricane Katrina hit the city of New Orleans in 2005 causing losses for at least 60 billion dollars.

A study published in the *Science* magazine in 2005 showed that the frequency of high-intensity hurricanes (categories 4 and 5 in the Saffir-Simpson scale) has been increasing over the last years; those hurricanes characteristically bring winds greater than 210 km/h, can destroy roofs, and cause flooding of the lower parts of buildings near the coastline even demanding evacuating the population (Figure 14). On the other hand, British scientists have suggested that, by 2008, an increase of 0.5°C in the temperature of the Atlantic Ocean could cause a 40% increase in the frequency of high-intensity hurricanes, as well as generating even more intense hurricanes.

Hurricanes are just one of the several kinds of natural disasters that are featured once and again in the news. According to the World Meteorological Organization, the number of victims of natural disasters increased from 147 million to 211 million worldwide, between 1991 and 2000. About 90% of those disasters were caused by or related to water: 50% of those involved floods, 28% epidemics and 11% droughts and the damages were estimated in nearly 200 billion US dollars. Disasters occurred mainly in Asia and Africa (35 and 29% of the total, respectively) although a substantial number occurred in America and Europe also (Figure 15). Floods affected the livelihoods of some 68 million people in Eastern Asia and 40 million people in

Figure 14 **Occurrence of category 4 and 5 hurricanes in the world between 1970 and 2004**



Southern Asia. In sub-Saharan Africa, 10 million people were affected by droughts and 2 million people by floods.

Although extreme weather disasters are affecting increasing numbers of people throughout the world, most of their victims live in developing countries (Figure 16). Between 2000 and 2004, one in every 19 people living in developing countries was affected by these events each year. By contrast, the corresponding figure for developed countries is quite different: disasters only affected one in every 1,500 inhabitants.

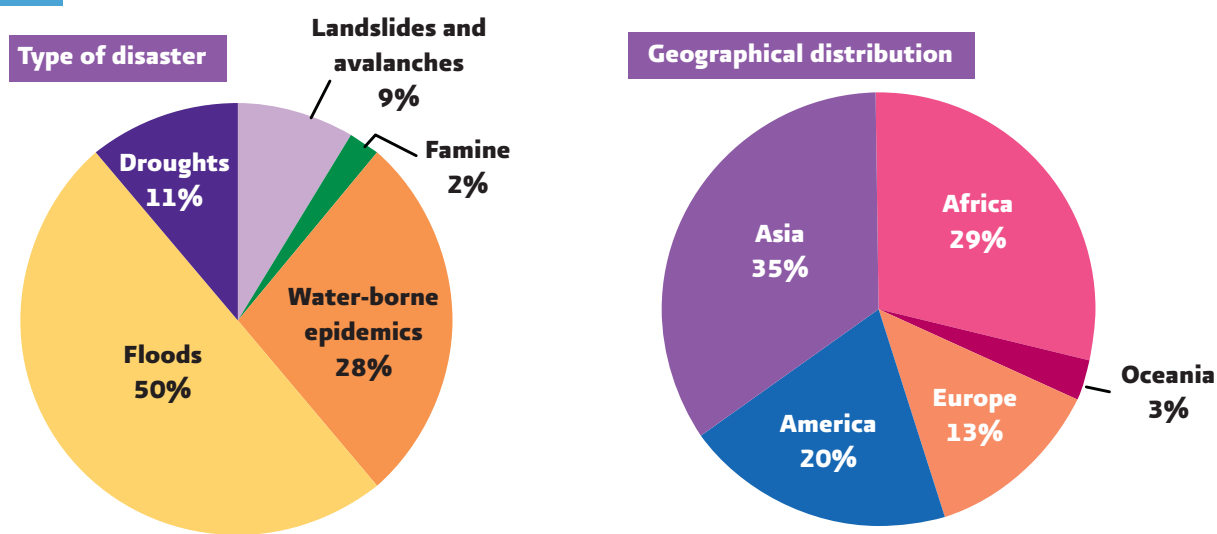
Effects on agriculture and fisheries

In 1998 we all endured very hot weather over several months. That year was one of the warmest of the 20th century due to the El Niño effect[4] which, in turn, has also been affected by climate change which has increased the frequency and intensity of this phenomenon. In Mexico and other parts of the world, rains diminished and began later in the year, causing a protracted drought that affected several productive activities, including agriculture, livestock raising and fisheries.

In 2005 -the warmest year in the last 100 years-, the delay in summer rains led to a fall of over 13% in the agricultural production of the country. The cultivated area affected was 669 thousand hectares and the total costs of the drought amounted to nearly 779 million pesos.

Climate change affects not only the amount of produce but also their quality. Although climate change might have some beneficial impacts on agriculture, this is not entirely true. For example, although a higher concentration of CO_2 makes

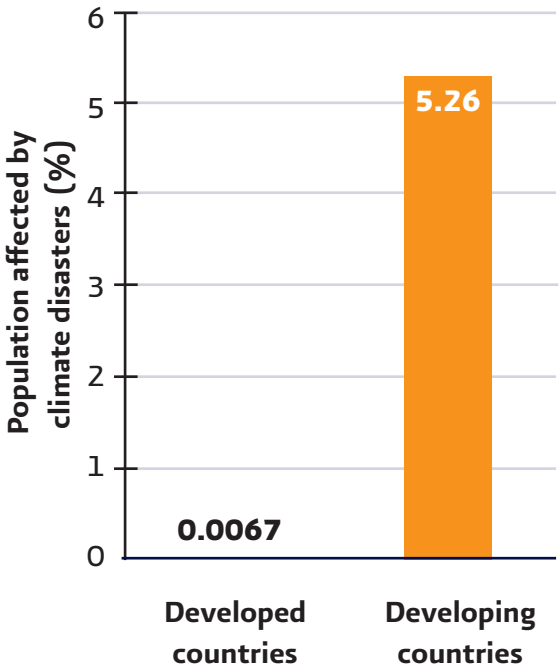
Figure 15 **Types and distribution of water-related natural disasters between 1991 and 2000**



[4]El Niño is a nearly periodic event, occurring about every three to seven years, in which a mass of warm oceanic water is transported from its usual location in the Western Pacific towards the coasts of the American continent, causing an increase in rainfall in Peru and droughts in the tropical forests of Indonesia, among other effects. This phenomenon is the result of the interaction between the atmosphere and the ocean (in the tropical Pacific) and is part of a larger phenomenon known as ENSO (El Niño Southern Oscillation) which also includes the counterpart La Niña.

Figure 16

Population affected by climate disasters in developed and developing countries between 2000 and 2004



some crops more productive in the short-term, their nutritional quality is negatively affected. A study published in 2008 in the journal *Global Change Biology* reported that the increase of CO_2 in the air reduces the protein content of several crop types. For example, reductions of between 10 and 15% were recorded in barley, rice, wheat and potato.

Droughts that hit Mexico in 2005 caused crop losses in 669,000 ha, with a monetary value of 779 million pesos. In 2006, droughts in China affected 18 million people and 12% of their agricultural production.

The national fisheries have also seen their production reduced in years with particularly unusual weather conditions. In 1998, the production volume of the sea-urchin, lobster, abalone and shrimp fisheries decreased. It is easy to imagine the social and economic consequences that such losses had for the communities that are directly or indirectly dependant on those products. The agriculture and fisheries sectors contribute significantly to the country's economy: In 2004, at least eight million people were dependant on agriculture and nearly 300 thousand were employed in fishery-related activities.

Mexican fisheries are not the only ones that have been negatively affected by climate change. The IPCC reported that the increase of sea temperature in the last ten years has led to the reduction of the North Sea cod populations -although it is just fair to add that overexploitation has also played a major role in the decline of these populations. This reduction has been mainly caused by the fact that plankton on which cod feeds has migrated towards the Arctic Ocean, following colder waters. Plankton populations have suffered a 70% reduction since the 1970's.

How does climate change affect biodiversity?

Biodiversity is defined by scientists as the variability existing between individuals within a species, between species and between ecosystems and has not been exempted from the effects of climate change. As temperature, precipitation and other environmental variables change, scientists observe consequences on many plant and animal species and ecosystems. Climate change adds, along with deforestation, the overexploitation of natural resources and contamination -among other human activities-,

to the list of factors responsible for the most serious crisis that biodiversity has faced since the extinction of dinosaurs some 65 million years ago. The severity of this problem is such that the Intergovernmental Panel on Climate Change has pointed out that about 50% of the species that have been studied have already been affected by climate change.

The effects of climate change on the planet's life are understandable if one considers that every organism of any species lives under a particular range of environmental conditions so that any significant alteration of those conditions precludes its survival and reproduction. Cloud forest frogs provide a good example of this.

These amphibians depend on the high humidity conditions prevailing in the cloud forest ecosystem for their reproduction, as their eggs can only develop in very humid sites (Figure 17). If humidity decreases for long periods of time – and this has already happened in some tropical regions-, adults bear no descent as their eggs desiccate and die rapidly. Biologists believe that this and other factors have led to the extinction of 74 frog species from the cloud forests of the world.

Climate change effects on living beings can be observed at various levels, ranging from the organisms' individual responses, their interaction with other species, the width of their distribution range or even in the distribution range of entire ecosystems. Examples of these effects are described in the following paragraphs.

At the physiological level, a higher CO_2 concentration in the atmosphere and sea water has important consequences for the feeding and growth processes of many species. For example, some species of trees and alpine plants have been benefited as they have been able to absorb and incorporate into their tissues a larger amount of carbon dioxide, which allows them to grow faster. The same effect has also been observed in some important crop species, such as sugar cane, which have seen their productivity enhanced (Figure 18). However, scientists still debate whether this might be a sustained effect as some other factors might eventually limit the growth of these species.

By contrast, the opposite effect has been observed in some marine species. When the atmosphere's carbon dioxide dissolves in sea water renders this more acidic, which hampers the growth of animals such as corals and molluscs, as it becomes more difficult for them to uptake calcium from sea water to build their skeletons and shells up, respectively. Although this acidification effect has not caused extensive impacts so far, for some organisms such as corals it might be significant, particularly in combination with other disturbance factors.

Sea temperature increase causes the so-called coral bleaching (Figure 19). In order to understand this phenomenon, we should remember that corals harbour single-celled microscopic algae in their tissues, from which they obtain nutrients in exchange for protection and access to waste particles which they use as food.

When sea temperature increases, the algae are expelled from corals. This turns the coral bodies colourless then making the underlying white skeleton of calcium carbonate apparent,

Figure 17

Frogs, cloud forests and climate change

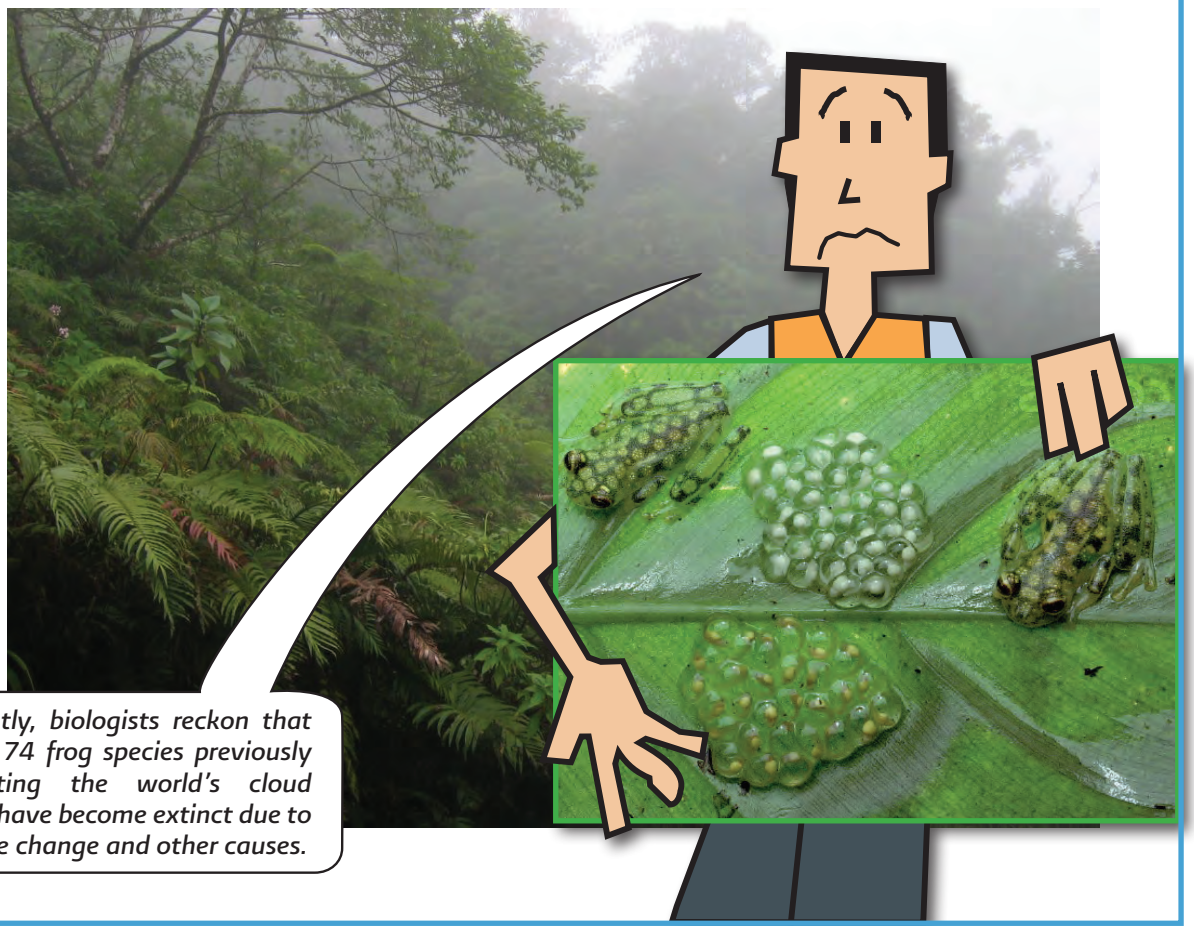


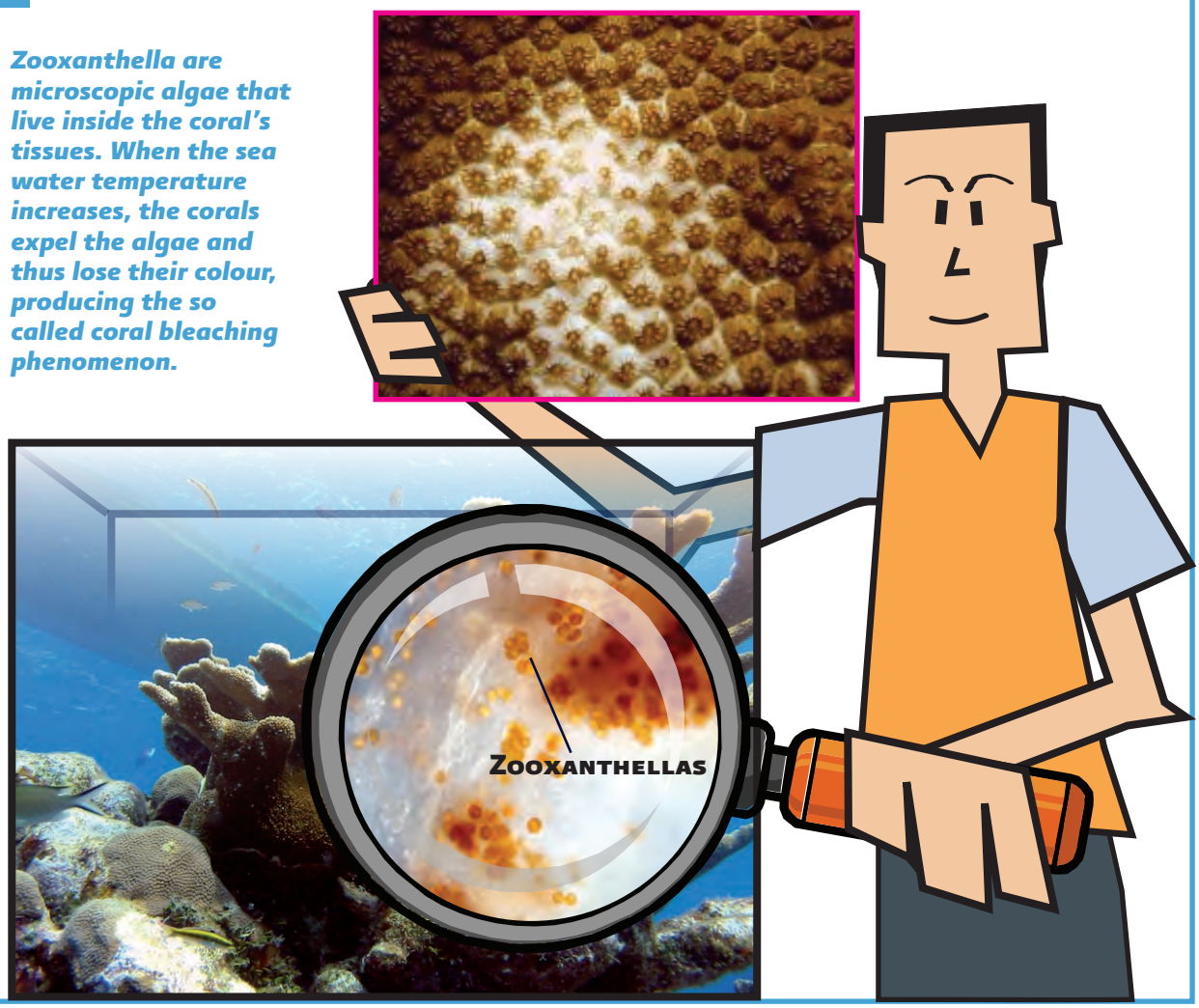
Figure 18

The productivity of some crops, such as sugar cane, can increase when growing under a CO_2-enriched environment.

Figure 19

Coral reef bleaching

Zooxanthella are microscopic algae that live inside the coral's tissues. When the sea water temperature increases, the corals expel the algae and thus lose their colour, producing the so called coral bleaching phenomenon.

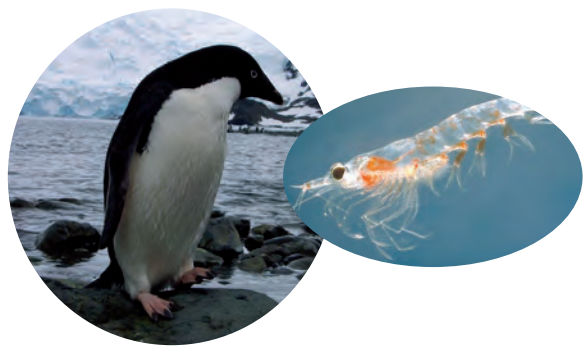


which gives this phenomenon its name. If the temperature increase has not been too intense and if other algae can re-associate with the corals, bleaching can be reverted and corals can recover their healthy state. However, a prolonged exposure to high temperatures –a 3°C increase or higher- leads to coral death.

Changes in ocean temperature can also make animals unable to find food in sufficient amounts. For example, one population of Adelia penguins in Antarctica (Figure 20) decreased from 320 pairs

Figure 20

The food chain of Adelie penguins



The population of Adelie penguins decreased due to the migration of krill, their main food item.

with chicks in 1990 to only 54 in 2004, at a site where the average temperature had increased 5.5°C over 50 years. This drastic reduction in the number of pairs seems to be related to the migration of "krill"[5], which is their main food item, towards colder zones farther southwards where penguins can hardly reach them. However, one of the most outstanding examples of the consequences of the reduction in food availability is that of polar bears, which is described in the ***Box Nanook, the polar bear***.

Climate change affects the seasonal processes of many species, such as flowering in plants, migration in birds and the emergence of trees' first leaves in the springtime. It has been found that some bird species in the United Kingdom are initiating breeding earlier and are modifying their distribution range as a consequence of the warmer winters that are being experienced in the isle. On the other side of the Atlantic, in North America, another study found that six bird species are also laying eggs earlier in the year as a response to the temperature increase in the springtime. A detailed example of this sort of alterations in birds and their consequences is given in the ***Box: Where is my caterpillar?***

As a response to changes in environmental variables, organisms of some species have been displaced to new sites where environmental features are similar to those in their original habitats. As a consequence, their geographical distribution ranges are no longer the same that were described by scientists some 50 years ago. For example, the American Pika (Figure 21), a relative of rabbits, had its distribution range in the mountainous areas of North America reduced while other species, such as many forest pests, have seen their distribution ranges enhanced (Figure 22). These changes have been observed in all continents, even in the polar regions, and in nearly all taxonomic groups, including plants, insects, amphibians, birds and mammals. Nevertheless, it should be pointed out that not all species are equally capable to move to other sites to avoid the impacts of climate change. This means that, if they are unable to adapt locally to the new conditions, they might become extinct in the medium or long-term.

Figure 21 **American pika**

The distribution range of the American pika (a relative of rabbits) in the mountainous zones of North America has been reduced due to climate change.

[5]This is the generic name given to a diverse set of marine crustaceans related to shrimp, which are at the basis of the food web and thus constitute a very important component of the diet of many marine species.

Nanook, the polar bear

Box

For the Inuit –who are better known to most of us as Eskimos- the polar bear, "Nanook", is the most valuable hunting prize, as they regard it as "wise, powerful, near-man". Now, this charismatic animal has become one of the most famous earliest victims of climate change.

Polar bears are the largest mammals inhabiting the Arctic Circle. Although their exact numbers are not known, some studies estimate that there should be between 20 and 25 thousand individuals inhabiting the Northern-most lands of Canada, Alaska, Greenland, Norway and Russia. Some 60% of the total population of polar bears is estimated to live in Canada alone.

Unrestricted hunting had been the largest threat to polar bears during the 60's and early 70's, until this was banned in 1973 when the International Agreement on Conservation of Polar Bears and Their Habitat was signed in Oslo, Norway. Nowadays, although the bears have gotten rid of hunters, they now face global warming as the major threat to their survival.

Ice floes are essential for polar bears to obtain food, breed and den formation. There they prey on ringed and bearded seals, which are the main components of its diet, although they can also hunt beluga whales and walruses. However, as Arctic temperatures have increased over the last decades, ice floes have become thinner and smaller: The ice lost during the summer of 2008 was estimated to be almost 90% of the size of Mexico. Ice loss makes it more difficult for bears to hunt for food and, therefore, they do not accumulate enough blubber reserves for the wintertime, suffer starvation and, even worse, cannot feed adequately their cubs all of which leads to increased mortality. Scientists estimate that, due to these causes, the bear

Nanook, the polar bear (conclusion)

Box

1962

2007

2010 - 2030

2040 - 2060

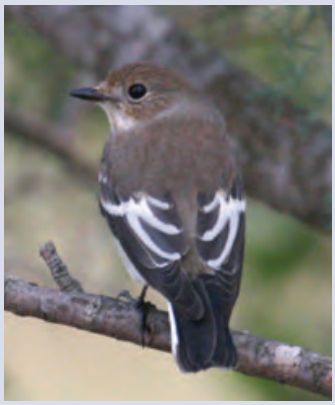
2070 - 2090

population of the Western Hudson Bay in Canada has diminished some 22% since the early 80's. In some other cases, ice melting has forced these powerful swimmers to reach to the sea searching for floes where to hunt. However, distances can now be so great that the animals drown before being able to reach another floe.

Nowadays, the International Union for the Conservation of Nature (IUCN) considers that, out of the 19 existent populations of polar bear, five are declining, other five are stable, two are increasing and there is not enough information about the status of the remaining seven populations. However, if the Arctic temperatures keep rising, it is likely that the polar bear cannot survive. Forecasts suggest that, over the next 50 years, summertime ice will be reduced in 60% (see maps in the Figure). Although the bears have migrated farther inland, it is doubtful whether they might shift their feeding habits to adjust to their new habitats.

Where is my caterpillar?

Box



In natural ecosystems, the rule is that some species feed on others. Just recall the examples of salmon and grizzly bears in Alaskan rivers, zebras and lions in the African savannah and caterpillars and birds all over the world, among others. Through generations, some species have synchronized their biological rhythms to exploit their prey at critical points in their life cycle. For grizzly bear, for example, the time of salmon upriver migration into its spawning grounds provides the best opportunity for the bears to replenish their fat reserves just before winter; for many birds, caterpillars hatch just at the time when the birds require the most food to feed their nestlings. And it has been in this case where climate change has made the migratory Pied Flycatcher to have a hard time in The Netherlands.

Until the 1980's, the migratory Pied Flycatcher (*Ficedula hypoleuca*) used to arrive to breed sometime between April and May. By early June, the number of recently hatched chicks was at its peak (see Figure below) but feeding them was relatively easy for their parents as, at that time of the year, newly hatched caterpillars were also at their peak. Thus, there was a constant supply of food available for the chicks. Twenty years later, however, temperature increase has made caterpillars to hatch about fifteen days earlier than before, thus reducing the caterpillar supply for the nestlings. Due to this mistiming, many chicks cannot be properly fed by their parents and die with serious consequences for the population. As a result of climate change, populations of the migratory Pied Flycatcher have declined by about 90% over only two decades.

Effects of climate change on the flycatcher

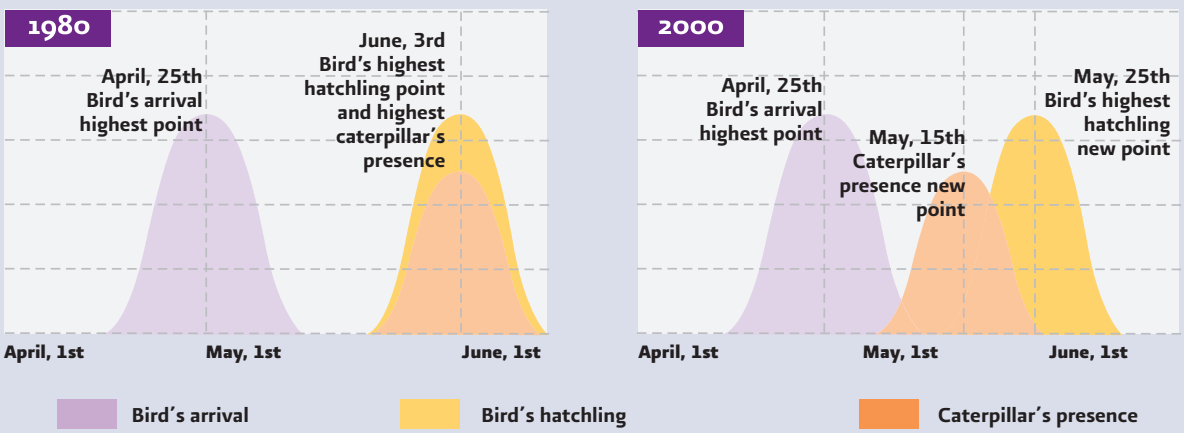
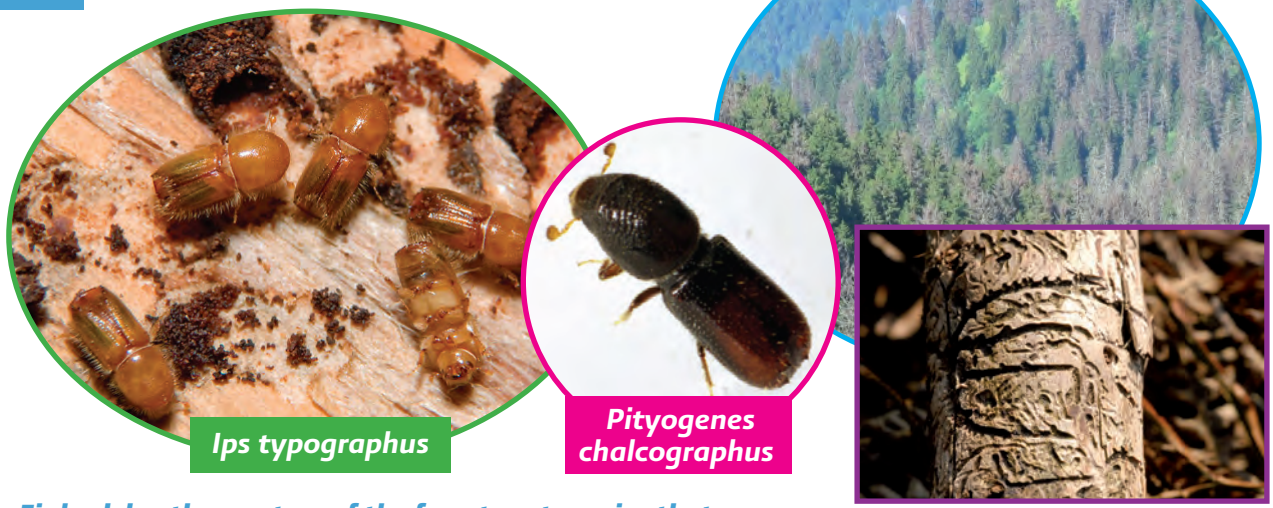


Figure 22

Forests pests and climate change



Fir bark beetles are two of the forest pest species that have become wider spread in the forests of Europe due to climate change.

Examples of damage caused by fir bark beetles.

Finally, responses to environmental change are being noticeable also at the ecosystem level. The replacement of entire ecosystems for others has already occurred in some parts of the planet. For example, a recent study demonstrated that, between 1957 and 1991, the high-altitude meadows at a locality in central Spain were replaced by juniper (plants belonging to the pine family) shrublands typical of warmer zones, as climatic records showed warmer temperatures in the zone. On the other side of the Atlantic, in Alaska, some boreal forests were replaced by wetlands due to the melting of the underlying permafrost soil with higher temperatures.

Temperature increase and ocean acidification have caused the degradation of coral reefs. The high temperatures recorded in 1998 –which will be remembered as one of the warmest years in history- caused about 16% of the world's coral reefs to suffer bleaching or die. In some regions the effect was even more extreme: In the Indic Ocean, for example, 46% of the coral reefs suffered bleaching while in the Mexican Pacific reef mortality reached between 18 and 70%. High sea temperatures leave behind coral reefs degraded and impoverished in species of both corals and others that depend on them, such as fish, crustaceans and molluscs among others. As they are so sensitive to temperature increase and ocean acidification, coral reefs are considered as one of the most vulnerable ecosystems to climate change.

Should we worry about biodiversity loss caused by climate change?

Think for a moment about where the food that you and your family eat every day came from or about where the materials that your clothing and furniture are made of came from. You will quickly realize that most of those materials come or derive from plants and animals that constitute biodiversity.

There are many other services that biodiversity provides for and that you may not be aware of. For example, natural vegetation captures part of the carbon dioxide that is emitted by motor cars and industries, which helps to reduce the concentration of GHG in the atmosphere and, thus, the global warming effect. Other examples of environmental services are the regulation of local climate, water capture, water quality maintenance, control of pests and diseases, decomposition of our wastes, soil formation and maintenance of soil fertility, and the polinization of crops that bees, butterflies, bats and other animals carry out.

Biodiversity loss, either due to climate change or to the combined effect of deforestation, overexploitation of natural resources or pollution, among other factors, might have important negative effects for our society, mostly due to the loss of environmental services that are freely provided by ecosystems. It is even likely that the ecosystems' capacity to regulate climate be lost (read the ***Box: Amazon, a finite source of good climate*** for more details on this topic).

Amazon, a finite source of good climate

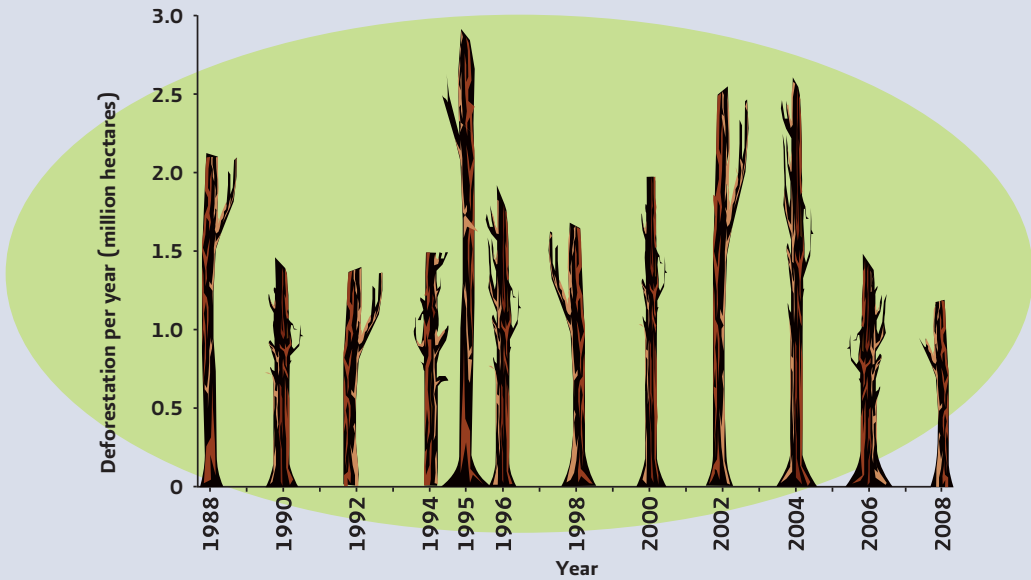
Box

The Amazon is the place of the world that most people would think of when talking about tropical forests. This vast South American ecosystem is the largest remnant of tropical forest in the world and harbours an unmatched richness of animal and plant species.

However, as most tropical forests in the planet, the Amazon is being seriously threatened. Deforestation has caused the loss of a little over 37 million hectares between 1988 and 2008 only in Brazil; that is an extension equivalent to 20% of the Mexican territory. In addition to the loss of vegetation, deforestation releases greenhouse gases, mostly due to the use of fire. The CO_2 emissions associated to deforestation in the Amazon account for between 5 and 10% of global emissions, according to a report published by the UK Royal Society. On top of that, vegetation loss also reduces the forests' capacity to regulate climate.

Amazon, a finite source of good climate (conclusion)

Box



How does the Amazon contribute to regulate the climate? The answer to this question can be found if we look at water flow in these ecosystems. Part of the water that is absorbed by plants evaporates from the leaves' surfaces through tiny pores known as stomata. Water evaporating from the thousands of leaves on the thousands of plants inhabiting the forest produces the jungle's oppressive humidity. It is estimated that trees in the Amazon release over 8 trillion cubic meters of water to the atmosphere through this process, which leads to cloud formation and, eventually, tropical thunderstorms that, in addition to irrigating the jungle, can be transported by wind and reach places so far away as the Andean region. Scientists estimate that, in tropical forests, between 50 and 80% of the moisture is continuously circulating between the soil, the vegetation and the atmosphere, without any significant influence from moisture from the sea. This mechanism makes humidity and other environmental variables in tropical forests and other ecosystems to be partially regulated by the vegetation itself. Because of this, plants and ecosystems are elements essential for regulating the local and regional climate.

When trees and other plants are eliminated by deforestation, all the water vapour that was stored in the air is lost and this reduces the amount of rainfall that would have been produced from it. The end result of this is, as you can easily imagine, a drier environment. And this is precisely what climatologists have predicted to happen in the Amazon. According to those predictions, with climate change vast zones of South America might suffer increasingly higher temperatures and scarcer rains, which, when added to deforestation, would enhance the drought effect. Some scientists have even predicted that, with these two factors acting simultaneously, vast zones of tropical forests would be converted into savannah, a drier and less biodiverse ecosystems. In such a case, South America and the whole planet would have not only lost a significant extension of one of the richest and most fascinating ecosystems of the Earth, along with a vast wealth of irreplaceable natural resources and environmental services, but also one of the most influential regulators of the regional and global climate.

Can you imagine how much money we should invest, with the currently available technology, to replace –were this possible at all- the environmental goods and services that nature provides? Estimates for this are breathtaking: The total value of the environmental services provided by the world's ecosystems might be something between 16 and 54 trillion–one 16 or 54 followed by 18 zeros- per year, an amount of money so huge that represents between 25 and 83% of the total value of products sold in the world every year. However, once lost, some environmental services can simply not be replaced with any amount of money. From this, you can realize that, because of its adverse effects on ecosystems and on the provision of environmental services, climate change can affect directly human life.

What would the future look like under climate change?

If you are one of those persons that go out with an umbrella whenever there is a rain warning, this section is for you. And, if you are sceptical, do not miss it either as we will try to convince you that climate change projections are reliable, as there exists sufficient evidence to back them up. In any case, if you wonder what the future world's climate –the one in which you will live the rest of your days or the one in which your children and grandchildren will live- might look like, then it will be helpful having a look at projections made by scientists.

Climate is such a complex phenomenon, involving so many intervening factors, that it is very difficult to make predictions with absolute certainty. This does not mean that forecasts made by climate scientists should not be believed, but it rather means that their results are reliable within certain margin of error. Nevertheless, predicting the main features of the future's climate is feasible, useful and necessary.

When scientists realized that the planet's temperature could be modified by the change in the GHG atmospheric concentration, they began making projections. What they wanted to know was, in essence, what temperatures could be reached in the planet under certain CO_2 concentrations in the atmosphere. The mathematical equations that they used were relatively simple at first –some 110 years ago-, both because of the little knowledge then existing about how climate works, and because of the difficulty of making too many computations at a time when computers were not yet available. Over time, equations became increasingly complex and included other new variables that were considered important, thus allowing a better "simulation" of the global climate system behaviour with the help of super computers. Those results have allowed us to understand what the consequences of the increase in GHG in the atmosphere might be under different scenarios, like those used by the Intergovernmental Panel on Climate Change (IPCC). Similar efforts have also been carried out in Mexico to generate likely scenarios and, although these are still in the development and improvement stage, national predictions are often similar to worldwide predictions.

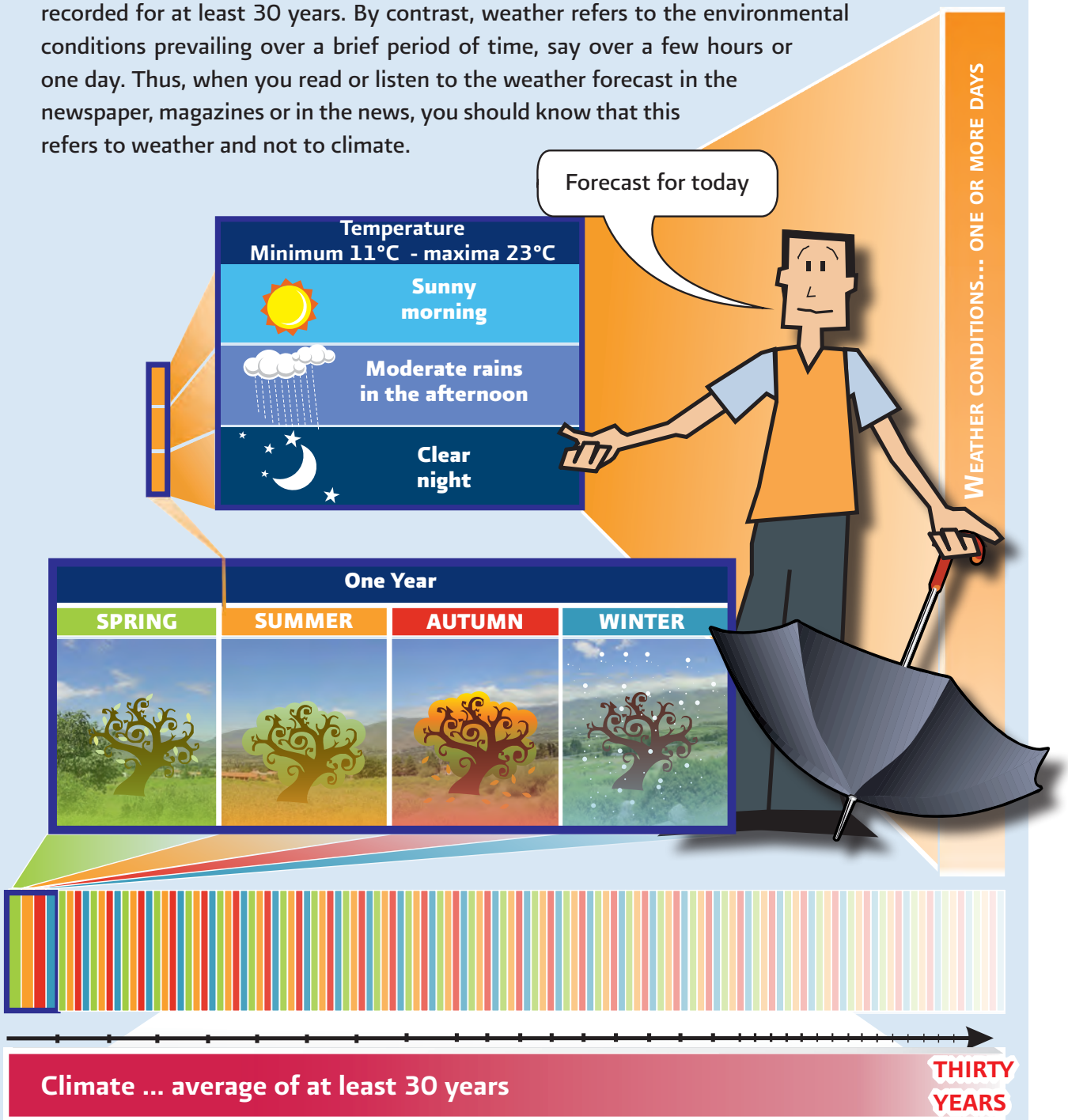
In the world

In 2007 the IPCC presented their Fourth Assessment Report, with worrisome conclusions. They concluded that, with the current trend of GHG emissions, by the year 2100 the global concentration of CO_2 could be something between 540 and 970 parts per million. In order to put this figure in perspective, one should remember that today's concentration is 385 parts and, during the preindustrial era, it was only 280 parts per million.

Climate *versus* weather

Box

Although many people use the terms climate and weather interchangeably, they are not quite the same. The traditional concept of climate refers to the set of environmental values that are characteristic of a given region. Those values are averages obtained from measurements of variables such as precipitation, atmospheric pressure, temperature, winds and humidity, recorded for at least 30 years. By contrast, weather refers to the environmental conditions prevailing over a brief period of time, say over a few hours or one day. Thus, when you read or listen to the weather forecast in the newspaper, magazines or in the news, you should know that this refers to weather and not to climate.



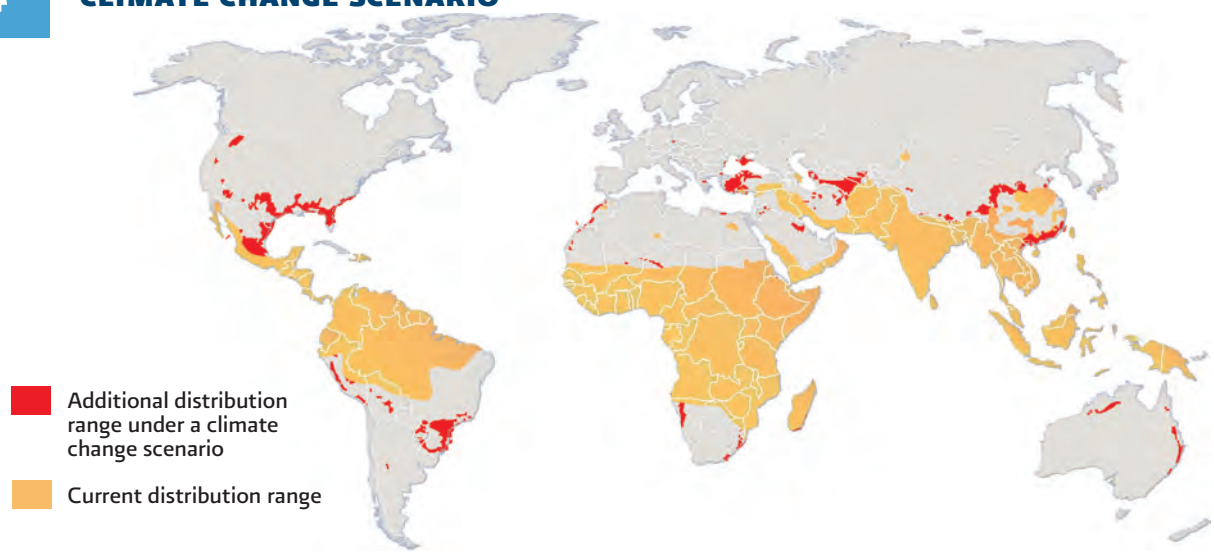
As we have seen, this increase in the GHG concentration will affect temperature. The IPCC foresees that, by the last decade of the 21st century, the global average temperature might increase between 1.8 and 4°C. Such an increase might seem small or little significant, as we all have experienced abrupt changes in temperature from one day to the other –such as when a cold spell or a heat wave occur-, but what one should bear in mind is that projections describe average changes, that is, changes in the overall temperature of the year, so to say, and not changes between individual days (see ***Box: Climate* versus *weather***). Were this not convincing enough, one should consider that a temperature only 5°C colder than the present day's average was enough to keep large part of Europe, Asia and North America under a huge mass of ice some 11,500 years ago, during the last glaciation.

The atmospheric concentration of GHG, as well as air and sea temperatures, are intimately interconnected with other elements of the environment. It would be naive to imagine that future consequences of climate change will be limited only to changes in the average temperature. Scientists know now, and with high confidence, that other important aspects such as precipitation regimes (that is, how, how much and where it rains), ice sheets present in polar regions and on the top of mountain ranges and volcanoes, sea level and marine species and ecosystems and, in the end, humans, will also be affected. In fact, most concerns about climate change stem from learning how the basic elements of our daily lives –such as food (due to the reduction in crop and fisheries production), health (due to the increase in vector transmitted diseases such as malaria, see Map 4) and security (due to the increase of, for example, deathly victims of hurricanes and storms) will be affected.

Figure 23 describes some of the impacts that the IPCC predicts might occur throughout the world under different scenarios of temperature increase. For example, it is projected that any temperature increase (regardless whether it is one or five degrees Celsius) will increase the number of people who suffer water shortage in the world. As to food supply, cereal production might be

Map 4

Malaria in the world: current and projected distribution under a climate change scenario



[6]Vectors are those organisms, such as mosquitoes, ticks and rats among others, that bear and transmit pathogens.

reduced in the lower latitudes of the globe if average temperature increases 2 or 3 degrees Celsius. Under that same scenario, a generalized mortality of coral reefs throughout the world's oceans is expected. Vector-transmitted infectious diseases might expand their distribution range with the increase in global temperature: By 2050, cases of malaria might appear in zones previously free of this disease, such as Southern United States and the North and East of Australia.

It is important to consider that the impacts of climate change on the environment will not be the same and will not have the same intensity in all parts of the world. It is likely that each region of the world, given its own particular characteristics and conditions, experience climate change and its consequences in a different manner. Figure 24 shows some projections of what might occur under a changed climate scenario for different regions of the world. In Latin America, Europe and Oceania, for example, an important loss of biodiversity is predicted; water availability might be reduced in nearly all regions, except for Polar Regions; and flooding of coastal zones would affect mainly Europe, Asia and Oceania.

Figure 23

Foreseeable impacts of climate change

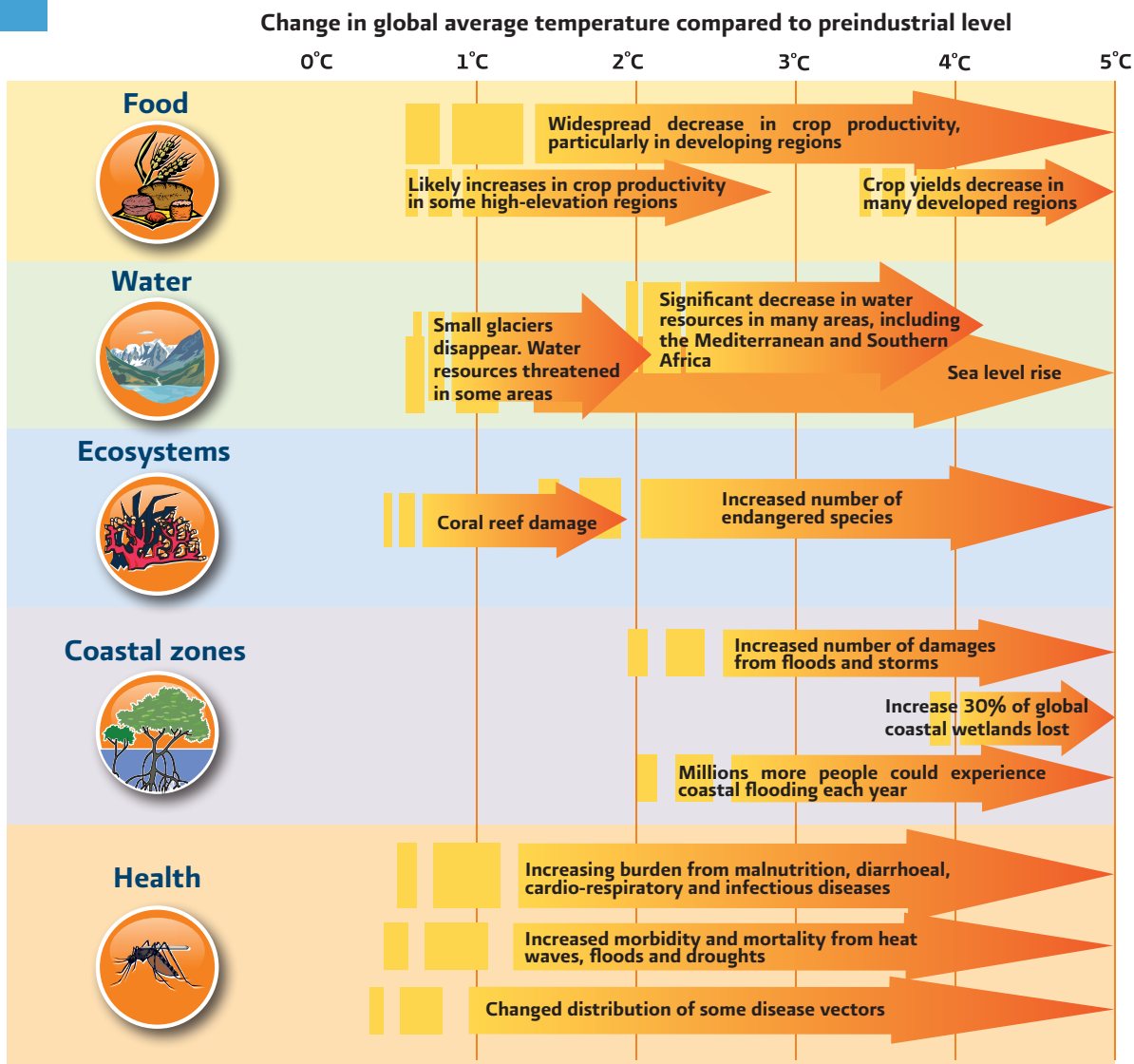
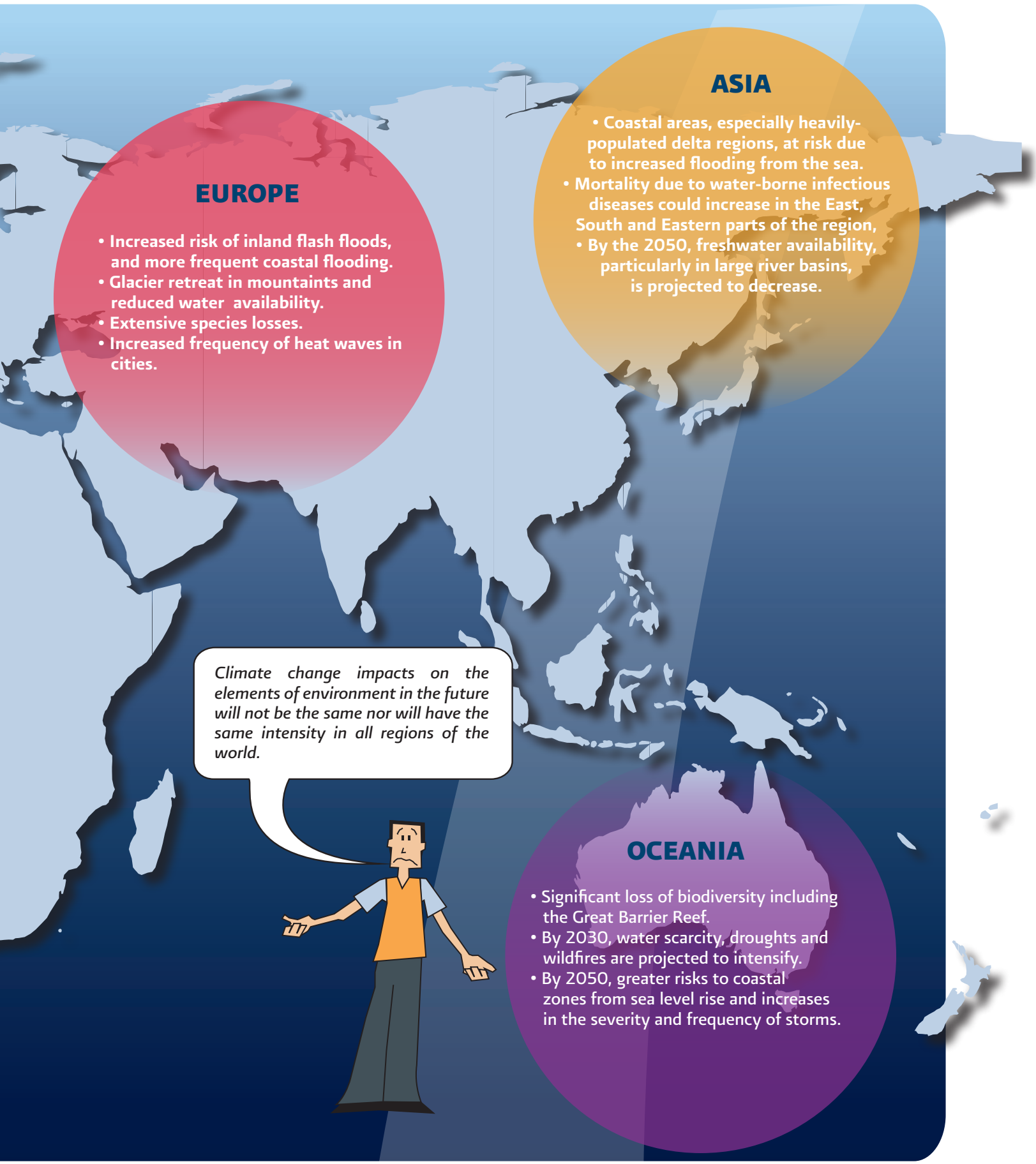



FIGURE 24
FUTURE IMPACTS OF CLIMATE CHANGE BY REGION
POLAR
• Reductions in thickness and extent of glaciers.
• Changes in natural ecosystems, possible invasion by species from other ecosystems.
• Detrimental impacts on traditional indigenous ways of life.
• Heat waves more frequent in cities.
NORTH AMERICA
• Increased frequency of heat waves.
• Decreased mountain's snowpack exacerbating competition for water.
AFRICA
• By 2020, between 75 and 250 million people exposed to increased water stress.
• By 2020, agricultural production and access to food severely compromised.
• By 2080, an increase of 5-8% of arid and semi-arid lands.
LATIN AMERICA
• Significant biodiversity loss through species extinction in tropical zones.
• Significant effects on water availability for human consumption, agriculture and energy generation.
• Productivity of important crops decreases and livestock productivity declines.


EUROPE
• Increased risk of inland flash floods, and more frequent coastal flooding.
• Glacier retreat in mountaints and reduced water availability.
• Extensive species losses.
• Increased frequency of heat waves in cities.
ASIA
• Coastal areas, especially heavily-populated delta regions, at risk due to increased flooding from the sea.
• Mortality due to water-borne infectious diseases could increase in the East, South and Eastern parts of the region,
• By the 2050, freshwater availability, particularly in large river basins, is projected to decrease.
Climate change impacts on the elements of environment in the future will not be the same nor will have the same intensity in all regions of the world.
OCEANIA
• Significant loss of biodiversity including the Great Barrier Reef.
• By 2030, water scarcity, droughts and wildfires are projected to intensify.
• By 2050, greater risks to coastal zones from sea level rise and increases in the severity and frequency of storms.

Greenland: The drop that will spill the cup?

Box

Water derived from the melting of glaciers in Greenland due to global warming has dug deep channels both, on the surface and beneath the icecap, on its journey to the Atlantic Ocean. According to the latest IPCC report, glacier melting in Greenland could keep adding to sea level rise well beyond the year 2100. In an extreme case, if all the ice in Greenland melts away, the rise in sea level might reach 7 metres.

In Mexico

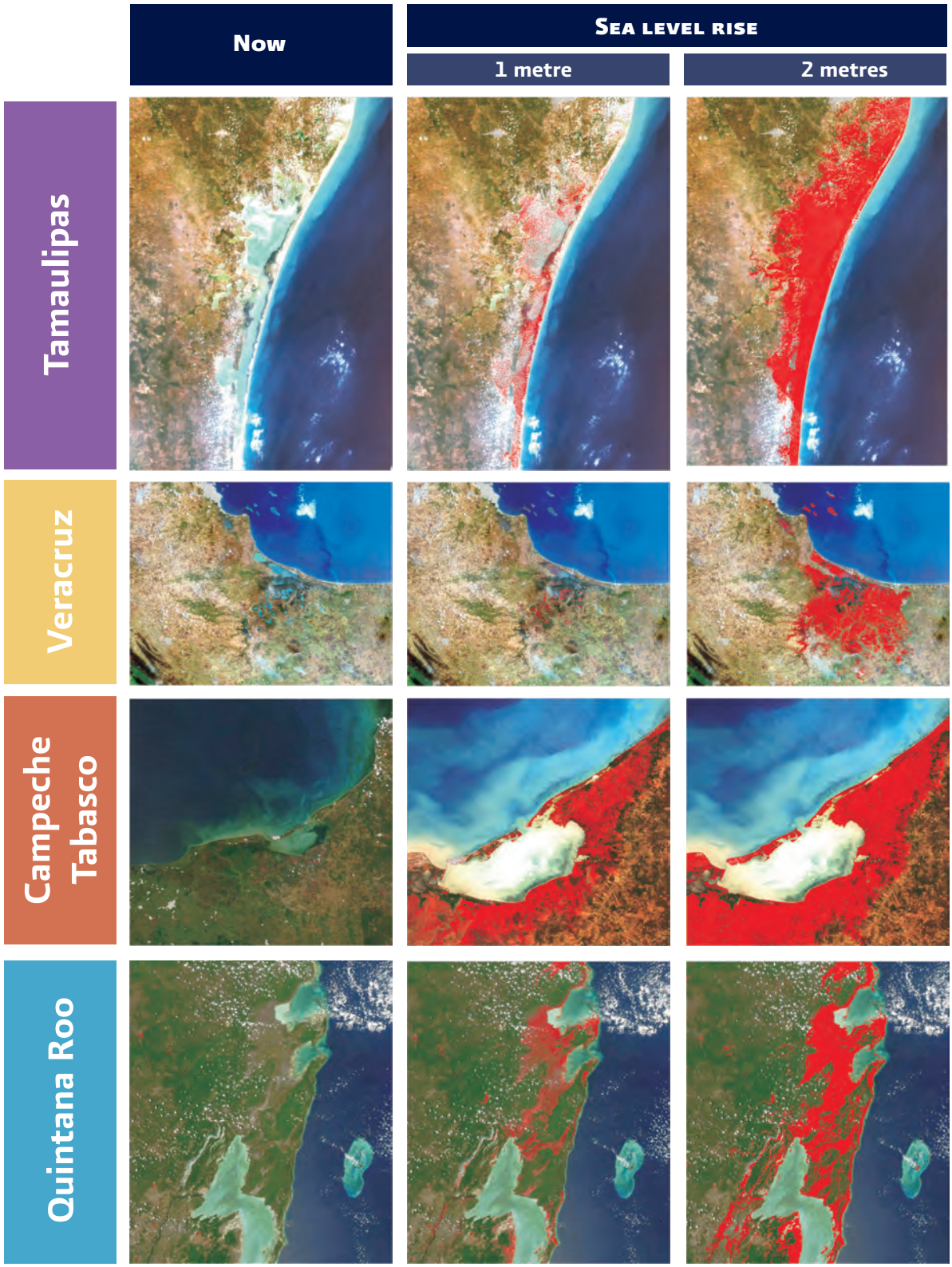
Some studies have been carried out to try to determine our vulnerability to global climate change. Experts have estimated that, by 2020, the average temperature in Mexico might be between 1.5 and 2.5 °C higher than today and it might reach 2 to 4°C by 2080, with regional variations: The Northern region will experience the largest increases in temperature.

Along with air temperature, the country's seas will also be warmer in the future: In the Caribbean, Gulf of Mexico and Pacific, sea water temperature might increase between 1 and 2°C by 2020. As a consequence, hurricanes' intensity is likely to increase and, with that, their impacts on human populations and coastal ecosystems. One should remember that hurricanes draw their energy from the condensation of humid air over oceanic waters and, if these are warmer, then they will evaporate more water thus strengthening tropical cyclones. Scientists predict that the frequency of hurricanes category 4 and 5 (in the Saffir-Simpson scale) – that is, the most intense ones- will increase along the Mexican coasts.

Hurricanes will not be the only consequence of sea water warming; floods are also predicted due to the increase in sea level. Mexico's National Institute for Ecology recently carried out an analysis to identify the zones of the country that might be affected. Figure 25 shows some of the country zones that would likely be flooded were sea level to rise one or five meters. Those floods would have important impacts on both ecosystems and localities. According to some computations, there are in the country some 20 million people living in zones prone to suffer extreme weather events such as floods and hurricanes.

Figure 25

Coastal zones in the Gulf of Mexico and the Caribbean that might be affected by sea level rise

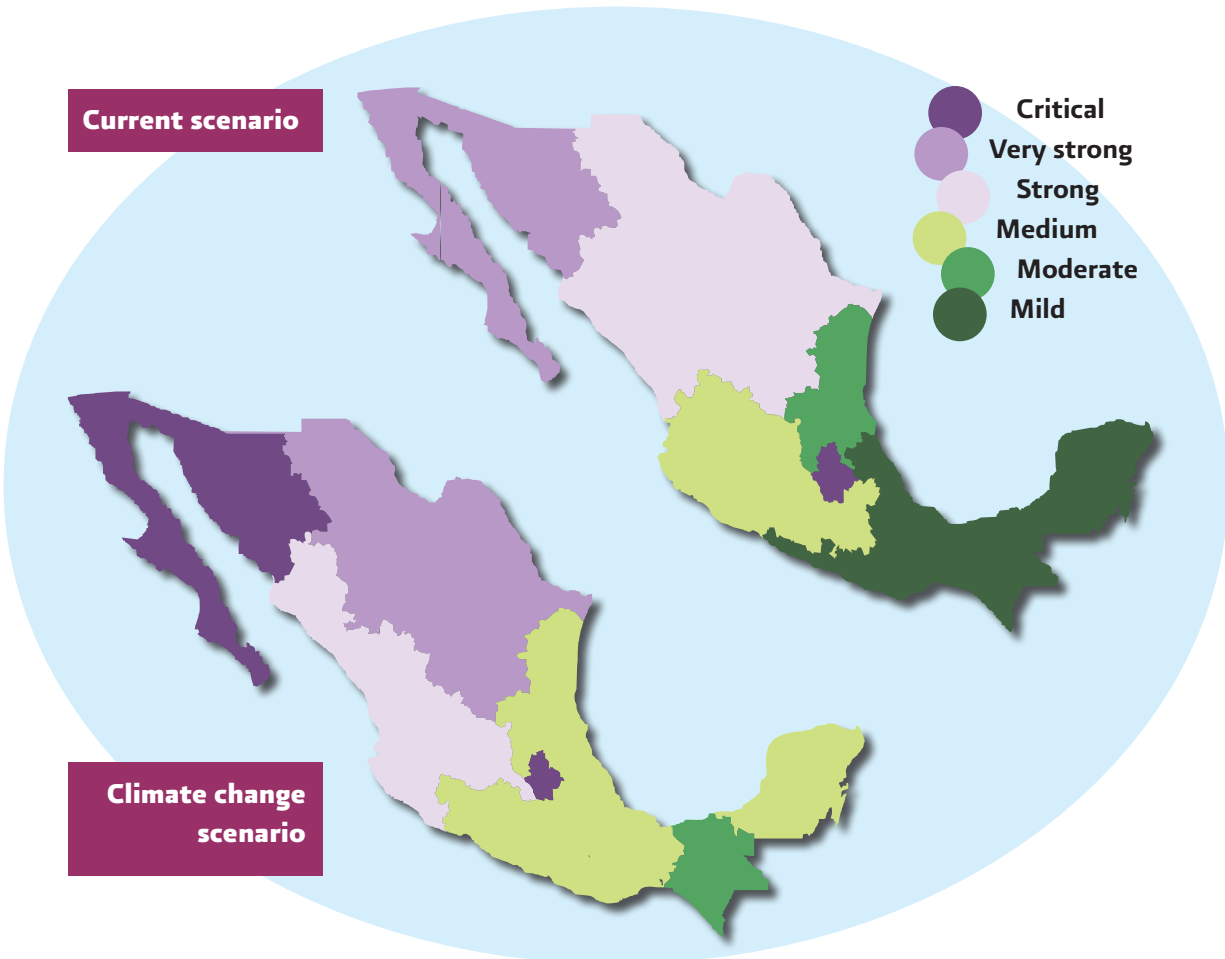


Areas shown in red could be flooded due to sea level rise

As for precipitation, some studies suggest that winter rainfall could be reduced up to 15% in some parts of Central Mexico and 5% in the Gulf zone, and the onset of the rainy season might also be delayed in several parts of the country. In addition, the number of severe storms might increase, that is, those weather events with torrential storms that cause floods and landslides will become more frequent.

By contrast, longer and more intense droughts are also expected. This means that the water scarcity that is already affecting most of the country will become even more severe with climate change. The upper map in Figure 26 shows that, even today, there is already a high pressure on water resources, particularly in the North-eastern region and in the Valley of Mexico. According to some studies, given the country's social and economic development and the climate change scenarios, the amount of water that might be available between 2020 and 2030 would be 10% lower than what was available in the year 2000. Under such scenario, the stress on water resources in both, Baja California and Sonora, will reach a critical level (lower map in Figure 26). Other parts of the country will also increase significantly their degree of stress on water resources, although not so much as to reach a critical level.

Figure 26 **Stress on water resources in the year 2000 and under a climate change scenario**



Mexican ecosystems will also suffer the impacts of climate change. The major causes will be temperature increase (which might cause larger and more intense wild fires), alterations of the hydrological cycle (expressed as changes in the amount, frequency and time of occurrence of rains) and extreme weather events (such as hurricanes and floods which, due to their increased frequency, might delay the natural regeneration of ecosystems).

It is also important to bear in mind that different ecosystems will also be affected differently by climate change. According to a study included in Mexico's Third National Communication on Greenhouse Gases of 2006, the vegetation types that might undergo the largest changes in their extensions are grasslands, arid zone shrublands and oak forests, three important, species-rich ecosystems. Future scenarios are worrisome, as studies suggest that between 53 and 62% of the country's natural vegetation might experience environmental conditions significantly different from today's and, therefore, tropical and temperate forests, along with other ecosystems, will also suffer the effects of climate change.

Along with the reduction in the extension of some ecosystems, changes in the geographical ranges of species will also occur. A recent study carried out by the Institute of Biology (UNAM, National Autonomous University of Mexico) and the National Institute for Ecology (SEMARNAT) assessed the likely impact that climate change might have on 40 endemic species[7] of terrestrial vertebrates. Results obtained showed that species inhabiting the Mexican high-plateau, such as prairie dogs (*Cynomys mexicanus*), a rodent from open grasslands (Figure 27), might suffer an important reduction in their habitats due to the effects of climate change. The same study looked also at the likely impact of deforestation, and they concluded that, in most cases, this would be lower than the impact of climate change.

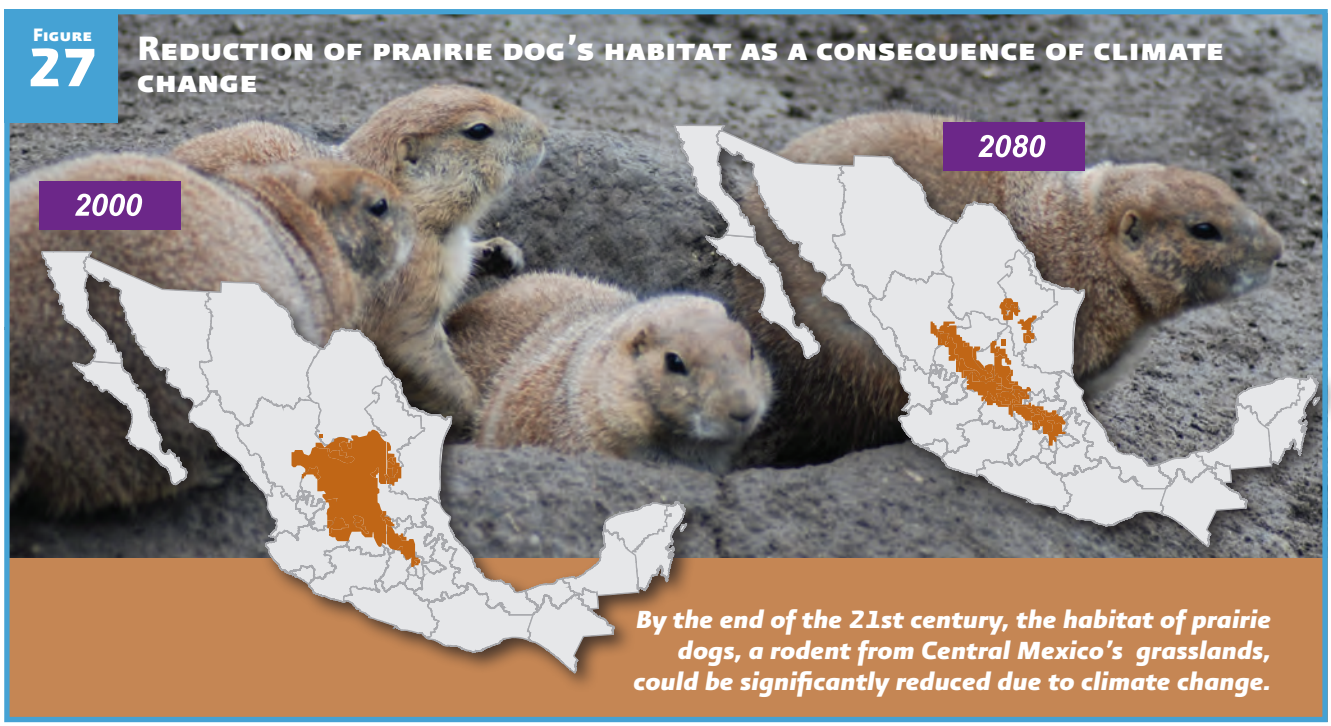


Figure 27 **Reduction of prairie dog's habitat as a consequence of climate change**

By the end of the 21st century, the habitat of prairie dogs, a rodent from Central Mexico's grasslands, could be significantly reduced due to climate change.

[7]Mexico's endemic species are those species that cannot be found in any other part of the world.

Climate change impacts on ecosystems will affect not only the plant and animal species inhabiting them but also human beings, as the environmental goods and services that they provide to us could be lost.

As a consequence of the reduction in water availability in the country, food production might also be affected. Experts point out that by 2020 the surface area with conditions suitable for rain-fed maize crops would shrink, particularly in the State of Sonora which will be the worst affected. Despite differences in the available estimates, several studies agree on the prediction that, by 2050, the suitability to grow rain-fed maize will change in some 40% of the country's territory. A recent study on the economic costs of climate change in Mexico has concluded that costs for the agricultural sector will represent between 15 and 22% of the GDP by 2100[8].

A direct effect of climate change on human health is the so called "heat stroke", a condition in which the body is impaired to dissipate excess heat and which might cause death, mainly in children and elderly people. The Northern states of Mexico, particularly Sonora and Baja California, are the ones where more deaths for this cause have occurred: Only in 2007 six people died for this cause. Were temperature to increase, events like these would cause far more victims, perhaps as it happened in Europe in the summer of 2003 when some 35,000 people, mostly elderly, died.

In addition to heat strokes, some infectious diseases might also be favoured by global warming. It is well known the direct relationship between ambient temperature and the number of cases of dengue, a mosquito-borne disease characteristic of tropical zones[9]. In Mexico, according to the Ministry of Health, this relationship has been documented in the states of Veracruz, Nuevo León, Guerrero and Colima. In the two latter states, it has been shown that the number of cases increases between 1.5 and 2% with each degree Celsius of temperature increase. In addition to dengue, the incidence of malaria –a mosquito-borne disease caused by a protozoan- and acute diarrheal disease –caused by bacterial infection- might also increase with higher temperatures.

From the information presented above one might imagine a devastating future for Mexico and the rest of the world due to climate change. However, we do not mean to convey a desolate picture of the future in which nothing can be done but, rather, to help you be well informed and aware of both, the magnitude of this problem and of the fact that there is still time to prevent the worst climate change scenarios. It is therefore important that you learn what is being done both in Mexico and throughout the world to address climate change issues and, more importantly, to learn that each of us can also contribute to solve this problem.

[8]The Gross Domestic Product (GDP) is the market value of all final goods and services officially made within the borders of a country in a certain period of time.

[9]This disease manifests as fever and intense muscle and joint pains, as well as swelling of ganglia and rash. Repeated infection can develop into Dengue Hemorrhagic Fever, with grave, often deadly consequences.

The timeline of climate change **Box**

For many people, the history of climate change dates back to only a couple of decades ago. However, the first scientist to predict the changes in average temperature as a consequence of the increase in the atmospheric concentration of GHG did so some 113 years ago, in 1896. Through this timeline, you will learn about some of the scientists that made important discoveries or put forward sound theories that earned them a prominent place in the history of climate change research, as well as facts and

What are we doing to help address climate change?

Having looked at the likely consequences of climate change, one can justifiably ask: Why did nobody act before to prevent this problem from happening? Why did countries not take measures to reduce their GHG emissions on time? What can we do in our daily lives to help solve this problem?

Being a global problem, with the responsible and affected people distributed throughout the world, its solution demands an integrated action. This should include a commitment by the international community –particularly by those countries having the largest emissions and plentiful economic resources to support mitigation measures-, actions within each country and, without any doubt, an active participation of society, adopting actions leading to a net reduction of emissions without compromising the quality of life, as nobody would dare to suggest that the solution is that we all live again as in the pre-industrial times.

In this section we will describe, first, what has been done in the international arena with regard to climate change issues and, secondly, the actions taken by the Mexican government to address this problem.

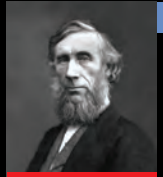
International actions

For many of us, with the information that is now available, there does not seem to be any explanation for the lack of opportune action by the world's governments. However, in order for us to make a better judgement, it is important to learn how this subject has evolved in the international arena, what progress and achievements have been made, and what difficulties have been faced, although the final result is still an admonishment for not having acted earlier.

The acceptance by governments to act against climate change has been dependent on how "certain" its occurrence is, what its consequences might be, how costly remedial actions would be and what benefits might be obtained (Figure 28). One has to consider that, although more than a century has passed since the first warnings about climate change were raised, sound scientific evidence about its occurrence and reliable information about its magnitude and the likely consequences of its impacts have been available only until the end of the last century (see ***Box: The timeline of climate change***).

It is also important to consider the enormous difficulties that countries should surmount in order to reduce their GHG emissions. You do not need to have a PhD in technology to guess that GHG emissions can be reduced by reducing fuel consumption. However, this would severely affect vital activities such as electricity generation, transport and industrial production which nowadays are the greatest fuel consumers. Halting such activities is not an acceptable solution; just imagine that in order to reduce fuel consumption a day without transport or a day without industry were decreed. A better alternative would be to improve the energy efficiency of those processes so that, without stopping them, less but better fuels are consumed. This could be achieved, for example, by promoting electricity generation from renewable sources such as solar, wind

events that have constituted milestones in the response of the international community to fight this global problem. In this trip trough time you will also learn about some natural events that announced or confirmed the impacts of climate change in today's world.



1859

John Tyndall

discovered that some gasses block infrared radiation and suggested that changes in the concentration of those gasses in the atmosphere could modify the climate.

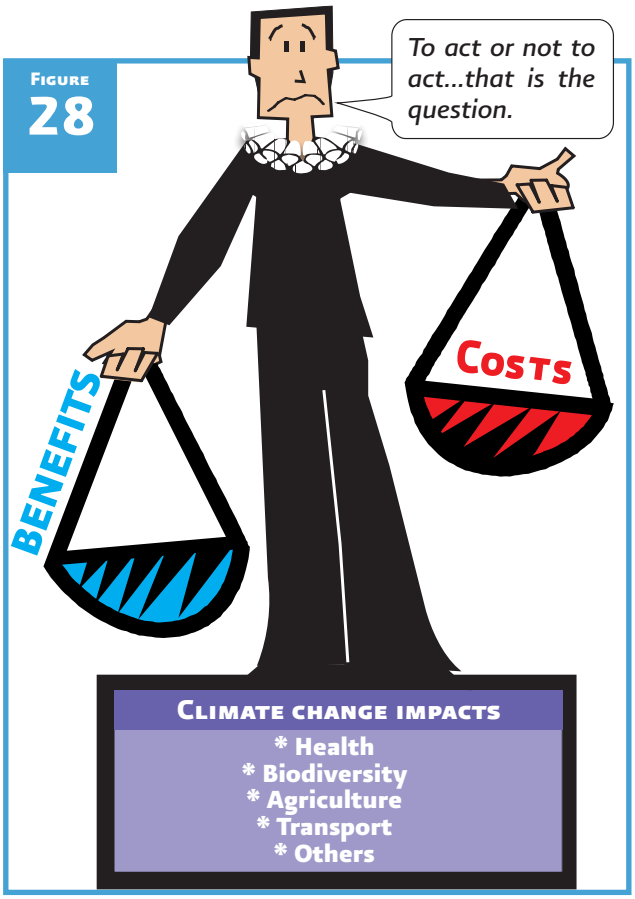
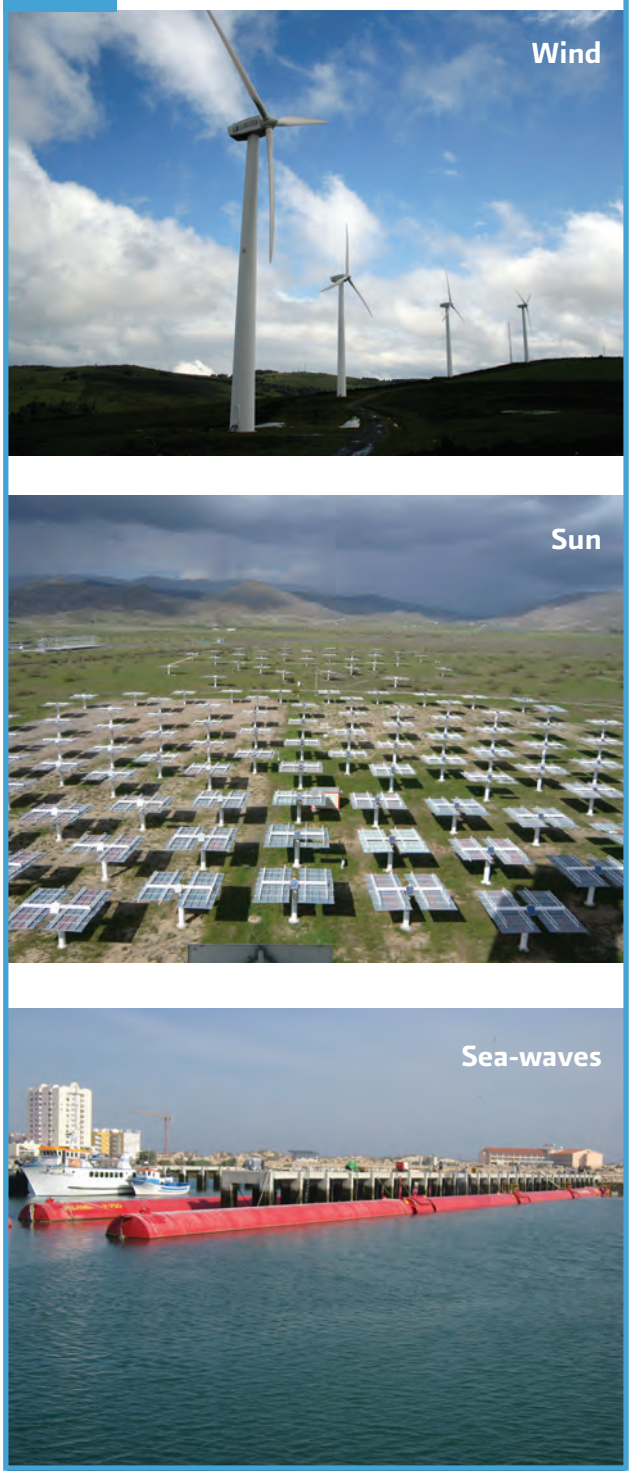


FIGURE 28

or tidal energy (Figure 29); by promoting the development of motor cars that release fewer emissions per litre of fuel consumed (such as hybrid cars); or by improving many of our electric appliances to reduce their electricity consumption without impairing their performance. These options demand substantial, and very expensive, investments in science and technology that, unfortunately, many countries of the world cannot afford, particularly considering that many countries –Mexico included- still face the huge challenge of reducing poverty and achieving a sustainable development.

One other aspect that has to be considered is that, although climate change is a global problem, the question of who should provide the monetary

FIGURE 29 RENEWABLE ENERGY SOURCES



1896 SVANTE A. ARRHENIUS estimated, for the first time, the global warming that could be produced as a consequence of changes in the atmospheric concentration of CO_2.

1897 THOMAS CHAMBERLAIN added the effects of volcanoes and oceans to the estimates of global warming.

1938 GUY S. CALLENDAR established, for the first time, an empirical relationship between rising CO_2 concentrations in the atmosphere and the increase in global temperature observed over the first four decades of the twentieth century.

resources needed to address it is still being hotly debated. It is justifiably argued that not all the world's countries have equally contributed to cause this problem and, therefore, those countries that have historically generated most of the emissions of greenhouse gases should take the largest responsibility in paying for the cost of actions to address climate change. It could also be argued that the most affluent countries should contribute with more resources.

Without entering into a long and tedious description of all the actions that the international community has undertaken to tackle climate change issues, in the following paragraphs we will describe some of the most significant events in this interesting story. As you will see, this story has some tones of thriller as there are characters that raised the alarm but were not paid attention, culprits who tried to elude their responsibility and heroes who tried to prevent damages and many victims, mostly poor people in developing countries. We could also imagine that there is a time bomb in this story, with very little time left in its clock, which keeps ticking inexorably, making nervousness and fear grow (Figure30).

Climate change is not a newly found phenomenon. Since the second half of the 19th century, work by John Tyndall and Svante Arrhenius laid the foundations for understanding and predicting climate change. Curiously enough, it was not only climate scientists and chemists who realized how important this subject was but, also, biologists such as Alfred Lotka and the ecologist George E. Hutchinson raised warnings about the emerging problem, its causes and consequences, over 50 years ago. However, those early warnings were not attended and the subject remained only within the academic field; it was not until several decades later that it was assumed as a matter of global security.

In 1979, over 80 years after Arrhenius suggested that the emission of pollutants could modify the climate, the World Meteorological Organization convened the first World Conference on Climate, in Geneva, Switzerland, to start formal discussions about climate change. The conference conclusions were the first warning to governments: Climate change should be considered as a real, global-wide threat and governments should make every effort to foresee and prevent possible changes to the climate caused by human activities. Nearly ten years later, in 1988, the United Nations General Assembly approved a proposal made by Malta, a small island country situated in the Mediterranean, south of Italy, requesting protection from climate change impacts for the present and future generations of humankind. Climate change had entered the international agenda.

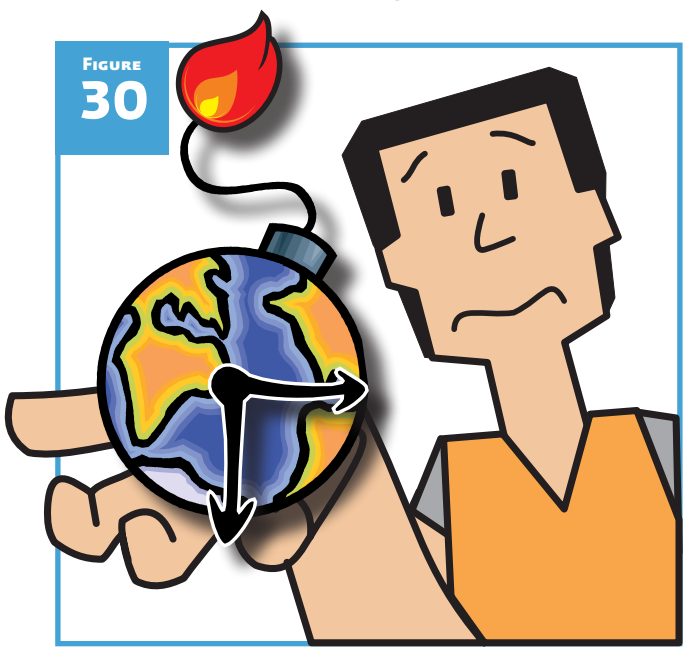


Figure 30


1956

Gilbert N. Plass

calculated a 3.6 °C surface temperature increase for a doubling of atmospheric CO_2 concentration.


1957

Roger R. Revelle

pioneered the study of the CO_2 balance in oceans and its effects on climate change.


1958

Charles D. Keeling

started the continuous recording of atmospheric CO_2 concentrations at the Mauna Loa Observatory in Hawaii.

Global warming caused by burning fossil fuels was first predicted over 100 years ago and was confirmed some 50 years ago. But it has been only in the last 10 to 20 years that concrete measures to address this problem have begun to be taken.

By then, climate change had become the subject of heated debate. Increasingly accurate data recorded since 1958 in the Mauna Loa observatory in Hawaii that documented the increase of CO_2 in the atmosphere, temperature measurements that paralleled the increase in CO_2 concentration, in addition to paleoclimate information and general climate models were, for many people, convincing evidence of the reality of this phenomenon and its implications. However, as often happens, some people were not convinced and argued that those changes might be due to natural causes instead and, therefore, that any actions aimed to reduce greenhouse gases emissions would be not only useless but also undesirable as they would impair the development of nations and the wellbeing of their inhabitants.

In that context, the World Meteorological Organization and the United Nations Environment Programme jointly sponsored the creation of the Intergovernmental Panel on Climate Change (IPCC) with the purpose of assessing the scientific information available about climate change. The panel is constituted by renown scientists from all over the world (see ***Box IPCC: The scientists behind climate change***), with the task of analyzing the information available and provide reliable, science-based opinions about the occurrence of climate change in the world and the contribution of human activities to this phenomenon. In 1990, the IPCC published its first assessment report, which confirmed what many had expected and feared: The threat of climate change was real.

A couple of years later, in 1992, during the United Nations Conference on Environment and Development in Rio de Janeiro, Brazil (informally known as the "Earth Summit") the United Nations Framework Convention on Climate Change was negotiated and adopted, with the objective of stabilizing ***"...greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system..."***

Fully aware of the complexity of such endeavour and of the lack of sufficient information to determine an acceptable concentration of GHG in the atmosphere, it was decided that the "concentration level" should be achieved soon enough to allow the ecosystems to adapt naturally to climate change, to ensure that food production were not affected and economic development could proceed in a sustainable manner.

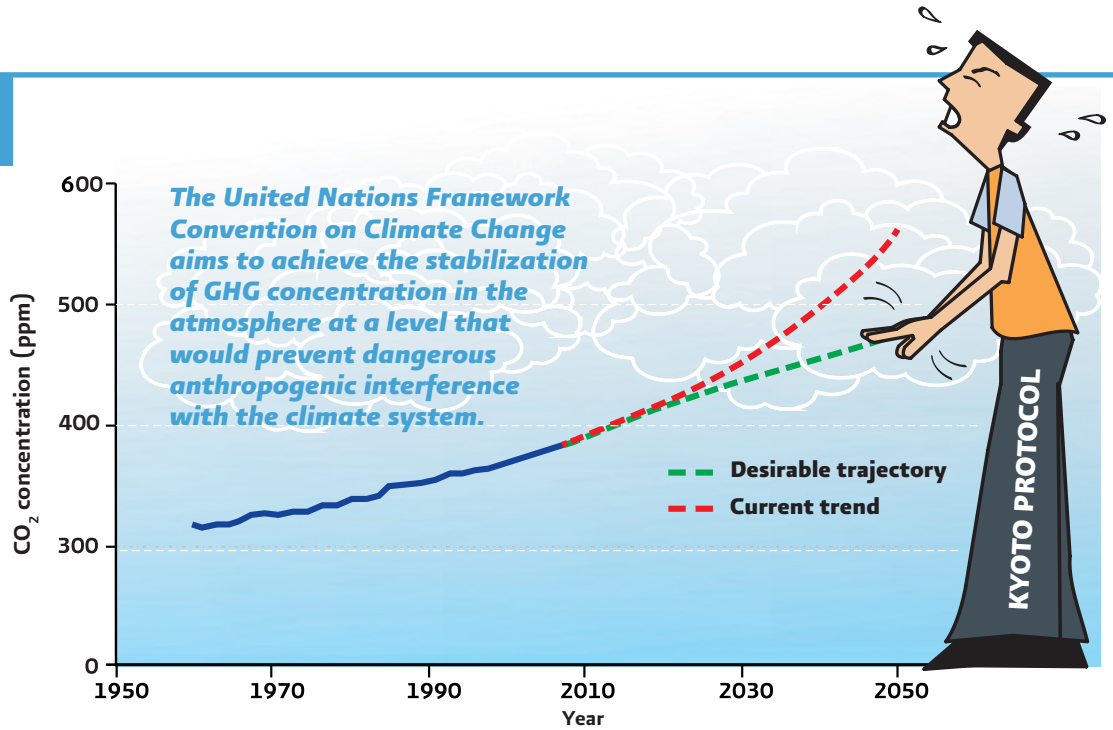
One can easily imagine how difficult it was to convince countries to accept such an agreement. Mexico signed and ratified this international agreement in 1992 and 1993, respectively. Finally, after a series of complicated international negotiations, the Framework Convention entered into force in March, 1994.

1968 **Edward Lorenz** introduced the notion of chaos in meteorology and suggested the possibility of abrupt, non-gradual changes in climate.

1968 A number of studies suggested that Antarctic ice shelf could collapse.

1972 A protracted drought and unusual changes in climate draw the attention of scientists and society at large to climate change.

Figure 31



One year later, in 1995, the second IPCC assessment report was published with a demolishing conclusion: "...the balance of evidence suggests a discernible human influence on global climate...". In other words, the report not only confirmed the evidence indicating the occurrence of climate change but also identified human activity as its most likely cause. Following on the thriller analogy, the existence of the bomb had been confirmed and the prime suspects had been identified.

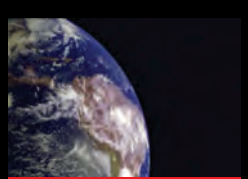
In 1997, a complementary, legally binding instrument was adopted: The Kyoto Protocol, which aimed to limit the net emissions of greenhouse gases by industrialized countries. Put in numbers, the Protocol aims to reduce GHG emissions of industrialized countries by 5%, compared to their 1990 level (Figure 31). No quantitative targets for reducing GHG emissions were established for developing countries but only specific commitments such as the elaboration of national emissions inventories. Mexico ratified the Protocol in the year 2000 as a non-Annex I country, that is, as a developing country.

Given the benefits that reducing GHG emissions would have for the planet, and, therefore, for ameliorating climate change, one would expect that all the countries involved would immediately have signed on and ratified the Protocol. But reality was quite different; the negotiations were tough, as usually happens when monetary resources are at stake; and meeting the Protocol reduction goals does demand substantial amounts of money.

In 2001, the IPCC presented its Third Assessment Report which, in addition to further confirming the conclusions from the two previous reports,

1975 ADN 1976

Several studies show that chlorofluorocarbons (CFCs), methane and ozone can also contribute significantly to the greenhouse effect.



1979

The World Climate Research Programme is established.

1985

The Villach Conference concludes that warming of climate appears inevitable; calls governments and intergovernmental organizations to consider international agreements to control emissions.

helped the climate change subject to get beyond the academic and government circles to reach the society at large, mostly thanks to the report's structure which aimed to answer, in simple but soundly documented terms, questions about the evidences for climate change and the consequences of climate change for humankind.

Despite the increasing body of evidence, some countries remained reluctant to ratifying the Protocol. It was until 2004 –seven years after its adoption- when the minimum number of countries necessary for its entering into force was reached, which finally happened on the 16th of February, 2005. Although this might be considered as an important achievement, actually the Protocol was about to become just dead letter as some of the largest emitting countries of the world, such as the United States which are responsible of over 20% of the global GHG emissions, refused to ratifying it. The US government, in particular, claimed that they would not accept this treaty as it was contrary to their economic interests.

One year later, in 2006, the Stern Review on the Economics of Climate Change was published. This report was commissioned by the UK's Chancellor of the Exchequer to Sir Nicholas Stern, a renowned British economist and academic. The Review explores the impact that actions –or inaction- for reducing GHG emissions and ameliorating climate change would have for the world's economy.

The Review looked at the changes expected from climate change on such important aspects as water availability, food production, incidence of diseases (and the overall population health), natural disasters (such as floods and hurricanes), damages to ecosystems (such as coral reefs) and infrastructure, among other aspects.

The main conclusion from this study was that the best economic alternative was to mitigate, that is, reduce GHG emissions to the atmosphere. According to their calculations, an investment equivalent to 1% of the world's GDP[10] would be required to mitigate climate change impacts but the cost of inaction could reach as much as 20%.

Perhaps because the review was carried out by an economist, instead of a climatologist, or because it touched upon the most sensitive spot of governments –their economic balance- or because it defeated, using sound arguments, the major counterargument of governments to devote economic funds to address this problem but, after the release of the Review, the world's interest on global warming and climate change grew.

In 2007, the IPCC presented its Fourth Assessment Report. Its conclusions left no doubt: Warming of the climate system is unequivocal, the influence of human activities is affecting

[10]The world's GDP is the market value of all final goods and services made in all the world's countries in a certain period of time.

1985 **Wallace S. Broecker** suggested that the rearrangement of oceanic circulation in the North Atlantic could drastically modify climate.

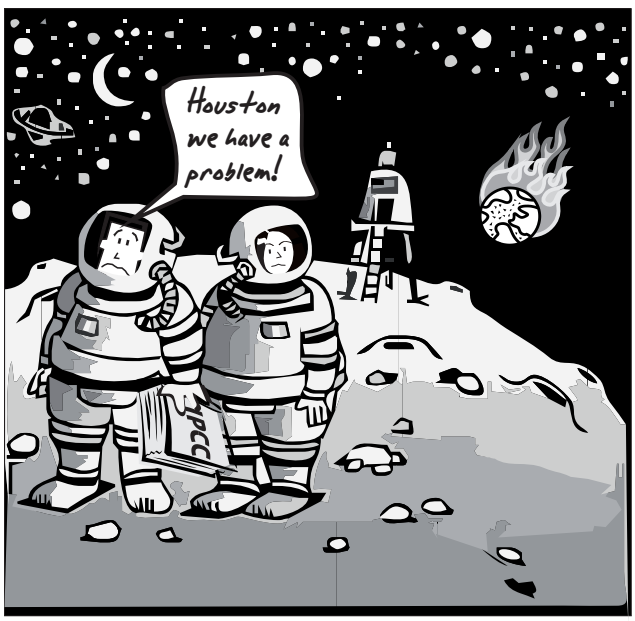
1988 The Intergovernmental Panel on Climate Change (IPCC) is established by the World Meteorological Organization (WMO) and the United Nations Environment Programme.

1990 The first IPCC report concludes that the Earth's temperature has increased and it is likely to keep increasing up in the future.

not only temperature but many other aspects of climate and anthropogenic warming over the last three decades has had a discernible influence on many physical and biological systems.

Another conclusion from the assessment, which raised the warning level even further, was that with the mitigation measures that were then being applied, GHG emissions -and, therefore, global warming and its consequences- would continue to grow over the following decades. A brief, clear-cut message: We are facing a most serious problem and what is being done to address it is just not enough.

Thus, out of environmental commitment or for their own benefit or even just for their mere survival, many countries finally included climate change as a top priority. The challenge for the future (and, given the projections, we hope that means the near future) is to turn those priorities into real actions.



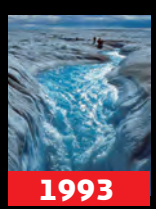
Fortunately enough, promising signs start to appear. For example, Europe has made important unilateral decisions and presented its 20/20/20/10 Energy Action Plan, which calls for, by the year of 2020, a 20% reduction of GHG emissions (compared with 1990 levels), a 20% share of renewable energy, a 20% increase in energy efficiency and, at least, a 10% share biofuels use. Another good news is that, under the Obama administration, the United States government is now willing to reach agreements leading to the reduction of their GHG emissions.

To complete the thriller analogy, the story seems to be at its climax: Time is running out but the good guys seem to be on their way to defuse the bomb...will they make it on time to prevent the bomb from exploding or, at least, to mitigate its effects so that only minor damages are caused? We will live the end of the story in the following years, hoping that this is a thriller story and not a tragedy.

What about Mexico?

Mexico has dutifully fulfilled its commitments under the major international environmental agreements and has promoted a number of measures for adapting to the impacts of climate change as well as for reducing its GHG emissions. Some of those measures are the elaboration of National Emissions Inventories which, in turn, are the bases of the National Communications on Climate Change. To date, Mexico has submitted three National Communications and the fourth communication is due to be published by the end of 2009. Mexico would then be the only developing country to submit a fourth National Communication (Figure 32).

1992 The United Nations Framework Convention on Climate Change (UNFCC) is adopted at the Earth Summit in Rio de Janeiro.



1993 Greenland ice core analyses conclude that drastic climate changes might occur over periods of time as short as a decade.

1995 The second IPCC report concludes that "the balance of evidence suggests a discernible human influence..:"

Figure 32

Some other actions carried out in Mexico are the formulation of the National Strategy on Climate Change (ENACC, for its initials in Spanish). The ENACC was published in 2007 and set the bases for reducing the country's emissions, for developing actions to prevent, avoid or reduce the climate change impacts and to create national and local capacities to adapt to those impacts. The strategy describes action lines and policies that provided the foundations for formulating the Special Program on Climate Change (PECC, for its initials in Spanish).

The PECC will be published later this year and will include concrete measures to control and reduce GHG emissions. Among those are the promotion of electricity generation from renewable sources

National Communications are reports presented by countries, along with National Greenhouse Gas Emission Inventories, to the United Nations Framework Convention on Climate Change. Those reports present details of the activities that parties have undertaken to implement the Convention.

(for example, solar and wind energy), projects for improving energy efficiency and reducing the consumption of fossil fuels, as well as projects for reducing GHG emissions from sanitary landfills, among many other measures. The PECC sets the aspirational target of achieving a 50% reduction of the country's GHG emissions, compared to the year 2000 emissions (Figure 33). Such an ambitious target could only be achieved with the financial and technological support from developed countries.

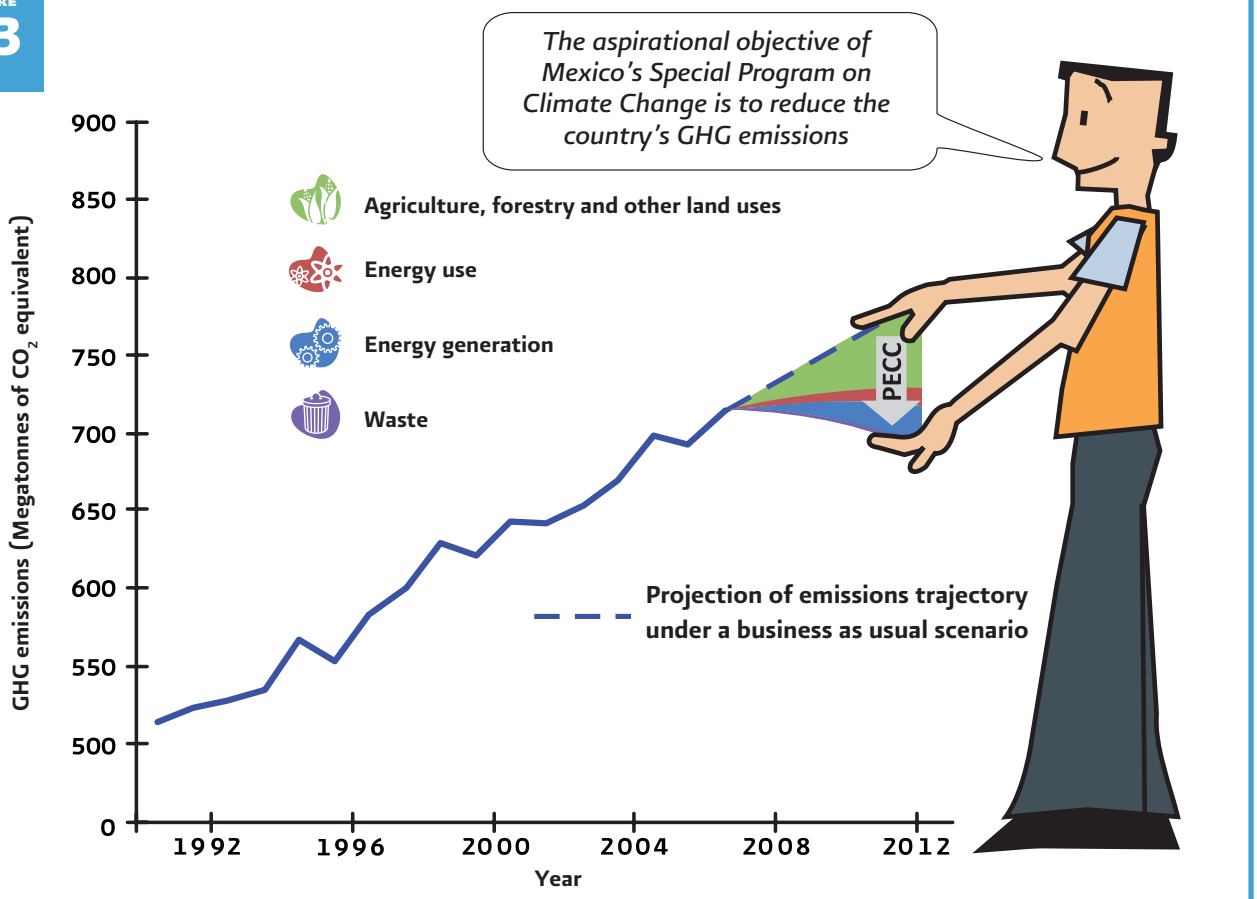
As it is unavoidable that climate change will affect Mexico, the PECC also includes adaptation measures aimed to reduce the country's vulnerability and the negative effects of climate change. Examples of those measures are the reforestation and plant cover protection of high-priority sites such as upper watersheds in order to reduce the risk of landslides and water floods. For coastal zones, the PECC aims to ameliorate the impacts of phenomena such as hurricanes and sea level rise.

1997 The Kyoto Protocol is adopted to achieve quantified reductions in the GHG emissions from developed countries.

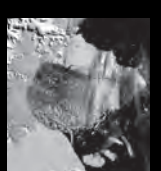
1998 Is the warmest year on record. Droughts, floods and wildfires predominate in the environmental scene.

2001 The Third IPCC report concludes that global warming, unprecedented since the end of the last Ice Age, is very likely.

Figure 33



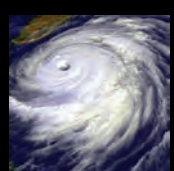
In parallel, and in order to provide fundamental information for the formulation of the PECC, a study on The Economics of Climate Change in Mexico was carried out based on the Stern report. Two major conclusions from this study are that the costs of climate change are far higher than the costs of reducing GHG emissions, in addition to other costs that are unacceptable but cannot be valued in monetary terms, such as the loss of biodiversity. According to this study, climate change costs in Mexico by the year 2050 (that is, how much should be paid in the future if no action is taken to address this problem) would represent between 4.2 and 15.3% of the country's GDP, whereas the costs of mitigation would only amount to between 0.56 and 5.6% of the GDP. Evidently, it is far more cost-effective to start taking measures at once. Those cost estimates assume, however, a scenario in which Mexico reduces its GHG emissions at the same time as other countries do. Were Mexico the only country to reduce its emissions, the increase in the concentration of CO_2 in the atmosphere and, thus, global warming, would remain essentially unaltered.



2002 In Antarctica, Larsen B ice shelf collapsed and broke up, 3,250 km² of ice 220 m thick disintegrated.

2003 A heat wave killed 35,000 people in Europe.

Several studies warned that the melting of Antarctica and Greenland could increase sea level.



2005 The Kyoto Protocol entered into force.
Hurricanes Katrina, Wilma and Stan hit the United States and Mexico.
The levels of CO_2 in the atmosphere reached 380 ppm.

Mexico has also promoted in a number of fora the creation of a Multinational Fund for Climate Change, better known as "Green Fund". The fund would aim to provide financial support for countries to implement actions for adaptation and GHG emissions reduction. All countries would participate in the Green Fund under the principle of shared but differentiated responsibility. That is, each country would contribute to the Green Fund in a way that is commensurate to its emissions and its affluence, according to its economy size.

As can be seen, Mexico has been working very actively, within its own capabilities, to address the global warming challenges as best as possible, but is also trying to encourage the international community to take decisive action to address this common problem.

So far, we have described actions that institutions, both in Mexico and abroad, are carrying out to face climate change. However, at the individual level, in your family and within your community, we can also help to alleviate this problem. Fortunately enough, there is a number of actions that can help to reduce the emission of greenhouse gases and do not involve any additional expense; some of those might even allow you to save money. In the following sections we will describe some of those actions and how to implement them.

What can I do to help address climate change?

Perhaps your first thinking upon reading this question was: Would it be really significant what I can do about this problem of planetary dimensions? The answer is a sound yes and now we will explain why. There currently are some 6,500 million inhabitants in the world. Even if the isolated actions of any one of us were insignificant, the sum of our actions, our relatives' and friends' and their relatives' and friends' would eventually add up to ten, 100 or perhaps one billion people working to face climate change issues. The actions of such an enormous network would certainly become noticeable and significant.

If we do not take action soon, we will face serious problems in the near future. As far as we know, there is no other planet with an atmosphere and environmental conditions similar enough to the Earth's to which we could move over in case the Earth becomes uninhabitable. Thus, we all should take full conscience of our common responsibility to preserve our planet's health, regardless our age, citizenship or economic position.

What sort of actions can we take to address climate change? Basically, we talk about little changes in our behaviour that would not affect significantly our quality of life. We do not mean living in the dark or stop using videogames or having to ride a bike to go to the school or to the office everyday but, rather, we mean making a more sensible, environmentally-friendly use of the resources, equipments and motor cars that are already available. We do not mean to invest huge amounts of money either.

Let us imagine the following scenario: You get back home at noon on a very hot day; you turn the light of your room on, and then the radio and the TV. Then you head to the kitchen to peek into the fridge for a couple of minutes just to realize that there is nothing that you like. Then you go out

The Stern Report is published, discussing the global costs of climate change on the countries' economies.

IPCC Fourth Assessment Report concludes that the warming of the climate system is unequivocal.

and step onto your car to drive to the store two blocks away to buy what you wanted. If you think about it, you will soon realize that, by acting like this, you are adding badly to GHG emissions and, thus, to global warming. But, what was wrong with this scenario? Let us have a closer look at it. Being midday, you hardly needed to turn any light on. Then, turning the radio and the TV on, you will not be able to pay attention to both at the same time. Keeping the fridge open for such a long time makes it work longer and, on the top of that, you drove the car to go to the store which was just two blocks away. The bottom-line of this story is that everybody should bear in mind that each action that we carry out in our daily life somehow leads to the generation of greenhouse gases.

In this section, we will show you how the way of life of a typical family, maybe like yours, does contribute to the emission of greenhouse gases. We will also describe a number of actions that you or your family can easily carry out without any additional expense. Most of those actions focus on making a better use of the electrical appliances at home and, thus, are meant to make a more adequate use of electricity.

When we think about electricity, we commonly think of it as a sort of "clean energy". However, the processes that are used to generate electricity are not necessarily environmentally friendly. While renewable sources, such as river waters, wind or solar radiation do not generate waste residues upon being converted into electricity, burning fossil fuels at power plants does generate solid waste and greenhouse gases.
Below you will find a section specifically devoted to transport which, doubtlessly, is one of the areas where we can be of great help. In that section we will compare the greenhouse gas emissions of different types of motor cars. We are confident that the data therein will surprise you and will help you to better appreciate the benefits of other types of transport, such as public transport and bicycles, and will also make you more fully aware of the importance of complementing your car usage with other transport modes.

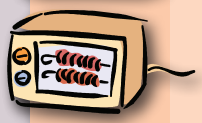
Finally, we will describe some other measures which, if you can afford them, can also help you to reduce your greenhouse gases emissions. Such measures range from replacing incandescent lamp bulbs for energy-saving compact fluorescent lamps, to investing in systems to harvest solar energy and use it for heating water, running electrical appliances and even cooking. We hope that, by reading this section, we will be able to convince you of the real possibility of addressing climate change challenges, from our own place and starting now. Without any further preamble, we invite you to become part of the solution.

How much CO_2 does a home like yours emit as a result of energy use?[1]

Your house, as all the houses in the world, contributes to global warming. In general, households emit GHG from two sources: Electricity use and the burning of natural gas and other fossil fuels. However, it is important to understand that, although the emission of GHG from this latter source does happen directly in your house, this is not the case with electricity. The emission of GHG due to the use of electricity might occur far away from your house, directly at the power plants that burn fossil fuels. Thus, when you turn the light or the television on, do remember that you are indirectly releasing GHG to the atmosphere. Now, let us look at the approximate amounts of CO_2 that different appliances emit and at how much electricity they consume.

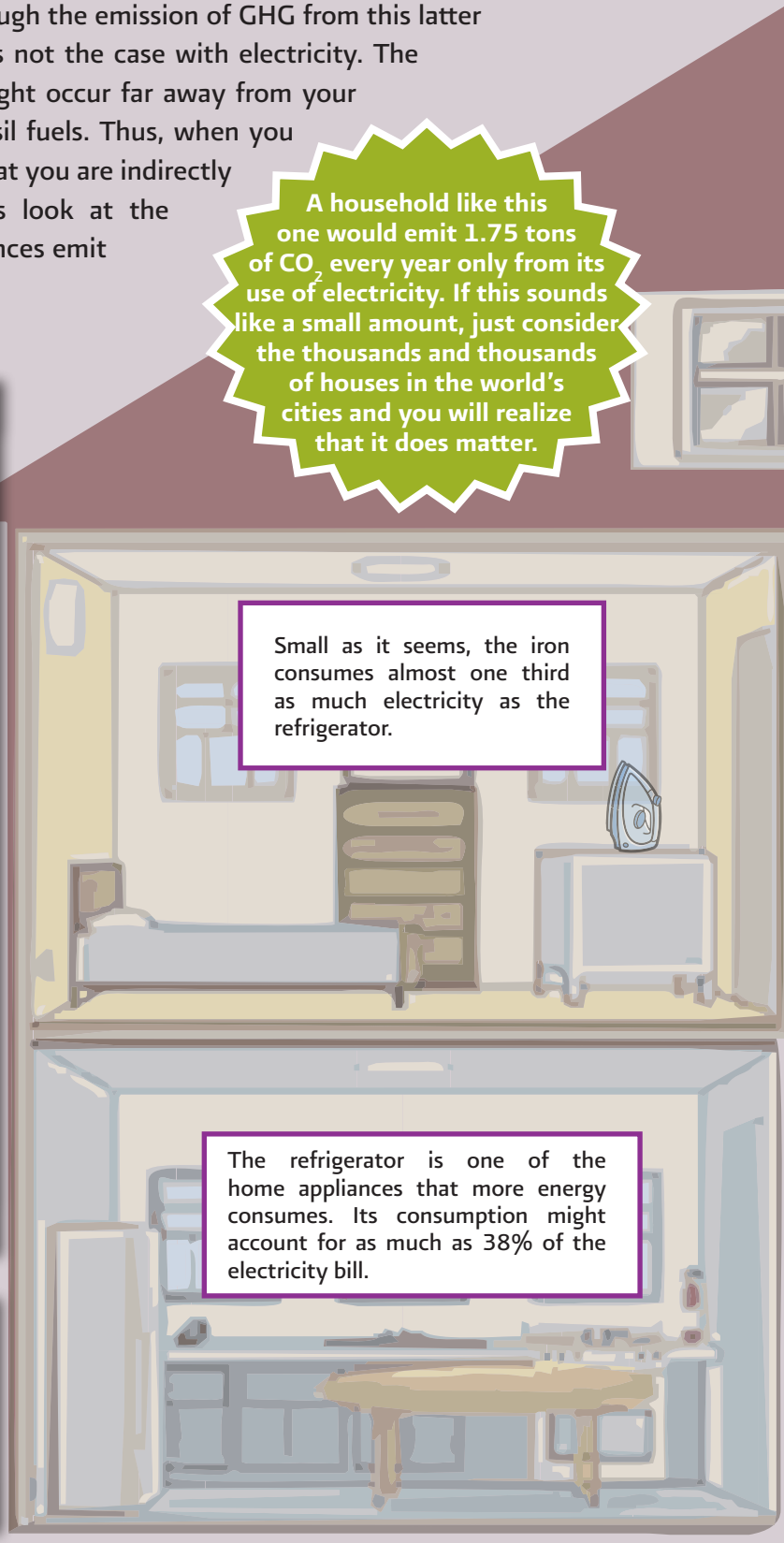
A household like this one would emit 1.75 tons of CO_2 every year only from its use of electricity. If this sounds like a small amount, just consider the thousands and thousands of houses in the world's cities and you will realize that it does matter.

KITCHEN

Appliance	Energy consumption (expressed in terms of number of 100 Watts light bulbs)	Average daily use	Emissions (kg of CO_2 equivalent) Daily	Emissions (kg of CO_2 equivalent) Annual
		X 8 hours	1.46	533.2
		X 1 hour	0.48	175.2
		X 15 minutes	0.27	99.0
		X 15 minutes	0.25	91.4
		X 10 minutes	0.04	15.2
		Total	2.5	914

HOUSE LIGHTING

60 Watts incandescent light bulbs	Average daily use	Emissions (kg of CO_2 equivalent) Daily	Emissions (kg of CO_2 equivalent) Annual
 X	6 hours	1.09	399.9



Small as it seems, the iron consumes almost one third as much electricity as the refrigerator.

The refrigerator is one of the home appliances that more energy consumes. Its consumption might account for as much as 38% of the electricity bill.

GAS CONSUMPTION

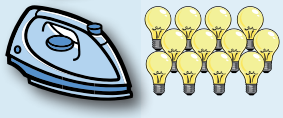
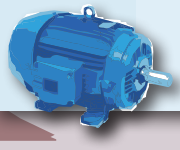
- In 2006, the houses in the Mexico City Metropolitan Zone emitted some 4 237,443 tons of CO_2 to the atmosphere, only from gas consumption. Fifty four per cent of these emissions came from food preparation and the rest from water heating for personal care.

- If one person has a shower every day, using on average some 65 litres of hot water, he/she would emit nearly 233 kilograms of CO_2 in one year.

A clothes drier can emit up to 685.5 kilograms of CO_2 in one year.

In households without air conditioning systems, lighting might account for one third of the electricity bill.

LAUNDERING AND IRONING

Appliance	Energy consumption (expressed in terms of number of 100 Watts light bulbs)	Average daily use	Emissions (kg of CO_2 equivalent) Daily	Emissions (kg of CO_2 equivalent) annual
	X	3 hours	0.27	99.0
	X	2 hours	0.5	182.8
	X	20 minutes	0.1	38.1
		Total	0.87	319.9

LIVING ROOM AND BEDROOM

Appliance	Energy consumption (expressed in terms of number of 100 Watts light bulbs)	Average daily use	Emissions (kg of CO_2 equivalent) Daily	Emissions (kg of CO_2 equivalent) annual
	X	4 hours	0.75	274.2
	X	6 hours	0.27	99.0
	X	4 hours	0.19	68.6
	X	4 hours	0.17	60.9
	X	2 hours	0.03	9.1
		Total	1.41	511.8

[1] All the figures in these tables are expressed in terms of CO_2 equivalent, that is, emissions of all the greenhouse gases, expressed in terms of CO_2. Figures in these tables were calculated assuming that the generation of Kilowatt hour (kWh) emits 0.635 Kg of CO_2.

How can you save energy and reduce your CO_2 emissions at home without investing any money?

Actually, saving electricity and gas and, thus, reducing the emission of greenhouse gases, is simpler than it might seem at first sight. It is just a matter of carrying out some simple tasks which do not involve any extra expenditure. In the following pages we will provide you with some practical advice that can help you in this noble duty of protecting the environment. If you require further information about energy savings at home, you can look at the websites of the Federal Trust for Electricity Savings (Fideicomiso para el Ahorro de Energía Eléctrica, FIDE; www.fide.org.mx), the National Commission for the Efficient Use of Energy (Comisión Nacional para el Uso Eficiente de la Energía, Conae; www.conae.gob.mx) and the Federal Commission for Electricity (Comisión Federal de Electricidad, CFE; www.cfe.gob.mx).

ELECTRICITY

REFRIGERATOR

- Place the refrigerator away from heat sources such as the stove and the oven and leave a space of at least 10 centimetres between the back of the refrigerator and the wall. With these measures you will prevent the refrigerator from heating up and the motor from working more than necessary.
- Make sure that the door closes tightly and avoid keeping it open longer than needed; otherwise, the cold air will escape, increasing up to three times the electricity consumption.
- Defrost regularly, as electricity consumption increases when the ice in the freezer is thicker than 5mm.
- Do not put hot items in the refrigerator; this will make the motor work more than necessary.
- It is not necessary to set the temperature control at the coldest level in order to preserve your food.

TELEVISION AND SOUND

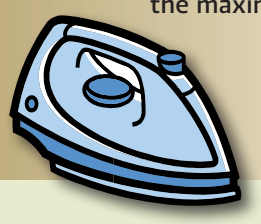
- Turn them off when you leave the room and avoid using them as “background noise”.
- Use a timer when you are tired; that way, the television or the stereo will turn automatically off in case you fall asleep.

COMPUTER

- Set up some energy saving profile.
- If you are not going to use the computer for a while, at least turn the monitor off. A standard CRT monitor uses up to 100 watts and a LCD flat-screen consumes between 25 and 40 watts

IRON

- Iron as many clothes as possible at each ironing session. That way, you will avoid the waste of electricity and heat that is caused by turning the iron on and off repeatedly over several sessions.
- While the iron warms up to the desired temperature, work on lighter clothes that require less heat. Do the same when you turn the iron off.
- You do not need to set the temperature at the maximum level all the time; it is better to adjust it according to the type of clothes you are ironing.



NATURAL LIGHTING

Take maximum advantage of natural light and avoid turning the light on in unoccupied places.

Natural gas, electricity and, by the way,...water!

SPRINKLER

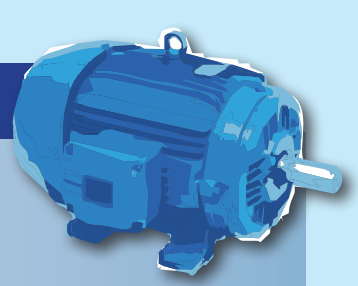
- Reduce the amount of water that you use when taking a shower. If 3.4 million people (about 20% of the Mexico City Metropolitan Zone population in 2006) were to reduce their consumption of hot water on each shower from 65 down to 45 litres, the emission of 262 tons of CO_2 equivalent would be prevented.
- If you leave for vacation or for a long period of time, switch the heater off.

WASHING

- Make sure you run the washing machine with full loads and short washing cycles.

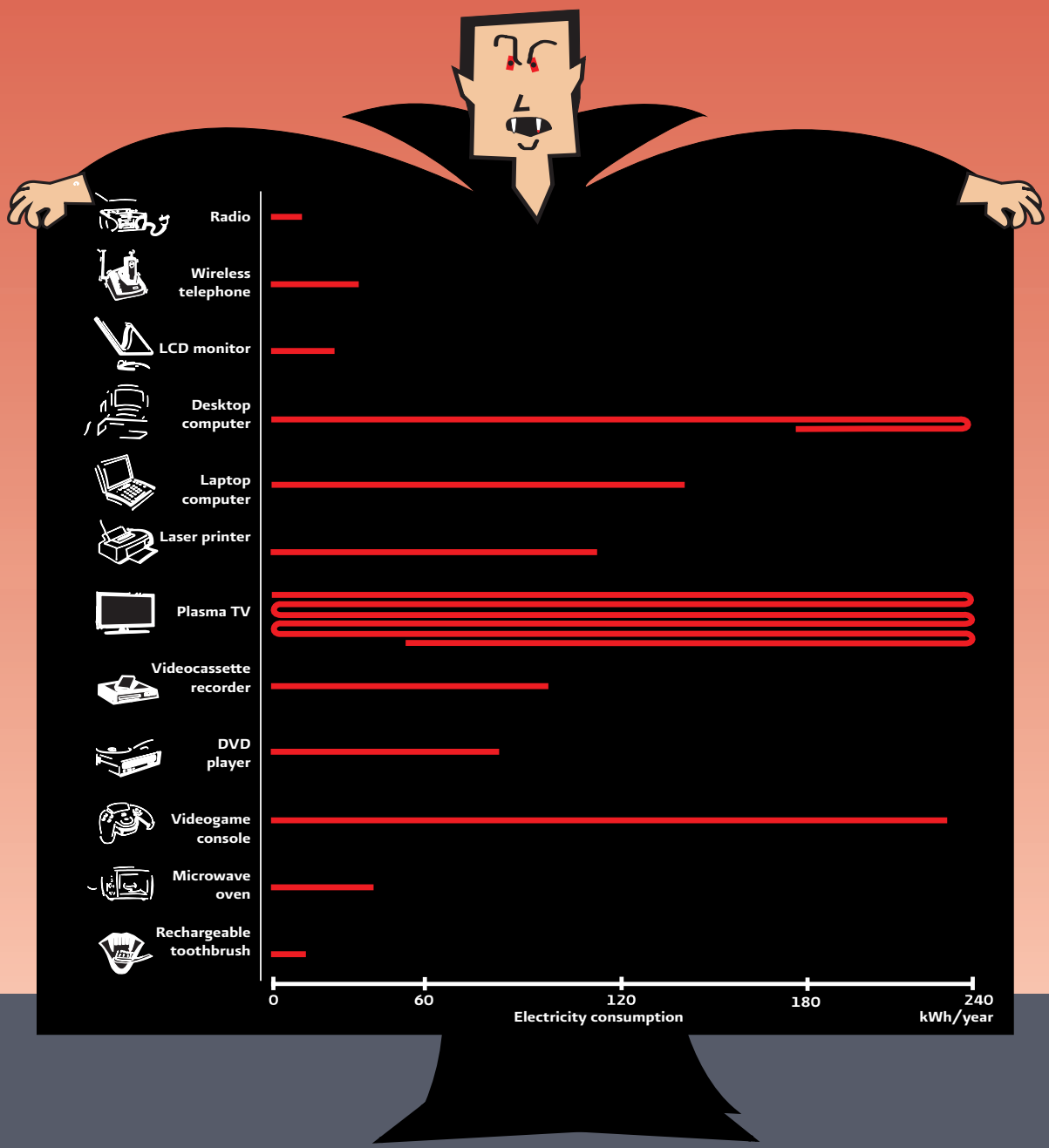
WATER PUMP

- If the water pump at your house does not have an automatic control, make sure to record the time that it takes to fill the cistern up; otherwise, the water will spill over and energy will be wasted.



Beware of vampires!

Although it might seem hard to believe, you may have some vampires right at home and closer than you imagine. They do not have sharp teeth and do not wear long capes but have, instead, cables connecting them to the wall socket. Electrical appliances that are left plugged in when turned off, literally "suck" electricity passively; this is why they are called "vampire appliances". Examples of this are microwave ovens, DVD players, stereo systems and computers. If you want to convince yourself of this, just look at the clocks and indicator lights that those appliances maintain active even when they are turned off. The figure shows data about the amount of electricity that some of those vampire appliances consume while being off. This will make you think that, in addition to wasting electricity, those appliances actually bleed your wallet.



"Vampire" electricity consumption by plasma TV, videocassette recorder, DVD player and videogame console are carried out in "active mode", as they carry out background or support actions while being turned off, for example, when they are programmed to turn automatically on or to record some show, etc. Other appliances suck electricity in "passive mode"; that is, when they are turned off but are left plugged in.

What other options there exist to save energy and reduce greenhouse gas emissions?

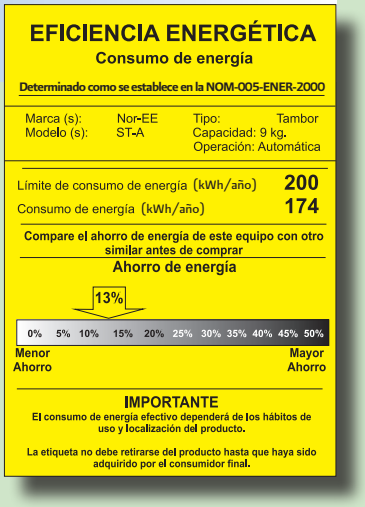
There exist some other alternatives that can also help you to significantly reduce your greenhouse gas emissions to the atmosphere but these do involve some investment. Some of those are inexpensive but some others do require a substantial initial investment and periodical expenses for maintenance. Despite that, those investments do pay off in either the medium or the long-term, through savings in the electricity or the gas bills. In the following pages we describe some of those alternatives.

REPLACING LAMP BULBS

Incandescent lamp bulbs have a thin metal thread called "filament" which emits light and heat as electricity passes through it. Some 85% of the electricity that these lamps use is actually lost in the form of heat and only 15% is actually delivered as light. By replacing your incandescent lamp bulbs for compact fluorescent lamps, this waste of energy will be significantly reduced as the electricity that passes through the compressed gas in these lamps does not heat them up. That way, compact fluorescent lamps consume 75% less electricity to deliver the same amount of light as incandescent lamp bulbs. In order for you to ponder the savings, consider that a 26 watt compact fluorescent lamp lights as much as a 100 watt incandescent lamp bulb and an 11 watt compact fluorescent lamp as much as a 40 watt incandescent lamp bulb...convenient, is it not?

REPLACING ELECTRICAL APPLIANCES

If you are thinking about buying a new electrical appliance, make sure you chose, among those that you like, the one that consume the less electricity. How can you ensure this? Labels like the one we depict here describe whether the appliance complies with the Official Mexican Standard for Energy Efficiency and how much electricity the appliance consumes. Do remember that new models usually consume less electricity than older models. For example, a brand new refrigerator typically consumes 60% less electricity than a similarly sized, 8 years old or older one.



USE LIGHT COLOURS FOR YOUR HOUSE

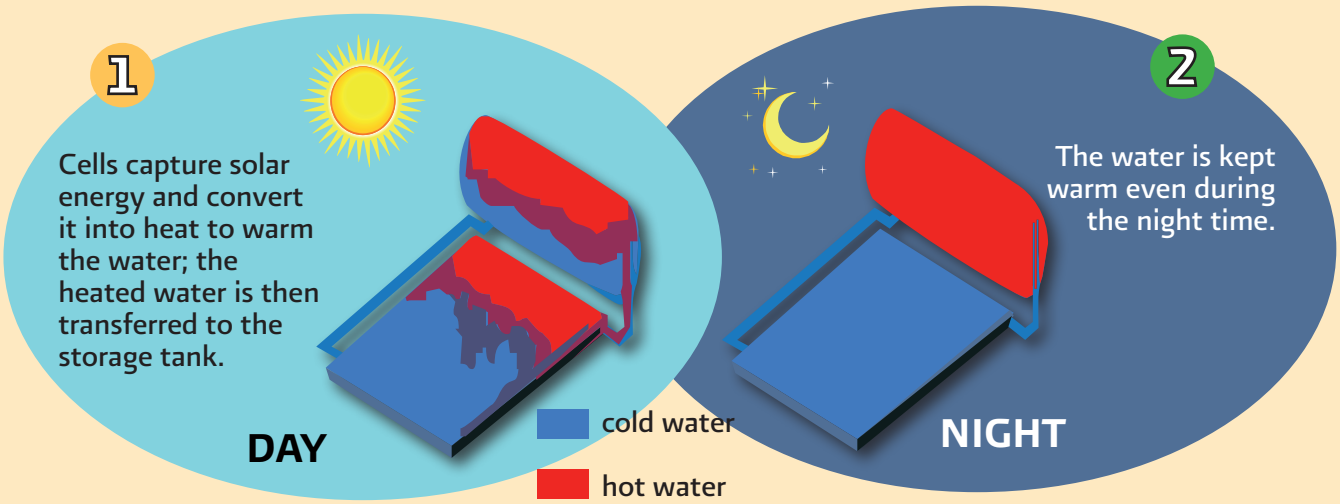
Paint your house with light colours, as these will reflect the light better, thus reducing the need to use higher intensity lamps.

Use of solar energy

Solar energy provides an excellent alternative for reducing CO_2 emissions at home. It has the enormous advantage that, after the initial investment to purchase and install the equipment, the supply of energy is inexhaustible, free and does not release greenhouse gases. In addition, many parts of the country receive huge amounts of insolation for most of the year; on average, some 5 kilowatts of solar energy fall on every square metre of the country's surface every day. Besides, many of the equipments that have been developed to take advantage of solar radiation can work quite well even at sites where cloudy days are frequent. Below you will find a description of some of the equipments most commonly used for different types of houses.

SOLAR WATER HEATERS

These systems have solar cells or vacuum tubes that transform the Sun's rays into heat; this is transmitted to the water which is then kept hot in a storage tank, even during the night or overcast days. Given the big amount of insolation that we receive in Mexico, one square metre of solar cells can receive on one day an amount of energy equivalent to one cubic metre of natural gas or 1.3 litres of liquefied petroleum gas (LPG).



SOLAR PANELS

Solar panels transform the Sun's rays into electricity, which is then conducted by cables to a battery where it is stored until it is used. The energy stored can then be used for lighting or for powering electric appliances. Solar panels can be installed on house roofs thus eliminating the need of additional space.

SOLAR STOVES

In general, solar stoves work by concentrating the Sun's rays into a specific point (for example, in the stove's burner) or by making them traverse a glass lid to be transformed into heat within an insulated container. These stoves can be used to bake, cook or fry food items, as they can reach temperatures above 200°C. You can construct your own solar stove by using simple materials such as clay and carton boxes. If you want to give it a try, you can find detailed instructions at **http://solarcooking.org/plans**

Saving gasoline

Hybrid cars

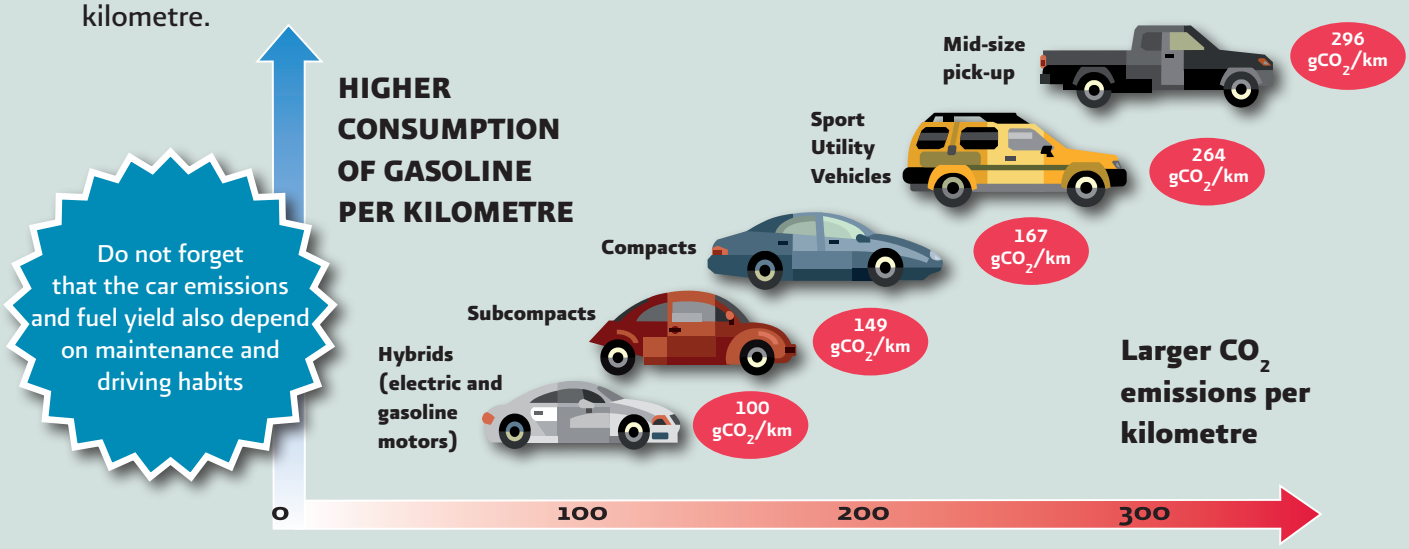
This sort of cars uses an electric motor and rechargeable batteries along with a conventional gasoline engine. With this arrangement, fuel consumption is reduced and the car's efficiency is improved in some cases up to 50%.

How do our motor cars contribute to CO_2 emissions?

Undoubtedly, motor cars have changed the way humanity lives since their inception and commercialization at the beginning of the twentieth century. Motor cars have made it possible not only to shorten travel times within and between cities, but also to move many passengers and huge volumes of merchandises between distant locations. Despite their usefulness, however, motor cars consume fossil fuels and emit greenhouse gases and other pollutants to the atmosphere, thus contributing to global climate change and to impoverish air quality, in detriment of our health and the environment. In the following pages you will see information about motor cars and public transport and the amount of GHG they emit to the atmosphere.

Just like in cats, there are also distinct classes among cars!

Probably the first thing that came to your mind upon reading the title of this section was a powerful, trendy sport car and, then, a common economy car. Although there in fact are noticeable differences as to the beauty, speed and price of both sorts of cars, they also differ significantly as to the amount of greenhouse gases that they emit to the atmosphere. Let us look now at some of the differences between some of the most commonly used types of motor cars as to their emissions and yields. As you can see in the figure, the sport utility vehicles are the ones with the largest CO_2 emissions and they, also in general, consume the largest amount of gasoline per kilometre travelled. By contrast, hybrid cars, which combine the use of electricity and gasoline, have the lowest emissions and the lowest consumption of gasoline per kilometre.

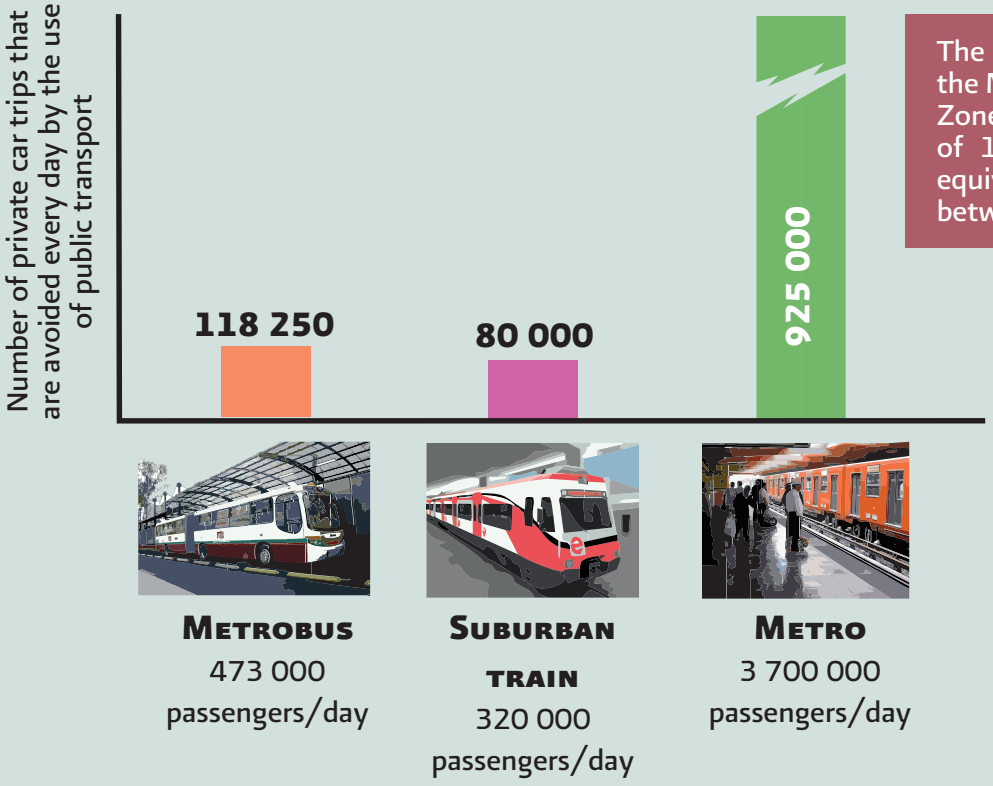


Although the emissions from an individual car might seem insignificant, if you multiply those by the millions of motor cars that run every day in big cities or in the whole country or in the whole world, the result is a huge amount. Just consider that, according to the Ministry of Communications and Transport (Secretaría de Comunicaciones y Transportes, SCT), there were nearly 22 million motor cars in Mexico in 2004, including privately-owned cars and public transport (passenger and cargo) units, which have emission values considerably higher than those of private cars.

If you are thinking about buying a new car and you want to consider energy efficiency and emission of contaminants as criteria for your choice, we suggest that you have a look at the website www.ecovehiculos.gob.mx. The information therein can help you discern whether your dreams' car is also environmentally friendly.

We travel more, but we shall give a minimum: public transport

In addition to privately-owned motor cars, there are also thousands of passenger transport units running up and down the cities' streets and avenues. Those public transport units also release greenhouse gases both, directly through their consumption of fossil fuels, or indirectly, through their use of electricity (as s the case for the metro and trams). However, in comparative terms, their emissions of carbon dioxide per capita are lower than those of privately-owned cars as they transport a large number of people on each trip.



Metrobus
473 000 passengers/day

Suburban train
320 000 passengers/day

Metro
3 700 000 passengers/day

The use of the Metrobus in the Mexico City Metropolitan Zone prevented the emission of 107,257 tonnes of CO_2 equivalent to the atmosphere between 2005 and 2008.

For this comparison, it was assumed that four passengers were driven on each private car trip.

Flights and climate change

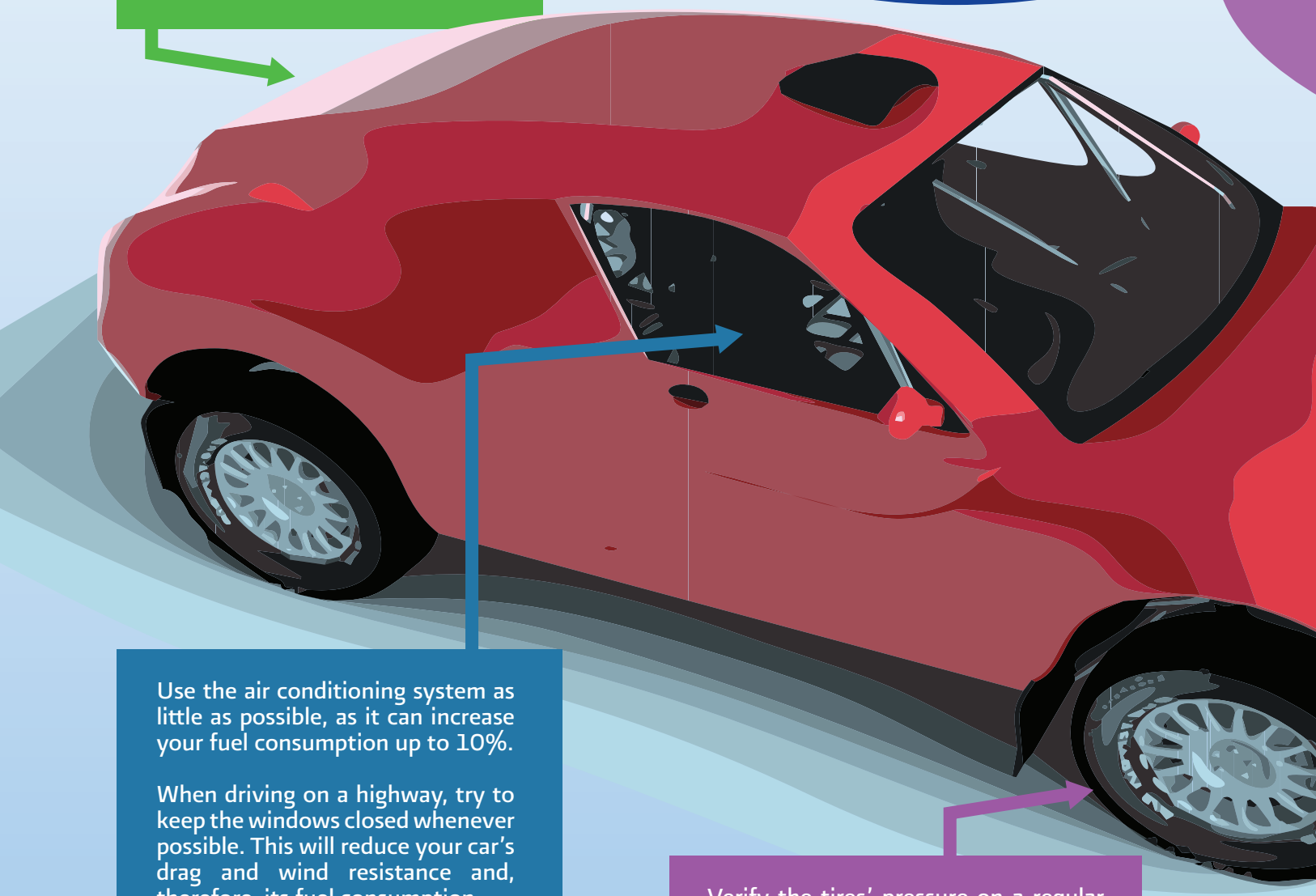
Maybe you have never stopped to think about this but, every time that you travel on an airplane, you are contributing to CO_2 emissions to the atmosphere. In the year 2002, the world's airplanes travelled some 32,950 million kilometres and, as they did so, they emitted about 489 million tonnes of CO_2, or about 2% of the total global emissions, slightly more than the total emissions of CO_2 in Mexico in the same year.

How do I get more value for my money, and less greenhouse gases, out of my car?

Regardless of the use that you give to your car, either as private transport or as a job tool, there are a number of things that you can carry out to reduce its greenhouse gas emissions. Some of those activities only involve minor modifications to your driving habits, while some others have to do with the maintenance that you give to your car. We can assure you that, if you take these recommendations into account both, its emissions and your expenses, will be reduced.

Avoid carrying unnecessary objects in the trunk. Every 50 kg added load increase fuel consumption by 2%.

If you drive at 110 km/h, your vehicle might use up to 20% more gasoline than if you drive at 90 km/h.



Use the air conditioning system as little as possible, as it can increase your fuel consumption up to 10%.

When driving on a highway, try to keep the windows closed whenever possible. This will reduce your car's drag and wind resistance and, therefore, its fuel consumption.

Verify the tires' pressure on a regular basis. If the tires are inflated at a pressure lower than the recommended one, their duration and safety will be reduced and they will cause greater drag, thereby increasing gasoline consumption up to 5%.

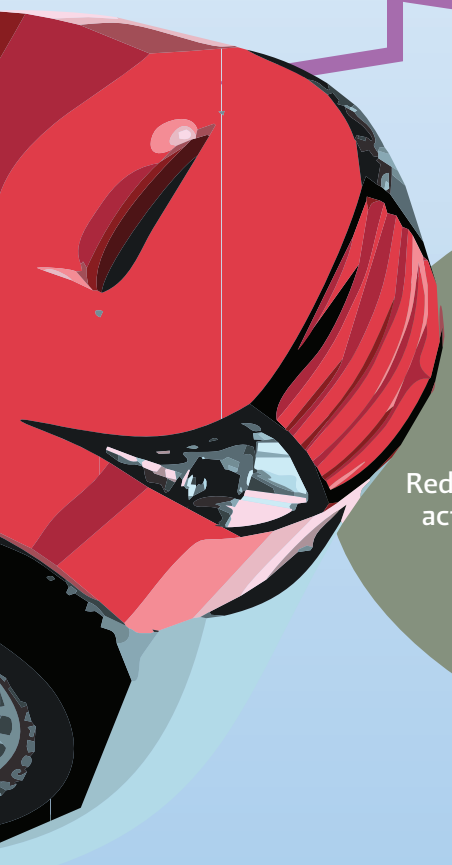
Tune up your car's engine on a regular basis.
A poorly tuned engine can increase gasoline consumption by as much as 20%.

Use a good-quality, multigrade oil of the adequate viscosity. This will reduce friction between the engine's moving parts and these will tear off more slowly. This will help you save between 1 and 3% of gasoline.

Rapid acceleration makes your car use 50% more fuel than if you use accelerate gradually.

Check and replace air filters regularly. That way you will reduce gasoline consumption by approximately 10%.

Do not pre-warm the engine before starting a drive. An automobile consumes some 10 ml of fuel, on average, for every minute that is sitting idle.



Will you make it ...?

Whenever you have to travel only short distances, it is better to ride a bike or walk. That way you will not emit GHG and other pollutants and, in addition, the exercise will benefit your health.

Share your car with other people; that way, the GHG emissions per person will be less than if each person drives its own car.

Reduce the number of trips: Organize your activities in order to carry out as many activities as possible on each trip. That way, you will make a more effective use of time and will reduce your fuel consumption and GHG emission.

If public transport routes are available at the places where you study, work or entertain yourself, you might consider using them at least once a week and let your car parked at home.
This way, you will save on gasoline and money.

You will find additional recommendations about the wise use of your car at the website of the National Commission for the Efficient Use of Energy (Comisión Nacional para el Uso Eficiente de la Energía, www.conae.gob.mx). There you will also find manuals on efficient driving which will help you to take full advantage of your car's capacities, without increasing the emission of GHG and pollutants.

Additional reading and relevant websites

Comisión Federal de Electricidad. Available in: www.cfe.gob.mx

Comisión Nacional para el Uso Eficiente de la Energía. Available in: www.conae.gob.mx and www.conuee.gob.mx

Conabio. Diversidad biológica y cambio climático. Available in: www.conabio.gob.mx/institucion/cooperacion_internacional/doctos/divbio_cambio_clim.html

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NOTES

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