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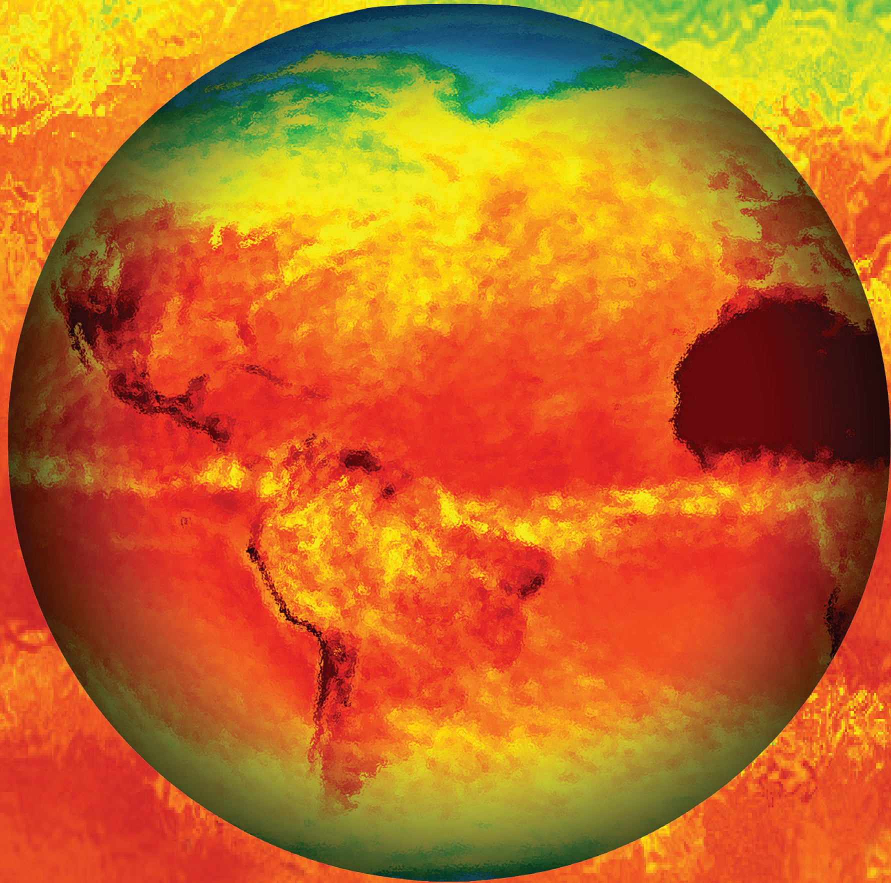
Trends of Global Change Climate Change



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Foreword

CLIMATE CHANGE is humankind's greatest challenge of the 21st century. The complex impacts will be felt across all continents and nations—no one will be exempt. The natural systems of the planet coupled with the human systems will be strained significantly. Our basic security issues of food, water and energy, when juxtaposed against a backdrop of 9 billion people, by mid-century will become a backdrop for disease, food insufficiency, human migration, and conflict at a scale unseen in our historical memories.

Maria Guadalupe Garibay-Chavez and her team of expert authors and editorial board have articulated a series of trends, assessments and drivers in this book about the impacts with a focus on selected vulnerable nations. With a focus on human health impacts, the authors examined a variety of scenarios across a spectrum of geographic, social and economic boundaries. They describe a series of mitigation strategies for preventing widespread pandemics and describe ways to increase resilience for communities and nations around the globe.

This is a must-read for health care planners, land use planners, and organizations that are building adaptation strategies for combating Climate Change. The economic impacts from this climate induced health crisis will also be significant to our financial institutions and economic structures—both in terms of direct and indirect medical costs and in terms of human productivity loss.

Our global and national securities are in jeopardy. As nations around the world spend significant percentages of their GDP in protecting their national interests from internal and external threats. They must take into account the human health threats posed by Climate Change and develop strong preventive and adaptation strategies—similar to what the world did during the Cold War to prevent nuclear annihilation—this time to prevent climate induced loss of human life and livelihoods.

René Dubos eloquently stated that, "Trend is not destiny. The future based on a logical extrapolation of existing trends is not inevitable, and neither is doomsday. We cannot escape from the past. But neither can we avoid inventing the future. With our knowledge and a sense of responsibility for the welfare of humankind and the Earth, we can create new environments that are ecologically sound, aesthetically satisfying, economically rewarding, and favorable to the continued growth of civilization".

Maria Guadalupe Garibay-Chavez has laid in *Trends of Global Change. Climate Change*, the path for humankind to take up this sense of responsibility to create the resilience to adapt to this "changing environment" for the health and welfare of all mankind.

Keith A. Wheeler
Chair – IUCN Commission on Education and Communication

1. Challenges for the 21st Century – Climate Change and Gender

Patricia Bifani-Richard
Consultant on Gender and Development
Food and Agriculture Organization

Thanks to Paolo Bifani for his constructive criticism and helpful suggestions. I am grateful to Salvatore Leggio and his colleagues of the United Nations Library, UN-Geneva, for their excellent and useful assistance; to Gordon Boy for the thoughtful editing, and to Guadalupe Garibay for her support and encouragement. I am indebted to Udo Simonis who first motivated me in this subject.

Introduction
Climate change – the greatest challenge ever faced by humankind

> *Unless we make significant changes in our economy, the coming decades will experience rapid global warming… Looking ahead 100 years and beyond, the planet that future generations will inherit could be unrecognizable to those of us living on it today* (UNEP, 2007).

CLIMATE CHANGE is the most serious and complex environmental, social, and economic problem ever faced by humankind. The impacts of climate change are no longer a potential threat; they are an unequivocal reality. For the past 10 000 years, global temperatures have been relatively stable, allowing human civilizations to develop. Since the Industrial Revolution, however, the earth's surface has been warming. An overall temperature rise of 0.74°C has been documented, and incremental rates of increase have accelerated beyond natural oscillations.

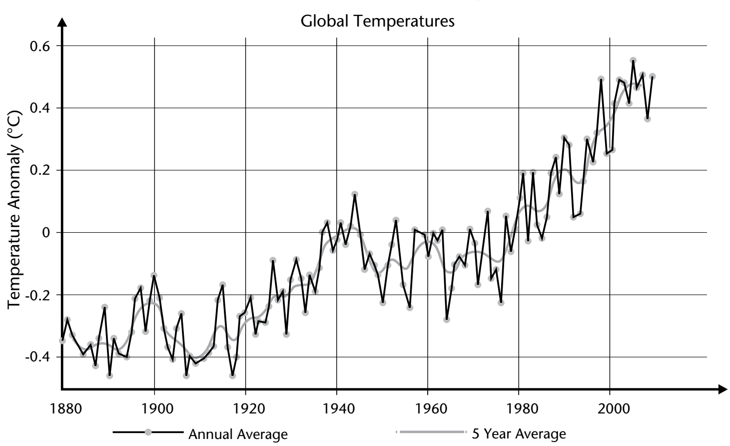

Figure 1. 1880-2009 mean global surface temperature change relative to the 1961-1990 average

Source: WMO World Meteorological Organization, December 2009.

The rate of climatic warming, also known as planet warming or global warming, is increasing. There is indisputable scientific evidence showing a close link between climatic warming and the accumulation of greenhouse gases in the earth's atmosphere. These gases absorb solar heat and warm the earth's surface.

The Intergovernmental Panel on Climate Change (IPCC) has established a threshold of 2°C above the pre-industrial era temperature level in order to stabilize greenhouse gas concentrations in the atmosphere (IPCC, 2007a). That level would prevent dangerous anthropogenic interference with the climate system (World Bank, 2010).

CO_2 released into the atmosphere remains there for centuries. CO_2 levels have increased from 280 ppm at the outset of the industrial revolution to 380 ppm in 2005 (Stern, 2007). Immediate action is needed if we are to start reducing emissions at the yearly rate of 1.5% that is required for warming to be stabilized within a range that comes as close as possible to reaching the prescribed threshold of 2°C above the pre-industrial era temperature. The reality, however, is that "Emissions from many high-income countries have increased over the two past decades, since the initiation of climate negotiations" (World Bank, 2010).

Impact of climate change on natural systems

> *…and into splinters of this world that is drowning under the sun* (Díaz Trillo, 2007).

An overwhelming body of scientific evidence shows that the earth's surface is warming at a rapid rate, affecting both natural and human systems (IPCC, 2007b). Extreme weather events are more frequent, with fewer cold days and frosts and more intense heat waves.

Global warming is responsible for a sequence of interrelated outcomes. Rising temperatures mean that plants and soils absorb less CO_2 from the atmosphere. Thawing of the permafrost is reducing carbon storage capacity and increasing methane emissions. The Asian peatlands, some of the planet's largest carbon reservoirs, are releasing CO_2 at a rate of 2 Gt per year—an amount equivalent to the total annual reduction laid out by the Kyoto Protocol for the 2008-2012 period (Tickell, 2009). Peatlands are especially vulnerable to warming. Their carbon-storage capacity depends to a large extent on the moisture content of the land. Higher temperatures dry out these deposits, which leads to a massive release of the carbon sequestered in the soil (UNFPA, 2009).

> The draining of the peatlands stimulates their decomposition, resulting in emissions of between 70 and 100 t/hectare of CO_2. Production of 1 ton of palm oil releases about 33 tons of CO_2.[1]

Global warming disrupts the hydrological cycle, which reinforces existing patterns of water shortage and water abundance, and thus increases the frequency and scale of floods and droughts. Globally, the combination of a more and more extreme water cycle with rising temperatures has led not only to increased rainfall, but also to an increase in the intensity of storms and tropical cyclones (World Bank, 2010).

Throughout most of the 20th century, average sea levels rose at a rate of about 1.7 or 1.8 mm/year, but during the last decade this rate increased to about 3 mm/year (IPCC, 2007b), owing to a thermal dilation of the oceans, the thawing of glaciers, and the melting of the polar ice caps and of other expanses of snow and ice, particularly in the Arctic and in Greenland (Tickell, 2009).

The impact of climate change is not equally distributed around the world. The poles are experiencing the greatest temperature changes. Satellite observations have established that the ice sheets in the Antarctic and Greenland are losing their mass at an increasing rate. Since 1950, the earth's snow shelves have decreased by between 10% and 15%. Periods of cold winter weather in the Northern Hemisphere are now two weeks shorter than they were 100 years ago. Since 1980, the Arctic Ocean's permanent ice shelf has shrunk by about 10% every ten years (*La documentation française*, 2010). James Lovelock, proponent of the Gaia Theory, spoke at a Royal Society of London conference about the unprecedented melting of the Arctic ice sheet during the summer of 2007. He also pointed out that the Earth System is entering into a positive feedback process and advancing inexorably towards a climate-stable state comparable to that of much earlier geological ages. Although water precipitation has increased throughout the world, droughts have become more frequent in Australia, central Asia, the Mediterranean Basin, the Sahel, and the western United States–to name just a few of the affected zones.

> On the iced slopes and plains leading down from the Huayna Potosi and Chacaltaya mountains lies a string of tiny communities that eke out a liv-

---

1 The production of biodiesel has become a major cause of deforestation in South-East Asia, notably in Indonesia, where thousands of square kilometres of tropical forest (including many peat swamp forests) are burned every year to open land for oil-palm plantations. Wetlands International studies have found that replacing fossil fuel with biodiesel from oil palms results in a net eleven-fold increase of CO_2 emissions because of the destruction of forests and peatlands (Wetlands International, 21.12, 2006), quoted by Tickell, 2009: 74.

> ing by keeping llamas, sheep, and chickens and by growing small crops of potatoes and oca.[2] The glaciers that used to provide water have shrunk dramatically over the last 15 to 20 years. According to Bolivian Government sources, the area of the glaciers providing water to these communities diminished by 84 km² between 1987 and 2004–that is, by about 24%. "Streams are no longer there," says one woman. "This has resulted in a shortage of fodder and in the starvation of some herds. Fetching water has become a more arduous task." She now spends hours every day collecting water from a river further up the valley… (UNFPA, 2009).

Climate change is threatening the world's biodiversity and changing forest ecosystems, wetlands, and coral reefs, as well as agricultural and fishery ecosystems. Coral reefs are affected by the warming of surface sea water and by a rising concentration of atmospheric CO_2. The first leads to coral bleaching, while the latter causes declining calcification, resulting in a weakening of coral skeletons. Reductions in warm-water coral cover over the past 20-25 years are estimated at 30%, or greater, reflecting the increasing frequency and duration of higher sea water surface temperatures. In some regions, such as the Caribbean, coral losses for the period are put at 80%. The combined effects of rising CO_2 levels and more frequent bleaching events, together with intensifying non-climatic impacts, including predatory activities (tourism, bottom trawling, over-fishing), invasions by non-native species and higher pollution and sediment loads, could mean that, by 2050, corals may become rare on tropical and sub-tropical reefs (IPCC, 2007b).

Increasing acidity of the oceans due to greater CO_2 absorption from the atmosphere is threatening marine ecosystems (UNDP, 2008). Changes in the circulation patterns of ocean currents are affecting fish populations and disrupting the aquatic food chain. Climate change is also affecting the agricultural lands, forests and grasslands that occupy 60% of the world's continental surface (FAO, 2007).

2 *Oxalis tuberosa* is an annual plant that overwinters as underground stem tubers. These tubers are known as oca, oka, or New Zealand Yam. The plant is cultivated in the central and southern Andes for its tubers, which are used as a root vegetable. Wild Oxalis species are found in the central Andean region. Oca is one of the important staple crops of the Andean highlands, second only to the potato due to its easy propagation, and tolerance for poor soil, high altitude, and harsh climates.

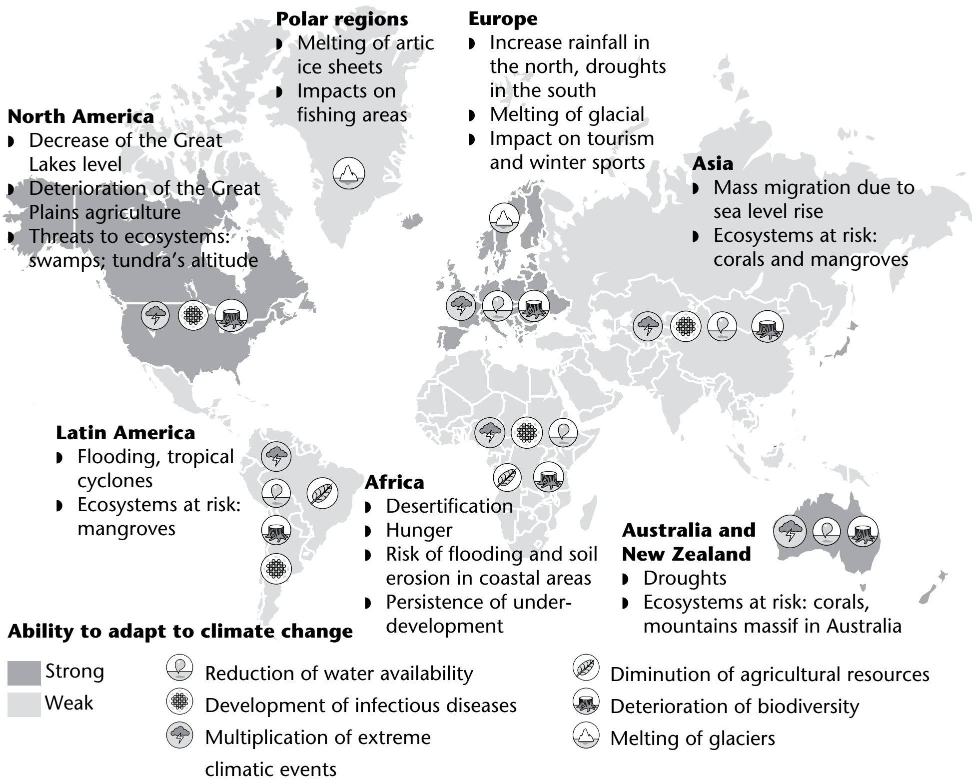

Figure 2. Global warming projections: 2050-2100

Source: http://www.ladocumentationfrancaise.fr/cartes/monde/c000810-le-rechauffement-climatique-dans-le-monde-projection-2050-2100. May 1, 2007.

Impact of climatic change on human beings

> *The impacts of climate change are unequally distributed:*
> *the poorest will be the first to suffer and will suffer the most* (Bridge, 2008).

Climate-related disasters are increasingly frequent and are affecting the lives of more people. Between 2000 and 2004, an average of 326 climatic disasters were reported annually. Over that period, about 262 million people were affected each year by these phenomena, which is more than double the number recorded for those affected in the first half of the 1980s. Developed regions have also suffered violent impacts, such as the heat wave that hit Europe in 2003. This was the most intense event of its kind in 50 years (UNDP, 2008), and claimed some 35 000 lives, mostly among the elderly and vulnerable sectors of society (IPCC, 2007b).

The effects of climate change on human beings are complex and interrelated. Vulnerable communities are least able to adapt to extreme and violent phenomena, and are therefore the most dramatically affected. Mostly in poor developing countries, these communities depend on agriculture and natural resources for their livelihoods, having few opportunities to diversify production. So, for example, the rising sea-level is threatening many of the world's low-lying, densely populated coastal areas and Small Island States. Indonesia, for instance, could lose as many as 2 000 small islands as a result of rising sea levels (UNFPA, 2009).

The inevitable consequences will include mass migration, the destruction of livelihood patterns, new health problems, and a disruption of the economy, which will weaken the development process and exacerbate inequalities between socio-cultural groups and the sexes.

Food Security: Many factors are seriously undermining global food security. A less and less dependable supply of water, in a climate marked by more frequent droughts and floods, is reducing agricultural productivity and production. Declining biodiversity and rising food prices are further compromising food security. Most vulnerable are the 1.4 billion people in the world who make their living from small-scale agriculture or hunting and gathering, the landless communities whose livelihoods depend on small-scale fisheries, nomadic herders, and the many fast-growing marginal urban populations. All of these vulnerable groups share an attachment to the yoke of poverty. A concomitant lack of resources and living options restrains their ability to cope with the effects of climate change.

Food production is particularly sensitive to climate change. Crop yields depend largely on prevailing temperature and rainfall patterns. Agriculture accounts for 24% of world output, employs 22% of the global population, and occupies 44% of the world's land area. No fewer than 75% of the poorest people in the world—those who live on less than US $1 a day—rely on agriculture for their livelihoods (Stern, 2007). In Least Developing Countries, 79% of all economically active women work in agriculture.

Women produce roughly half of the world's food (60-80% of this in the case of most developing countries) and account for 70% of the world's poor. The vast majority of the poor inhabit sub-Saharan Africa, the Asia-Pacific region, South Asia, China, and the Small Island Developing States (SIDS). Declining crop yields, especially in Africa, are likely to result in a dramatic increase in the world's hungry—now amounting to one-sixth of the global population.

Drought and vulnerability in Africa

Drought and food vulnerability in Niger: Niger is one of the world's poorest countries. In 'normal' years, food security is precarious and agricultural production systems face uncertain rainfall patterns. Seven million people—more than half of the population—suffer from chronic hunger, affecting mostly children below 5 years of age (Van Eeckhout, 2010). In 2004-2005, the country's extreme vulnerability was tested further by shorter-than-usual rains, followed by a locust invasion. Agricultural production was immediately affected, causing a cereal deficit. Average prices of sorghum and millet have risen by 80% over the past five years' average. A decline of 40% in available pasture has affected cattle, depriving the population of another key source of nourishment (World Bank, 2010). Child malnutrition rates rose from 12.3% in 2009 to 16.7% in 2010 (Van Eeckhout, 2010).

Drought in eastern Africa: Africa's worst drought since 2000 was in 2009. Failure of the rains in Ethiopia added another 8 million hungry people to that country's already starving mass of 80 million people. In Kenya, production of corn, the staple food, declined by more than one-third, and in northern Uganda by one half. South Sudan, Eritrea, the Central African Republic, and Tanzania also suffered. In Somalia, 3.6 million people required urgent food assistance. In Kenya's Ukambani region, crops failed completely, and people had to depend on rations of corn flour, rice, and a little oil provided by the government in order to survive. Thirst, though, is more terrible than hunger. People dig wells by hand in the absence of more effective tools. In the grazing lands of northern Kenya, southern Ethiopia, and Somalia, the mass deaths of domestic livestock exacerbated the problem. Heavier-than-usual rainfall was then predicted, increasing the risk of floods and landslides (*Economist*, 2009a).

Mass migration: As early as 1990, the Intergovernmental Panel on Climate Change noted that one of climate change's most serious effects on populations would be the displacement of people. Forced migration in the face of environmental problems is nothing new, however. The drought that affected the United States in 1930 and 1936, known as the Dust Bowl, displaced hundreds of thousands of people. Something similar happened during the Sahel droughts of the 1970s, which forced farmers and nomads to migrate to the cities. Today's more intense weather events, coupled with rising sea levels and accelerated environmental degradation, foreshadow unprecedented displacements. Loss of state territory in low-lying coastal areas and in Small Island Developing States (including Vanuatu, Tuvalu and the Maldives) has prompted fears that some countries may already be "sinking" (UNFPA, 2009).

Destruction of coastal areas

> A couple living in a low coastal area of the Kiribati atoll tells how, over the past decade, as the sea level has risen, they have been obliged to keep adding sand to the floor of their home to keep it dry. Some other people are building sea walls along the shoreline to protect their land from the advancing sea, but these walls will not suffice. And where to go? There is no higher ground for the population of Kiribati to migrate to. As Kiribati's President says, the choice will be to drown or leave. Women, meanwhile, are fighting coastal erosion by planting mangrove seedlings (UNFPA, 2009).

Estimates for the number of people at risk of forced migration, displacement, or relocation due to climate change between now and 2050 range from 200 million to 1 billion (World Bank, 2010). The migrations will be from the rural areas of developing countries into the cities, putting yet more pressure on already stressed urban infrastructures, worsening the problems of supplies, housing, and employment. Adaptive measures, such as coastal protection, may help reduce the scale of the migrations.

Health: "Increased knowledge about climate change is transforming our understanding of the limits of human health and the factors determining it," states a WHO/WMO/UNEP study (OMS/OMM/PNUMA, 2003). This study stresses the link between the health of populations and the life-sustaining "services" of the biosphere. Climate change may affect health in many ways–either directly, through high or low temperatures or weather events, or indirectly, by altering the range of disease vectors such as mosquitoes and water-borne pathogens, or rather through compromising air quality and the quality and availability of food.

Increases in mosquito-borne diseases

> Diseases transmitted by mosquitoes and other insects are particularly sensitive to climatic variations. The incidence of mosquito bites increases with heat, which also accelerates the development of the parasites they carry. Mosquitoes transmit malaria, which kills about one million people every year. As temperatures rise, the distribution of the Anopheles Mosquito, which transmits the disease, is spreading north and south, and is reaching altitudes where the species was previously absent, such as the highlands of East Africa. Lymphatic filariasis, or elephantiasis, is another mosquito-borne disease that is likely to spread due to a rise in temperature (WHO, 2008). The geographical range of dengue is also expanding. Indeed, it has been esti-

mated that, by 2070, the number of people at risk of contracting this disease will double, from 30% to 60% of the global population (World Bank, 2010).

Increased maternal and infant mortality rates and reduced disease-resistance due to malnutrition have added to the burden created by infectious and parasitic diseases such as malaria and dengue. Malnutrition will be exacerbated by the declining agricultural productivity resulting from pests and plant diseases, droughts and famines, crop failures, the lack of water, population displacement by natural disasters, and conflicts over natural resources. Rising temperatures also increase the incidence of diarrhea. In some regions, the risk estimate for 2030 is 10% higher than it would be in the absence of climate change (OMS/OMM/PNUMA, 2003). Cardiovascular diseases will also become more prevalent, both in the tropics and at higher latitudes (World Bank, 2010).

Another effect of climate change will be the disruption of social duties and socially assigned gender roles. For example, according to WHO, the less developed countries depend on traditional medicines for addressing 80% of their health needs. Knowledge about the healing properties of plants is held mostly by women (UNDP, 2008). Traditional administration of cures will be undermined by loss of biodiversity, which is limiting the range and availability of medicinal plants, as well as by seasonal changes affecting the production and harvesting of such plants.

Human settlements and infrastructure: Urban populations account for more than half of the world's people. This figure will continue to increase, and may reach 75% by 2050. One problem is that cities are warmer than other parts of their regions, representing "urban heat islands" (*Economist*, 2010).

Floods and landslides pose a serious threat to houses, especially on slopes and in low-lying coastal areas. Hurricanes and cyclones wreak havoc in many tropical regions, where changes in rainfall, both in space and time, tend to be more marked than in milder climates.

Historically, cities have thrived in coastal areas and at the confluences of rivers. More than half of the world's population lives within 60 km of the sea, and 75% of all large cities are located on coastlines. The melting of ice caps and the resulting rise in sea levels will threaten coastal infrastructure, while a thawing of the soil will destabilize the infrastructure of cities built on permafrost. The supply of water, energy, and sanitation in cities will be affected (UN Habitat/UNEP, 2009).

Water availability:

> *Just as oil conflicts were central to 20th-century history, the struggle over fresh water is set to shape a new turning point in the world order and in the destiny of civilization* (Solomon, 2010).

When the United Nations' Declaration on Human Rights was adopted, the right of access to water was omitted. In July 2010, this omission was rectified, when the General Assembly declared the Right to Drinking Water and Sanitation a fundamental right. Yet, despite this recognition, almost 2 billion people live in water-stressed areas and 3 billion people have no access to running water within one kilometer of their homes. Women and girls, who have traditionally been responsible for collecting water, now have to travel ever greater distances to fetch their water.

Every eight seconds, a child dies from a water-borne disease that could have been avoided had clean water and appropriate sanitation been available (UN, General Assembly, 2010). Climate change is putting severe strains on water availability–now one of the most alarming problems facing humanity. "A decade ago, it was predicted that one-third of the world's population would be facing water scarcity by the year 2025. But this threshold has already been reached" (Khor, 2010a).

Shrinking glaciers

> The Himalayan glaciers feed most of the great rivers in India, China, and South-East Asia. According to Yao Taodong, from the Chinese Academy of Sciences, (quoted by Martin Khor), shrinkage of glaciers in the plateau regions could eventually lead to an ecological catastrophe (Khor, 2010a).
>
> Today, 1.4 billion people live in closed river basins where water use exceeds discharge levels. Symptoms of stress include the collapse of river systems in northern China, a decline in groundwater levels in South Asia and the Middle East, and mounting conflicts and disputes over access to water (UNDP, 2008). Such conflicts will escalate further in cases where the same river flows through two or more countries.

In Africa, about 50 rivers supply more than one country (Khor, 2010a). The Nile, Zambezi, Niger, and Volta basins are all sources of potential conflict. Some conflict is already taking place–for example, among Egypt, Sudan, and Ethiopia, over access to the Nile's water resources. The Jordan River basin is the subject of ongoing disputes involving Israel, Palestine, Syria, and Jordan, in a region that once had enough water to meet the needs of all.

Floods in Pakistan

Floods in Pakistan between July and September 2010, which affected 20 million people, were linked to climate change and foreshadowed other calamities. High temperatures of the Atlantic reportedly contributed to the flooding by releasing greater amounts of water vapor into the atmosphere, thereby enhancing the power of the monsoon. These phenomena were exacerbated by deforestation, poor management of rivers, and changes in the use of soils in affected areas. The Indus River reached its highest level in 110 years, when records began to be kept. The disaster was magnified by the country's high vulnerability to the adverse effects of climate change. The floods cost the country tens of billions of dollars and delayed development for many years. Nearly one million homes were destroyed or damaged, 10 million people lost their homes and many millions were deprived of water, food, and medicine. There was extensive damage to farming and to the livelihood systems that rely on it (Khor, 2010b).

Threat to cultural heritage: Climate change will trigger changes in environmental conditions that may threaten buried evidence by exacerbating decay mechanisms at archaeological sites. Archaeological evidence is preserved in the ground because it has attained a balance with the hydrological, chemical, and biological processes of the soil. Changes in these parameters may result in a poorer level of survival of sensitive classes of material (UNESCO, 2007).

Climate change is threatening many historical monuments. On the Greek island of Thasos, rising water is destroying the foundations of the ancient Agora. Rainfall and flooding caused by El Niño has damaged the Peruvian city of Chan Chan, capital of the Chimu kingdom, the largest in pre-Columbian America, while in Bangladesh, Sonargaon-Panam City, center of the ancient kingdom of Bengali, is being inundated. Sand dunes are advancing on the pyramids, shrines, and carved decorations of Meroe, capital of the Nubian kingdom in the third century BC, located in present-day Sudan. Rising temperatures are reviving parasites, bacteria, and fungi in what has been, until now, dormant organic matter, which are accelerating the decomposition of monuments. The higher salinity of the sea is eroding archaeological remains, thereby depriving humanity of essential aspects of its collective heritage, memory, and history, says a researcher from the CNRS (Le Hir, 2010).

Climate change – a human-induced phenomenon

> *Climate change is about people. People cause climate change.*
> *People are affected by it. People need to adapt to it.*
> *And only people have the power to stop it* (UNFPA, 2009).

Human activity releases billions of tons of greenhouse gases into the atmosphere each year. Carbon dioxide (CO_2) is generated when fossil fuels are used for energy and when forests are cut down and burned. Methane (CH_4) and nitrous oxide (N_2O) come from agriculture and other sources such as livestock production, extraction of fossil fuels, rice cultivation, landfills, effluents from industrial processes, and the use of fertilizers (table 1).

Table 1. Processes generating greenhouse gases

Greenhouse Gases	Generating Processes
Carbon dioxide (CO_2)	Burning oil and other fossil fuels, deforestation, changes in land use, production of cement
Methane (CH_4)	Livestock production, fossil fuel extraction, rice cultivation, landfills, wastewater
Nitrous oxide (N_2O)	Industrial processes, use of nitrogen fertilizers
Fluorinated gases:	
Hydrofluorocarbons (HFCs)	Aerosols, air conditioning, refrigerator leaks
Perfluorocarbons (PFCs)	Aluminum production, semi-conductor industry
Sulfur hexafluoride (SF_6)	Casting of magnesium, electrical insulation

Source: UNFPA, 2009.

The different gases all contribute to a greater or lesser extent towards creating the greenhouse effect, depending on their heating power and their persistence in the atmosphere. Even released in very small quantities, these gases can reinforce the greenhouse effect in a durable way. With regard to persistence of these gases in the atmosphere, the aforementioned WHO/WMO/UNEP (2003) study notes that time spent in the atmosphere "is a parameter of great interest to policy makers because long-standing gas emissions are a sort of nearly irreversible commitment to sustained climate change over decades or even centuries".

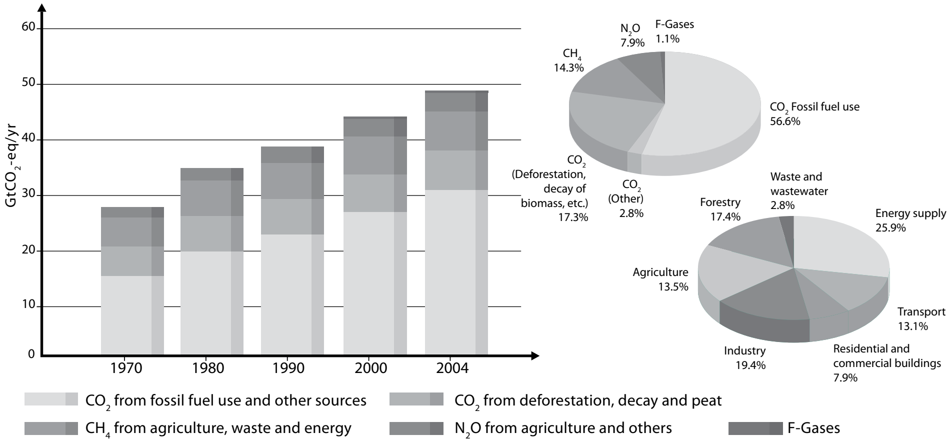

Figure 3. Percentage of greenhouse gas emissions

Source: GIEC, 2001.

The rate at which emissions are increasing has already exceeded the forecasts of even the most extreme scenarios. Emissions of CO_2 resulting from the burning of fossil fuels and from industrial processes has accelerated globally from 1.1% between 1990 and 1999 to 3% over the period from 2000-2004 (Tickell, 2009).

The table below shows how the contribution of different economic sectors and activities to the release of greenhouse gases varies widely, depending on the income levels of countries. So, while energy production and transportation are the principal sources in middle- and high-income countries, changes in land use and deforestation, followed by agriculture, are far more pronounced in low-income countries, although such activities are also significant sources of green-house gas emissions in middle-income countries.

Table 2. Greenhouse gas emissions by sector

World	**%**	**High-income countries**	**%**	**Middle-income countries**	**%**	**Low-income countries**	**%**
Energy	**26**	Energy	**36**	Energy	**26**	Energy	**5**
Transportation	**13**	Transportation	**23**	Transportation	**7**	Transportation	**4**
Residential and commercial build-ings	**8**						
Industry	**19**	Industry	**15**	Industry	**16**	Industry	**7**
Agriculture	**14**	Agriculture	**8**	Agriculture	**14**	Agriculture	**20**
Land-use changes, deforestation	**17**			Land-use changes, deforestation	**23**	Land-use changes, deforestation	**50**
Waste, waste water	**3**	Other	**18**	Other	**14**	Other	14

Source: adapted from the World Bank, 2010.

Uneven impacts in an unequal world

> *The most vulnerable countries are the least able to protect themselves. They are also those that contribute least to the emission of greenhouse gases* Kofi Annan (UNDP, 2007).

> Collectively, rich countries have been responsible for seven out of every 10 tons of CO_2 released into the atmosphere since the onset of the industrial age. This fact is significant, the UNDP has noted, for two reasons: first, in that it is the cumulative effect of the emissions that is driving current climate change; and secondly, in that the atmosphere's capacity to absorb future emissions is a residual function of past emissions (UNDP, 2008).

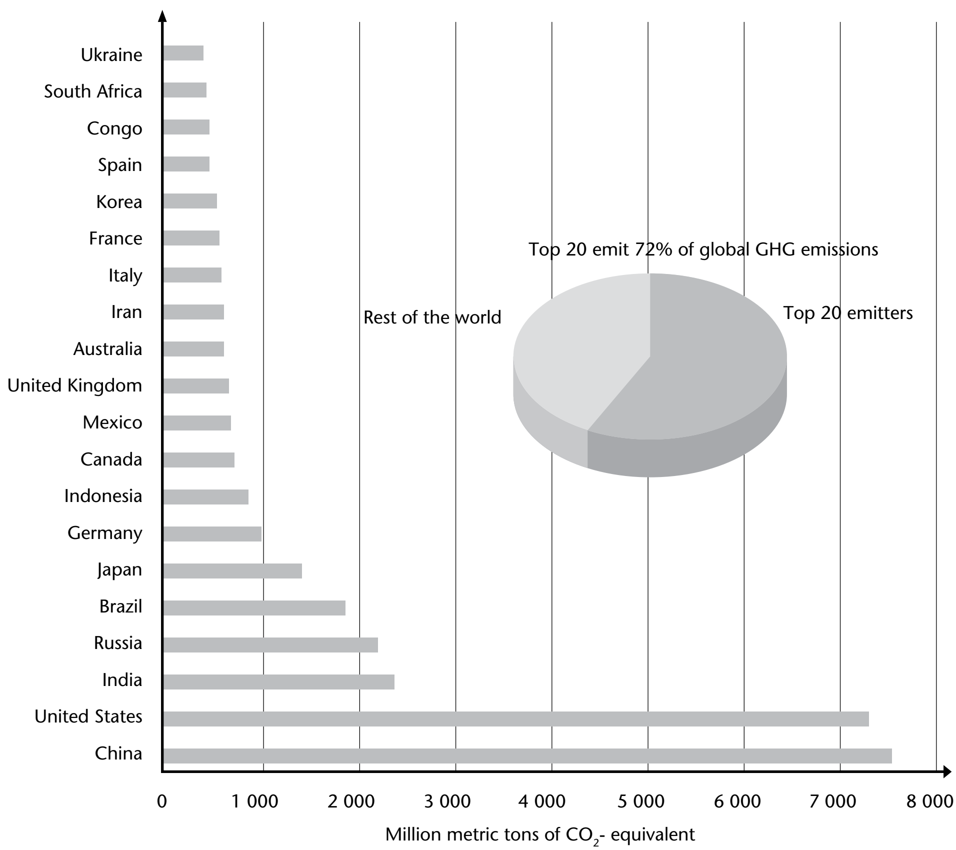

Figure 4. Top 20 Emitters of greenhouse gases in 2005

Source: CRS graph with emission estimates from International Energy Agency. Data extracted 5 May 2008.

Table 3. Contribution of major regions to global climate warming measured by greenhouse gas (GHGs) emissions from combustion of fossil fuels, 1900-2000 (%)

Countries or groups of countries	Contribution to global greenhouse gas emission as a percentage of total global emissions
G8	61.98
United States of America	29.95
European Union	25.49
Former USSR	8.53
China	7.57
Germany	7.18
United Kingdom	5.46
Middle East and North Africa	2.92
France	2.77
South America	2.28
Canada	2.20
India	2.09
Sub-Saharan Africa	1.59
Central America and the Caribbean	1.33
Oceania	1.22
Alliance of Small Island States (AOSIS)	0.37

Source: World Resources Institute, September 2005.

The United States and Europe together account for more than 60% of the Earth's greenhouse gas emissions. Yet the world's poor, whose ecological footprint[3] amounts to just 3% of the global ecological footprint, will be the first to suffer. Indeed, poor communities are already bearing the brunt of the effects of climate change. Those living in high-risk areas along coastlines exposed to flooding, or in arid regions prone to fluctuating, unpredictable rainfall patterns, are especially vulnerable.

The contributions made by nations and individuals to global warming can be measured by their respective ecological footprints. The impact on the planet of a way of life with a particular ecological footprint can then be compared with the planet's bio-capacity. This is defined as "the area of ecologically productive land (under crops, pasture, forest, or aquatic ecosystems) that is required to produce the resources used and to assimilate the waste generated". The bio-capacity of the planet for each individual person has been estimated at 1.8 ha. Using 2005 data, the average consumption per person per year is

3 The ecological footprint calculation is complex, using several methods of estimation based on observation of: hectares used to develop and build infrastructure and workplaces, hectares needed to provide necessary plant food, hectares required to feed livestock, and marine areas required to produce fish.

2.7 ha. Globally, then, we are consuming more resources and generating more waste than the planet can generate and support. The ecological footprint of the average German citizen is 6.0 ha, while the US average is 12.5 ha.

Some studies point to a gender difference in the ecological footprint.

> It is postulated that women have smaller ecological footprints than men due to differences in consumption patterns and lifestyles. This is true regardless of whether they are rich or poor. In OECD countries, women are more likely to recycle, to buy organic food, to eco-label products and to value more energy-efficient transportation. They make more ethical consumer choices, pay more attention to issues such as child labor or to patterns of sustainable living, and are more likely to buy products with the label 'fair trade'… (ILO, 2010).

The study refers to women in both OECD countries and Sweden. Systematic and comparative studies are needed in order to establish the extent and meaning of greenhouse gas emissions from women in different geopolitical regions and in different socio-economic systems.

It seems logical to assume that poor women, by having less access to productive resources, lower wages, and more limited access to paid work and credit, are necessarily at a greater distance from the consumer society, and may therefore have a smaller ecological footprint. On average, the world's poor spend 70% of their income on food, whereas the populations of industrialized countries disburse between 15% and 18% of their incomes on food (Leigh, 2008), with the rest being spent on other goods, many of which fall into the category of luxury items that are often most responsible for pollution, such as cars, travel, and residential air conditioning.

The waste produced by poor women and by households headed by women may be another indicator of their environmental footprint, for it is the women who best reflect the consumption patterns of a population. An average American produces about 700 kg of garbage per person per year, while a resident of Nairobi produces 220 kg. From garbage alone, the number of persons living in a household, their ages, and their ethnicity can be reliably determined (*Economist*, 2009b).

International frameworks for coping with climate change

> *The human race has the knowledge and technology necessary to reduce global greenhouse gas emissions over the next several decades despite growing incomes and populations… Decision makers are increasingly aware of the links between climate change policies and sustainable development practices* (UNEP, 2007).

The magnitude of the potential consequences of climate change has prompted the international community to outline strategies and measures to tackle this problem.

Table 4. Summary of policies and instruments for tackling climate change

Climate Change Policy	Measures
In 1990 the UN established a **Negotiating Committee**, and in 1992 –at the Earth Summit in Rio de Janeiro– the **UN Framework Convention on Climate Change** (UNFCCC) was signed. This came into effect in 1994	**Actions of mitigation and adaptation:** ◗ stabilization of emissions ◗ national inventories of anthropogenic emissions ◗ sinks
	Multilateral measures for adaptation to climate change: ◗ long-term cooperation ◗ financial resources ◗ development and technology transfer ◗ education and training ◗ citizenship awareness
Failure of reduction commitments, come the mid-1990s, lead to adoption –at the third Conference of the Parties, Kyoto, 1997– of the **Kyoto Protocol**	The ultimate goal of the Convention was a reduction of emissions and the establishment of quantitative goals for countries and regions
The Protocol took effect in 2005 and remained in force until 2012	Legally-binding emissions targets for OECD and EIT countries are central to the Protocol
The Protocol was ratified by 141 countries. Signatories for 36 industrialized countries undertook to reducing emissions by 5.2% of 1990 levels. The US and Australia, which together produce more than one-third of all emissions, did not ratify the Protocol. Australia signed it in 2007 The 101 developing countries that ratified the Protocol were to make inventories of their pollutant emissions The **Kyoto Protocol** is hailed as 'one of the most far-reaching environmental documents to have emanated from the political arena' (Moreno, n.d.)	**The Protocol introduces three innovative mechanisms:** ◗ Joint Implementation ◗ clean development ◗ emissions trading **General commitments include:** ◗ Establishment of national mitigation and adaptation programs; ◗ Improvements in the quality of emissions data; ◗ Promotion of environmentally sound technologies; ◗ Cooperation among scientific research and international climate observation networks; ◗ Education and training; ◗ Public awareness and capacity building
Negotiations on **post-Kyoto Agreements**: UN High Level Meeting on Climate Change, New York, 2007	**Pledges:** Increased awareness among scientists, politicians, business people and civil society about the urgency of tackling climate-change-related matters

Climate Change Policy	Measures
XIII Conference of the Parties to the UNFCCC, Bali, 2007 Agreements set out in the **Bali Roadmap** replaced those negotiated under the Kyoto Protocol	Commitments on long-term cooperation to achieve UNFCCC goals are negotiated **Actions to promote mitigation and adaptation include:** ◗ technology transfer ◗ mobilisation of financial resources
XIV Conference of the Parties to the Convention, Poznan, Poland, 2008	An '**Adaptation Fund**' was established. The focus was on: ◗ Risk reduction ◗ Reductions in emissions due to deforestation ◗ Disaster management ◗ Evaluation of progress achieved so far
XV Conference of the Parties to the Convention, Copenhagen, Denmark, 2009	The 193 participating countries achieved no consensus. No new regulations, goals, or actions are forthcoming
XVI Conference of the Parties to the Convention, Cancun, Mexico, 2010	A **Green Climate Fund** was established. Developed countries were to provide funds for adaptation. The need for deep cuts in industrial emissions was reiterated. Mexico pressed for more progress on forest protection. Bolivia sought guarantees for indigenous communities over control of ancestral lands. Critical views included those of the Continental Social Alliance[4]

Source: Elaborated by the author.

4 In its statement of 11 December 2010, on the Cancun agreed text, the Continental Social Alliance notes that the text shows no progress, avoiding completely the search for real solutions to the climate crisis. On the process, it notes that approval was achieved through negotiations among small groups and informal gatherings, facilitating a division of the poorest countries and using financial inducements to convince them to change their positions, in a far from democratic way, mirroring the patterns of WTO negotiations. The agreement does not address the urgent need to reduce greenhouse gas emissions and is not explicit on dates or mechanisms for reductions, leaving these to be adopted voluntarily by willing countries and not as part of a common global goal. There is no commitment even to ensuring voluntary compliance. The creation of flexible mechanisms and of compensation schemes is just an extension, into the climate arena, of the 'market logic' of financial speculators. The resources of the approved global fund are insufficient and are not guaranteed, and there is no mention of the fund's origin or of how it might be administered. The World Bank does not seem the appropriate institution to coordinate the fund, despite the interest shown by some countries. The agreement includes only financial considerations on forest management, invoking market mechanisms that ignore the rights of communities over their territories. The Alliance laments the omission of all references to sustainable new alternative technologies.

The most important documents presented so far on the effects and implications of climate change have been those of the Intergovernmental Panel on Climate Change (IPCC) and the Stern Report. In compiling the first document, 2000 scientists from around the world worked under the auspices of UNEP and the World Meteorological Organization. Neither report considers gender aspects, however, thereby ignoring the inequality of women, the impacts of climate change on women, and the potential of women as agents of change. Subsequently, there have been a series of efforts to include a gender dimension in these scientific discussions (UNFPA, 2009).

Table 5. IPCC reports and the Stern Report

IPCC	Stern
The Intergovernmental Panel on Climate Change (IPCC, organized in 1988) issues regular evaluations summarizing the current state of scientific knowledge on Climate Change. The first of the IPCC reports was completed in 1990, the second in 1995, the third in 2001, and the fourth in 2007	The Stern Report is the work of Nicholas Stern. It was first published by Cambridge University Press in the UK in 2006 under the title The Economics of Climate Change
Distinguishing features:	Distinguishing features:
Provides exhaustive scientific data on the physical effects of Climate Change. Stresses the evidence for global warming and the anthropogenic character of some of its causes	Deals with the effects of global warming on the world economy
Presents various possible scenarios for emissions and their effects around the world	Establishes that impact will be greater than previously suggested, causing annual GDP reductions of at least 5%. Shows how, if greater risks and impacts are taken into account, damage could amount to 20% of GDP
Concludes that regional climate changes are affecting the natural system	Concludes that benefits of early and decisive action far exceed the costs of inaction. Mitigation actions would cost less than 1% of annual world GDP
Assumes that changes in lifestyle and behavior are essential for mitigation	Suggested actions include: ◗ The pricing of carbon emissions ◗ Policies aimed at developing new or improved technologies in key sectors ◗ Removal of barriers limiting information, education and public discussion, as a basis for reasonable behavior

Source: Elaborated by the author, based on UNFPA; Stern Report; WB, UNDP; Oliver Tickell.

World governments, obliged to find solutions to the crisis and to provide answers to ensure the survival of humankind, conspicuously failed to do so. The outcome of the negotiations shows how the profit motive overrules life and the fate of the planet (Continental Social Alliance).

There is, in the agreements and in concomitant studies, no disputing the scientific evidence for Climate Change or for its anthropogenic character. This places an undeniable responsibility on institutions, companies, groups of people and individuals. It involves not only the scientific community and agencies of global governance but also civil society from all parts of the world. Adaptation and mitigation are global efforts that call for the cooperation and involvement of all citizens, irrespective of their skill levels and life circumstances.

Women and climate change negotiations

> *Addressing climate change will require all the capacity for innovation and all the skills the human race possesses* (World Bank, 2010).

To this it might be added that such an effort will also require the commitment, knowledge, and participation of *all* members of the human race, which includes women as well as men. Yet, humanity does not appear to make decisions on the basis of equality.

As Fatma Denton has remarked, "The climate negotiations could be seen as a parody of an unequal world economy, in which men, and the bigger nations, get to define the basis on which they participate and contribute towards the reduction of growing environmental problems, while women and smaller and poor countries look in from the outside, with virtually no power to change or influence the scope of the discussions" (2002).

Gender issues are overlooked in the two most important policy instruments addressing climate change: the 1992 UN Framework Convention on Climate Change (UNFCCC) and the Kyoto Protocol. Gender is not considered in relation to development and poverty, even though the feminization of poverty makes women more vulnerable to the effects of climate change (Skutsch, 2002).

At Conference XIV of the Parties to the UNFCCC in Poznan, Poland, the Secretariat conceded that climate change may have "a gender dimension", adding: "Its impacts are likely to affect men and women differently". The Secretariat went on to advocate the "formulation of gender-inclusive policy measures for addressing climate change, as women are important actors and agents in coping with and adapting to change". It is astounding to note, however, that in the 976 pages of the 2007 Report of the Intergovernmental Panel on Climate Change, only half a page is dedicated to "gender-related aspects of vulnerability and adaptive capacity" (UNFPA, 2009).

Lambrou and Piana (2006) believe that, so far, the only legal instrument that assigns to the women of the developing world a role in adaptation and mitigation efforts is the "Clean Development Mechanism" (CDM). The main applications envisaged for this mechanism of combining poverty reduction with a reduction of greenhouse gas emissions are in small-scale agro-forestry and reforestation projects in poor communities and in projects for the small-scale generation of hydropower and bio-energy (Lambrou and Piana, 2006).

The participation of women and gender experts in future climate-change negotiations should be encouraged. In the meantime, efforts should be made to gather sound gender-related data, to be fed into discussions on commitments and mechanisms. Mitigation issues need to be clarified, through establishing how the energy-use, transportation, and consumption patterns of men and women are influencing climate change. The effects of climate change on the lives, livelihoods, and health of men and women, as well as on their respective abilities to cope with, and adapt to, a changing climate need to be researched. Both sexes are equally vulnerable, so it is important to ensure that different strengths and skills each might bring to bear are harnessed for the common cause of strengthening adaptation mechanisms.

Adaptation and mitigation initiatives

> *There is still time to avoid the worst impacts of climate change if action is taken today* (Stern, 2007).

One line of thinking in climate politics tends to view mitigation and adaptation as investment alternatives. Yet, as author Udo Simonis argues "This is a specious argument. We need both: Both mitigation and adaptation are imperative. Even a successful climate policy will not stop the climate from changing. Given the long-term dynamics of the climate system, it seems quite impossible to reduce global warming to below an average increase of 2˚C. Adaptation and mitigation are two sides of the same coin, but there are a number of distinctions to be made. Adaptation implies that actors–people, communities, regions, states–can and will pursue their own specific strategies" (2010). These strategies will depend on the nature of the impacts each must face (floods, droughts, crop failures, heat, sandstorms, and so on). "Regarding mitigation, we're all in the same boat, space-ship Earth. Every mitigation measure, such as installing more efficient energy and transport systems, or planting trees, will benefit not only the actor doing the mitigating, but also the world at large. It is this systemic global effect of mitigation that requires better understanding and enhanced international cooperation" (*idem.*).

Barriers and threats to adaptation and mitigation

One of the most serious problems to be overcome is the inertia of institutions and the difficulty of initiating reform. The first step is to translate vague concerns about climate change into an understanding of the problem, and then to translate this understanding into action. Institutional inertia has many behavioral, organizational, and political aspects, which must be addressed all at once. Public institutions should be re-organized to facilitate necessary interventions. Institutional support is needed to ensure that interventions are efficient and sustainable. These institutional changes are achievable and should include gender considerations, while also making room for individual and civil society initiatives, as well as for the property rights of indigenous communities (World Bank, 2010).

Institutional inertia mirrors, at another level, the inertia in the decision-making behavior of individuals–in relation to travel, buying food, heating, and transportation. This can have substantial effects on mitigation: Households, for example, account for about 33% of emissions in the US, which is more than that country's industries emit. Yet individuals can determine and guide institutional behavior. In recent decades, awareness about climate change has increased. This awareness, though, has not been translated into changes in individual behavior. On the contrary, the numbers of cheap foreign vacations, private vehicles, and household appliances have increased worldwide. How to explain the "disconnect" between perception and action is a question that is puzzling the World Bank (*idem.*). Evidently, people do not understand the connection between individual behavior and climate change. It is important that information presented to the public should be clear, so as not to cause more confusion, but rather motivate concrete actions. Often, media coverage of natural disasters makes people turn off their TVs or radios, because they feel the climate is beyond human control. Another common attitude is that these disasters are best left to future generations to solve. Moreover, the magnitude of the problem appears so great that changing a conventional light bulb for one that is more energy-efficient seems almost insignificant (*idem.*). Opinion polls have shown that concern about global warming decreases as income levels increase.

While developed countries have contributed most to CO_2 emissions from the burning of fossil fuels, developing countries are waiting their turn to enjoy the benefits of development. This will surely increase their contribution to emission levels. One-quarter of the world's population (1.6 billion people) is still seeking access to connection to electrical systems. The projections of the International Energy Agency indicate that developing countries will account for most of the increased volumes in CO_2 emissions (Simonis, 2010), unless they can make a leap forward in seeking clean energy alternatives. Emerging economies not yet tied to development and industrialization models requiring intensive use of fossil fuels can become the pioneers of new models based on cleaner values, on healthy and efficient technologies, and on a fairer distribution of resources and wiser management of waste (*idem.*).

Adaptation and mitigation–changes in consumption patterns

Changes in individual behavior are essential for tackling climate change. The cue for making these changes is linked directly to the types of activities that men and women engage in, the resources they have, and their needs and expectations. In this predicament, it is expected that poor rural women will continue to increase their efforts to stop the advance of deserts, to select more resistant seeds, to safeguard biodiversity… and so on. Men from wealthier countries make decisions on installing more energy-efficient air conditioning, insulation, and lighting in their homes, while women in these income groups decide on the type of transportation and also manage household purchases and daily expenses. Better information about the links between behavior and greenhouse gas emissions can extend the range of interventions for each sex and increase overall efficiency.

If we include emissions associated with electricity and heating, 20% of greenhouse gases originate from buildings, both residential and commercial (Stern, 2007). Countries that are experiencing a construction boom such as China and India, along with developing countries in general, could use a multilateral fund to establish building codes and to train building inspectors to monitor compliance with the regulations (Tickell, 2009). Rich countries can implement such measures themselves.

Transportation accounts for nearly one-quarter of global greenhouse gas emissions. Road transport accounts for nearly 75% of the emissions. In recent decades, transportation-related emissions have increased at a faster rate than in any other sector. Emissions in the transportation sector will continue to grow in the coming decades unless there is a change in current patterns. This will result in an increase of 80% over current levels. Transport demand tends to increase with income growth. Passenger transport is now consuming between 60% and 75% of total transport energy (UNEP/WMO, 2007).

> Small local adjustments can result in large overall benefits: Replacing the sports utility vehicle (SUV) in the US with fuel-efficient passenger vehicles such as those sold in the EU can offset the emissions that would occur through providing basic electricity to the 1.6 billion people who lack it (World Bank, 2010).

Some evidence suggests that women in developed countries use means of transport that are less intensive in their greenhouse gas emissions than those used by men. They are less likely to own cars and tend to make much more use of public transportation than their male counterparts. If they own a car, it is likely to be smaller and more fuel-efficient, in Europe at least. The same study (Lambrou and Piana, 2006) discusses data from Sweden, Finland, and the US. We do not know how conclusive these data are, relative to similar studies conducted in other countries and regions. It would be interesting to know if, as some claim, women harbor a greater environmental awareness, as there is still no evidence for this. It may be that female private transportation patterns are related simply to the traditionally lower access among women to resources of all kinds. This would favor the hypothesis that in countries where there is greater equality of opportunities, women tend to adopt consumption patterns similar to those of men.

Regulatory measures play a key role in the transportation sector. Reduced availability of fuel-inefficient vehicles (Stern, 2007), higher sales taxes, investment in attractive public transport facilities and non-motorized forms of transportation, and mandatory use of fuel-efficient vehicles all play a part (UNEP/WMO, 2007).

Have mandatory regulatory measures for the transportation of weapons been considered? We know that "Military spending by UN member countries has increased by 50% in the past 10 years and now exceeds US $1.5 billion" (Ban Ki-moon, 2010). Emissions resulting from transporting troops, weapons, military convoys, troop supplies, bombers, and missiles must surely be significant–and increasing. Their mitigation must therefore be considered.

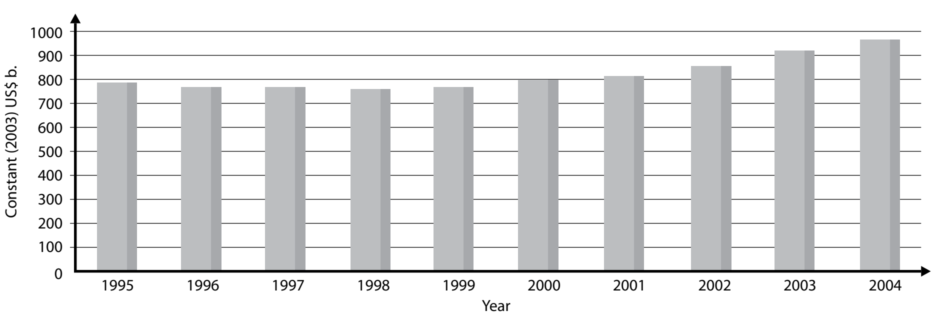

Figure 5. World Millitary Expenditure, 1995-2004

Source: Sköns *et al.*, 2005.

It has been noted that the IPCC follows a sectorial approach and does not focus on urbanization. Yet, "urban areas, cities, and towns are the major vehicles of climate change", according to one expert in this field (Simonis, 2010), who has estimated that 80% of CO_2 emissions originate in urban areas. In Europe, such emissions account for roughly 70% of all emissions; hence the importance of urban mitigation. Many European cities have introduced mitigation measures. Spanish cities have opted to use solar energy, while cities in Sweden have turned to biomass. Some German cities produce as much energy as they consume. Other measures will depend on lifestyle changes. Accelerating urbanization is yet another factor driving emission increases (*idem.*).

Gender analysis, documenting division of labor by sex, and differential access to resources may shed light on gender patterns of emission in urban areas, just as has been observed in rural contexts.

Women in adaptation and mitigation measures

If we consider the CO_2 sinks in the atmosphere, oceans, biota, humus, and soil (Bolin, 1981), the division of labor by sex gives women a direct role in the management of natural resources (biodiversity, forestry, soil nutrients), as part of their responsibility for food supply. Indeed, the knowledge that women have of the environment and of plant and animal species and their characteristics and usability amounts to a priceless heritage for tackling the vagaries of climate change. Added to this is the resilience of women, which is evident in this quote from a woman in India:

> As we never know when the rain will come, we have had to change our planting patterns. I started to change the way I prepare my seedbeds, so we don't lose all our crops. I am also using different crops, depending on the conditions (Mitchell *et al.*, 2007).

Biodiversity in all its aspects–genes, species and ecological communities–increases levels of resilience in ecosystems under stress. Protection of biodiversity and management of forests are two key areas for adapting to and mitigating climate change. The cultivation and harvesting of fruits, roots, herbs, woodlots, and medicinal plants, as well as the collection of water, animal fodder, and branches and foliage for housing, requires a deep knowledge of ecosystems and of peculiarities in natural cycles. Women have historically played a vital role in maintaining crop diversity through collection, selection, propagation, storage, and exchange of wild plant species. Women have also been responsible for planting, soil conservation, integrated pest management, and utilization of plants for nutrition, health, and economic purposes.

The protection and sustainable use of forests, park lands, and perennial crops help to absorb carbon from the atmosphere. Soils rich in organic matter halt erosion and absorb water. Genetically diverse ecosystems are more resilient to climate change.

> The Climate Change Convention stresses the need to conserve and enhance forests and their capacity to absorb carbon, pledging "preservation and enhancement of sinks and reservoirs for all greenhouse gases... including biomass, forests, and oceans, as well as other terrestrial, coastal, and marine environments." However, logging and forest fires have reached unprecedented levels...and it is estimated that 17.5% of the increase in global emissions comes from this source (Tickell, 2009).

Greater subordination of the poor over access to surrounding natural resources is making poor communities more vulnerable to biodiversity losses. Such losses are damaging enough already, given that, in the event of a temperature increase of 1.5-2.5°C, between 20% and 30% of all species will become extinct. In this context, the possibility of being able to turn instead to wild plant varieties resistant to drastic climatic changes seems increasingly unlikely. Predictions indicate, for example, that one-quarter of all wild potato varieties will disappear within the next 50 years. This makes efforts to safeguard the planet's genetic heritage crucially significant.

> Experiences in the mountainous northern region of Peru show that in traditional communities, such as Chetilla in Cajamarca, the duties of seed selection and storage belong exclusively to women. Seed selection starts with the classification of vegetables according to their different uses. Selection criteria depend on the productivity of each agro-ecological zone. In one Quechua area that relies on corn for subsistence, there are five qualities for corn, my mother told me (Tapia and De la Torre, 1997). "The first is for seed, the second for peeling, the next for cancha (roasting), the next for chochoca (flour and soup), and the last one for jora (corn beer). With potatoes, one has first to sort the tubers damaged in the harvest. These, we cook promptly, along with those with spots or worms (Andean Potato Weevil). From the good ones, we choose the biggest for food. The middle-sized ones are for seed, and the rest–the smallest and spotted and diseased ones–we cook and peel, for making dried potatoes. Potato seeds have to be very healthy. So we take care to ensure these are free of blight and disease and have no damage from worms or nematodes or from cuts during the harvest." Domesticated genetic material kept for centuries by rural families is the basis for the genetic richness in Andean production systems, and is also the origin of new varieties in the gene bank.

In subsistence cultures, gardens managed by women growing experimental crops for domestic use are the most effective safeguard against hunger, in the absence of purchasing power. These are some of the most complex agricultural systems known, and their greenhouse gas emissions are negligible. They take full advantage of traditional wisdom on the nature of ecosystems and the pace of natural cycles. The gardens provide a wide variety of vegetables and seasonings, and act as a sort of laboratory where women can adapt and test wild indigenous plant species.

> An FAO study of 60 gardens in Thailand found 230 different plant species, many rescued from nearby forests before logging.

> When Wangari Maathai returned from the United States after earning her doctorate, she was sent to the outskirts of Nairobi to research a parasite that was causing a serious disease in cattle. While walking through the green hills of her childhood, she noticed how the river's once pristine waters were muddy with silt. "Erosion," she told herself. "We must do something about that." She also noticed that cows were so skinny she could count their ribs. People also looked malnourished and poor. The livestock industry, once one of the pillars of the Kenyan economy was threatened more, she realized, by environmental degradation than it was by parasites. The native forests that once covered the hills had been cut down and replaced with coffee and tea plantations. By the early 1970s, landslides were frequent and clean drinking water was becoming scarce. Cash crops covered land previously devoted to growing food. Firewood had become scarce due to deforestation begun by the colonial administration, and changing diets were causing malnutrition among children and rural populations (2007).

From these findings emerged one of the most exciting and productive initiatives in the history of the restoration of degraded lands. This was an initiative that showed the power of women's effort, perseverance and collective strength. Its mental trajectory is also worth following: "The connection between the symptoms of environmental degradation and their causes–namely, deforestation, devegetation, unsustainable agriculture, and soil loss–were self-evident", Maathai said, adding: "It is one thing to understand the issues. It is quite another to do something about them".

"Think of what can be done, rather than worrying about what cannot", she thought. From this came the idea of planting trees. "Trees provide a supply of wood that will allow women to cook nutritious food. Trees also provide fencing materials and fodder for cattle and goats, protect water sheets, and bind the soil, and if they were fruit trees, they might provide food as well… allowing birds and small animals to come back and regain the vitality of the earth".

And that is how the Green Belt Movement was born. Through its initiatives, 40 million trees have been planted in Kenya. Some native species have been restored. Thousands of women have been provided with jobs, creating nurseries in countless communities, experimenting with appropriate species for each ecosystem, defending the green parts of urban areas, and extending the reach of the movement into other countries and regions–Ethiopia, Malawi, Tanzania, Uganda, and Haiti–thanks to the efforts of interested donors and through bilateral and multilateral cooperation.

Women and environmentally-focused companies

> *The world needs innovative ideas on how to induce countries with high emissions and low emissions to conclude an agreement that would reduce emissions and provide the necessary financing and technology…so that all countries and peoples can adapt and promote their resilience to climate change* (UNFPA, 2009).

A significant proportion of women in the developing world are not tied to technologies that require intensive use of fossil fuels. So they can be steered instead towards innovations based on sustainable energy and on new social patterns and priorities that address global warming. As such, they can "leap-frog" stages in conventional models and redirect their behavior.

One area where women have excelled is in urban waste management. This accounts for about 5% of greenhouse gas emissions. As countries urbanize and their populations grow, consumption patterns become more sophisticated. Waste amounts increase, as do emissions: of methane from landfills, and of methane and nitrous oxide from waste water. The incineration of waste containing plastics and synthetic fabrics also produces small amounts of methane (UNEP, 2007).

There are now technologies that can reduce emissions from waste, while also providing other benefits such as improved public health and environmental protection. Around the world, many of these technologies are being used by women entrepreneurs, who are creating more and more employment opportunities.

The livelihoods of thousands of people in the developing world depend on the collection, transport, and eventual re-use of garbage. These people—who number roughly 7 000 in Manila, 8 000 in Jakarta, and 10 000 in Mexico City, according to World Bank estimates—now constitute an important part of the informal sectors of economies. Five cities in Mexico employ 3 000 people, who generate income equivalent to US $21 million annually (Bifani, 2009). The "three Rs"—Reduce, Re-use, and Recycle—are becoming a way of life.

Good examples abound, such as the one mentioned below, which includes an element of innovation: that of using recycled products to improve agricultural productivity by replacing chemical fertilizers with organic fertilizers.

Social cohesion, entrepreneurship, and urban waste management

> The Ressoc program supported by the European Commission's URB-Al III initiative aims to improve social cohesion in urban metropolitan areas of Barcelona (Spain), San Salvador (El Salvador), Callao (Peru), and Managua (Nicaragua) by creating micro-enterprises for urban waste management, involving the building of transfer paths for segregation, storage, and recycling of waste and a network for composting and production of organic fertilizer to supply to accredited small organic farms and urban gardens. At the same time, the program is contributing to the economic and social advancement of families who work or live in landfills and/or those who carry out collection and marketing of waste in an irregular, unhealthy, and precarious way.
>
> UWEP (Urban Waste Expertise Program) has indicated that such activities constitute an important source of income for poor women. Compared with men, women engage in activities that require less education, fewer skills, and a more limited range of physical activities. So waste management can provide employment opportunities for illiterate women (Muller and Schienberg, 1997).

The ability of women to work together in organized groups contributes to their effectiveness. Their initiatives cover a wide range of activities, many undertaken in response to particular difficulties faced by women. Such activities may include awareness and protest campaigns lobbying for infrastructure to provide protection against floods, or for installation of waste-treatment systems, improved forest and natural resource management, or better access to health care… the list goes on and on. Greater awareness of new and sustainable technologies has led to an increase in protests organized by women to defend their right to a healthy environment.

Organization of the Niger Delta Women for Justice

> In 1999, Nigerian women headed a global movement to stop the flaring of natural gas (methane). In Nigeria, a transnational oil company was burning the natural gas to cut its maintenance costs and avoid involvement with other industries. The amount of gas being burned in the country was more than in any other part of the world—and was emitting more greenhouse gases into the atmosphere than the whole of the sub-Saharan region combined. The women of the Niger Delta organized simultaneous protests in Nigeria and the UK. These resulted in the company's London headquarters being closed and the temporary closing down of the wells. As the protests continued, the company

> resorted to military control. In the ensuing confrontation, 200 people were killed and many women were raped. On January 11, 1999, hundreds of members of the Niger Delta Women's Organization for Justice, indignant about the rapes and murders, staged a mass protest, along with several political awareness workshops for women. Finally, in January 2006, the social pressure forced Nigeria's courts to cancel the gas company's license and order to put a stop to natural gas flaring in petroleum wells in the western Niger Delta. This unprecedented international action demonstrates women's ability to act as agents of reform in the struggle to mitigate climate change (UNDP, 2008).

The search for new development paradigms

The gender dimension of climate change is the subject of a remarkable assessment offered by indigenous peasants in Cochabamba, Bolivia. Showing clear similarities with the conceptions of Western eco-feminists, their assessment is as follows:

> It must be recognized that the main cause of global warming is the capitalist system. Driven by consumerism, this system triggers the excessive exploitation of natural resources by large industrial companies. The whole system is based on the use of fossil fuels, which are the main cause of global warming, along with the emergence of oil companies that prey on and damage ecosystems. At the global level, war is the main contaminant because it uses chemicals whose combustion generates greenhouse gas emissions…
>
> …The capitalist system and climate change affect women in a particular way. They affect the reproductive role of women by increasing maternal mortality, miscarriages, and related infections. Yet this situation is not considered among the different effects attributed to climate change. Nor is the family role of women, in ensuring provision of food, medicines, and household goods, taken into account. Women are increasingly hindered in these roles by the crisis of the system and of the environment. The consumerism of industrialized countries and the actions of companies and states that do not respect life are contributing to pollution and adversely affecting climate change. Our earth is alive and, as our mother, has the right to life and to conservation. The referendum on climate change is a global consultation involving all peoples. All countries should have the option to decide on issues related to climate change. Developed countries that have been polluting our mother earth for many years owe us an ancestral debt. Women are most affected by climate change because of their vulnerability and because of the additional workload it represents for them (CNMCIOB-BS, 2010).

Both conceptions see women as having a special bond with nature. For some thinkers, this alleged closeness is something intrinsic to feminine nature (being described as "essentialist" under other theoretical frameworks). For Vandana Shiva, women have a "natural affinity" with nature: "Woman is the source of life and the basis of sustainable development", says this author. The other view that strikes a common chord is the critique, articulated by the indigenous peasants, of the capitalist system, which is seen as a Western patriarchal system of domination, in which gender oppression is associated with environmental degradation, and which calls for a common opposition. Eco-feminism combines feminist and ecological concerns to the extent that both groups are working towards equitable and non-hierarchical structures (Manion, n.d.).

Others associate this closeness to nature with the roles that women play in the social system and with their heightened exposure and vulnerability to natural events. Without going into the details of this discussion, it seems important to emphasize two facts:

The first is an early awareness on the part of some women and women's groups regarding the seriousness of the environmental problem. In 1964, Rachel Carson wrote her famous book *Silent Spring*, in which she denounced the negative impact of pesticides on natural systems. The environmental debate was thrust into the public sphere in the 1960s, coinciding with the period of post-war economic growth. Various environmental movements became involved in the construction of global scenarios (Meadows *et al.*, 1972; Mesarovic and Pestel, 1974; Herrera *et al.*, 1976; Kaya and Siebker, 1973; Leontief *et al.*, 1976), all reflecting the need to explore the future and consider climatic phenomena in terms of mutual interactions on a planetary scale. One concern was the exhaustion of natural resources and the limited and finite nature of our living space. While global models developed in the North laid emphasis on the physical dimensions of global issues, the Bariloche, or Latin American, model stressed the added burden of socio-political problems (Cole, 1977).

In 1974, Françoise d'Eaubonne coined the term "eco-feminism". This idea spawned a rash of new theoretical approaches. Yet, while these contained some invaluable suggestions for the molding of future world views on attaining alternative development goals, their usefulness was compromised by a lack of operational measures.

Today, given the rate at which climate change-related environmental and human problems are intensifying, the need to apply operational models of these concepts and assumptions has become essential. The implementation of the world views put forward by eco-feminism eventually may contribute to a more comprehensive understanding of climate change, through highlighting the interrelatedness of physical and sociopolitical phenomena.

Until now, feminist movements and women in general have struggled to achieve integration within a universe defined by men. They have had to fight for the equal rights they deserve, as well as for a place and a voice in decision-making. It remains to be seen, however, whether women in leadership positions will act differently from their male counterparts.

Whether decades of women's protest and rebellion against exclusionary and discriminatory systems have produced viable alternative models for society and human relations built on an axis of equality remains a speculative question. The history of human thought, both scientific and philosophical, has yet to produce paradigms arising from the female mind. Instead, what we have is a civilization developed within paradigms of the male stamp.

The second fact worth emphasizing is the critical stance that women have adopted towards prevailing development patterns, technological options, and power relationships. Women are challenging the dominant capitalist paradigm and the values it embodies regarding socio-economic and power relations. Eco-feminism condemns the "Patriarchal Capitalist World System" (Mies and Shiva, 1993) and the growing alienation of humanity from nature. The criticism of feminists, environmentalists and other movements incorporates elements closely associated with climate change dynamics:

- A pernicious dualism in attitudes toward the environment, viewing human beings as intrinsically separate from nature, is supporting human predatory behavior. This dualistic view has long been denounced, by (among others) Barry Commoner, who more than 40 years ago stated: "Human beings participate in the environment system as subsidiary parts of the whole" (Commoner, 1971).
- A reductionist conception of reality is selectively highlighting some aspects while ignoring those that do not suit the interests of dominant groups. Examples are the arms race and war, both highly polluting activities involving intensive energy use. By ignoring the interdependence of all phenomena, dualism and reductionism are depriving policy planning of one of its paramount considerations.
- The hierarchical, authoritarian thinking dominating global geopolitics is defining the agenda for fighting climate change. Debate is occurring within the same discredited socio-economic order and system of gender relations that has perpetrated past abuses in natural resource use and management. As Wangari Maathai has remarked: "The missionaries were followed by traders and administrators who introduced new methods of exploiting our rich natural resources: logging, clear-cutting of native forests, establishing plantations of imported trees, hunting wildlife, and engaging in expansive commercial agriculture" (2007). The historical exploitation of natural resources lies at the root of so many events that today are contributing to climate change, such as biodi-

versity loss through expansion of monocultures; conversion of lands originally producing food crops into lands for export crops; pursuit of deforestation to satisfy the demand for timber; and over-exploitation of marine fisheries.

- Last, but not least, the capitalist paradigm is dehumanizing and selectively marginalizing groups and cultures along with their stores of knowledge.

Table 6. Summary of actions and events confronting environmental problems

Women's actions	International agenda
◗ **Rachel Carson: *Silent Spring*** (1962) Concern for global problems and their inter-relatedness ◗ **Wangari Maathai** (Green Belt Movement): ***Start Planting Trees*** (1970) Relevance of community action and involvement of women in confronting environmental problems	◗ **Meadows** *et al.* ***The Limits to Growth*** (1972) ◗ **Mesarovic & Pestel**: ***Mankind at the Turning Point*** (1974) ◗ **Herrera** *et al.* (Fundacion Bariloche): ***Catastrophe or New Society?*** (1976) Concern for global problems and their inter-relatedness; simulation models; system analysis
◗ **Françoise d'Eaubonne: *Ecofeminism*** (1974) Ecological/Feminist movements	◗ **UN Conference on Human Environment**: Stockholm (1972); creation of **UNEP** Concern about depletion of limited natural resources, pollution and economic growth
◗ ***Women and Life on the Earth – Amherst after the Three Mile Island Nuclear Plant Meltdown***: Peace, Anti-nuclear and Eco-feminist Network (1980) Devastation on the earth denounced; relationships between militarism, feminism, health, and ecology explored (King, 1983)	◗ ***Our Common Future*** (Brundtland Report): World Commission on Environment and Development (1987) Formulation of the concept of sustainable development, incorporating provision for environmental protection, economic growth, and social equity
◗ **World Women's Congress for a Healthy Planet** Miami (1991): Women's Action – Agenda 21 (WAA21) **WEDO (Women's Environment & Development Organization)** is formed (1992) to empower women in decision-making; to achieve economic, social, and gender justice and to create a healthy, peaceful planet with human rights for all. Through initiatives on climate change, corporate accountability, UN reform, and political participation and leadership for women, WEDO emphasizes gender equality and the critical role of women in the social, economic, and political spheres. Central to WEDO's mission is the recognition that women's empowerment and gender equality are key levers for change ◗ International Consultation: **To Advance Women in Ecosystem Management**. (Washington, DC, 1993)	◗ United Nations Conference on Environment and Development (UNCED): **Rio De Janeiro "Earth Summit"** (1992) – Agenda 21 Binding Agreements: Conventions on Biological Diversity, Climate Change, and Desertification ◗ **UN Commission on the Advancement of Women** (1997) Gender aspects are considered to be a cross-cutting issue in environmental conferences and agreements. The role of women in natural resource management is acknowledged (Lambrou and Laub, 2004)

Women's actions	International agenda
◗ **Climate Action Network (CAN)**: A global network of more than 550 NGOs is established to work on promoting government and individual actions to limit human-induced climate change to ecologically sustainable levels. The emphasis is on information exchange and coordinated development of NGO strategies on international, regional, and national climate issues	◗ The **UN Millennium Development Goals** (set in 2000, for attainment by 2015) provide concrete, numerical benchmarks for tackling extreme poverty in all its forms. The Goals provide a framework for the international community to rally together in pursuing a common end – that of making sure that human development reaches everyone, everywhere. Individual countries can develop their own action plans, in keeping with their MDG priorities. The idea is to provide governments with a systematic way of focusing on disparities and inequalities, while being able to respond to the needs of the most vulnerable Although all of the MDGs make references to gender issues, Goal 3 specifically promotes gender equality and the empowerment of women. Gender equality is seen as a sine qua non in the fight against hunger, poverty, and disease, and as an essential element in the achievement of other MDGs
There are proposals for the mainstreaming of gender issues in climate-change-oriented actions and for setting up female quotas in the different bodies and commissions dealing with climate change ◗ Areas in which gender might assist in promoting efficiency and equity are: responsibility for emissions, vulnerability to climate change, and participation in climate-change-related funded activities (Skutsch, 2002) ◗ **Global Gender and Climate Alliance (GGCA)**: A network of NGOs, intergovernmental organizations, and UN agencies aims to ensure that all decision-making in the formulation of policies and initiatives on climate change, at all levels, are gender-responsive	◗ The **Kyoto Protocol** (adopted in December 1997; entered into force in February 2005) takes the form of a binding international agreement linked to the **UN Framework Convention on Climate Change**. The agreement commits signatory countries to stabilizing greenhouse gas concentrations in the atmosphere at a level that will prevent dangerous anthropogenic interference with the climate system The UNFCCC encourages all industrialized countries to stabilize greenhouse gas (GHGS) emissions. The Protocol commits them to doing so by setting binding reduction targets for 37 industrialized countries, as well as the EU

Source: Elaborated by the author.

Gender considerations in the climate change debate

The literature under review here focuses primarily on two major aspects. The first is the greater vulnerability of women to climate change. This vulnerability is determined by the same factors that make women a majority group among the poor of the world: namely, a lack of productive resources, lower incomes, less education and training, and less access to information. Being an especially vulnerable group, women require targeted policies complete with provisions for risk-prevention and post-catastrophe support measures.

> As the Women's Environment & Development Organization puts it: "Climate change and environmental policies should be intrinsically related to

gender, as women are often the first to be affected by our changing environment." (WEDO). According to WEDO, the historical disadvantages experienced by women, given their relatively poor access to resources and information and their limited access to power and decision-making, have rendered them more vulnerable to the impacts of climate change.

The second aspect focuses on adaptation activities, with the accent on factors that might help to strengthen women's resilience in the face of disasters. In some policy formulations, this second predicament, though necessary, calls to mind those made as a response to the Structural Adjustment, and known as the "Efficiency Approach" (Moser, 1993). Efficiency policies ascribe to women an unlimited capacity to work and cope with adversity. To increase the resilience of women, we must rely, not on myths, but rather on comprehensive development packages that include, first and foremost, technical information on the phenomenon and its links with human activities, education and training that will lead to the adoption of appropriate strategies, new technologies, rehabilitation and enhancement of traditional technologies, financial resources, and additional support in times of crisis.

To see women as being responsible for actions of greater or lesser potential benefit does not preclude the need for their involvement as policy initiators and managers. Their participation in climate change discussions and agreements will not only bring new dimensions to such talks; it will also introduce the pressure mechanisms that are needed to impel actions.

It is well documented that in developing countries women play vital roles in the managing of energy resources within households, as well as in agriculture, the maintenance of biodiversity, and the management of forests. These sectors require high-priority policies geared toward enhancing capacities and disseminating best practices in anticipation of expected changes. Strategies might include cultivation of drought-resistant crops, recourse to less wasteful water supply and irrigation systems, and use of new crop varieties. In low-income countries, support networks for tackling the consequences of environmental disasters are scarce or non-existent. Adaptation calls for setting up effective financial, labor, and social networks, and for strengthening the existing informal networks that are common among poor women. New technologies, know-how, and scientific and technological support mechanisms will be needed if the collective capacity of women to carry out tasks of public benefit is to be enhanced. The entrepreneurial abilities of women across the developing world are well known, despite their scarce resources. These improvisational skills may prove decisive in cases where established trade links are disrupted, or where extreme situations call for novel responses.

In high- and middle-income countries, and in upper-middle-income groups in developing countries, energy-saving devices and improved energy efficiency have a crucial role to play at the household level. Choices with regard to personal transportation warrant particular attention. Improved transportation arrangements involving a wider use of public transport, and of more energy-efficient vehicles, to travel to and from the workplace can contribute substantially to reducing greenhouse gas emissions. Urban planning must reflect the need for a new paradigm of behavior that favors the proximity of schools and supply centers and encourages pedestrian and non-motorized transportation.

While technological changes are essential, there now exists an urgent need for individuals everywhere to question and, where necessary, to re-orientate some of the internationally held values and social "norms" that are guiding our behavior and informing our life choices and priorities. New voices–from women, minorities, traditional indigenous communities, young people, and civil society–should all be encouraged to become involved in helping to broaden the discussion. Universities, scientific institutions, global governance bodies, and commerce and industry should engage, both among themselves and with ordinary citizens, in expanded networks devoted to finding and publicizing practical responses, big and small, to counteracting the negative impacts of climate change on our lifestyles and behavior.

Conclusions

The considerations discussed above may provide some insights into the shape a radical new paradigm might have to take. Such a paradigm will, however, require new measuring criteria; for, as Stiglitz (2010) put it, "what you measure is what you value, and vice versa. In a performance-oriented society, we may strive to do well, but what we do is affected by what we measure". Indicators are needed to monitor fulfillment of the Kyoto Agreement, or to measure the social and economic costs of both climatic change itself and any of the ways and means adopted to counteract it, including its gender dimension. If we proceed from the oft-stated argument that climate change precludes the realization of sustainable development, then we can attempt to express the impediments in terms of indicators by giving estimates of the resources required to confront the problem with the most favorable and most efficient outcome.

Take, for example, the traditional indicator of economic growth. A process of economic growth conducive to sustainable development cannot be assessed only on the basis of the rate of increase in its GDP. To reflect sustainable development, some complementary or adjusting parameter is needed. For this, let us consider using mitigation efforts, as measured by rate of decline in CO_2 emissions. The resulting index would be: GDP + RGG (reduction of greenhouse gases), or GDP– IGG (in cases where CO_2 emissions increase). A country might register high rates of economic growth (measured by GDP) if it does not have to absorb the social costs of emitting more CO_2, or of maintaining a low rate of emissions. Countries on a more sustainable development path would be those that grow without sacrificing the environment.

The World Bank has stated that "until recently… the climate change debate was isolated from mainstream decision-making" (2010). For the World Bank, "mainstream decision-making" still refers primarily to financing, investment, technology, and institutional wherewithal. This approach could–and should–be expanded to include the explicit involvement, in all decision-making mechanisms, of the gender and social dimensions of climate change. Only then can we start developing the operative and quantitative tools that we need in order to define targets and set in place indicators that will effectively monitor the implications of climate change for the social advancement of communities in terms of food security, empowerment of women, and overall sustainable development.

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2. The Health Challenges to Climate Change

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Reducing our impact on the global climate requires individuals, communities and governments to make the behavior and policy changes–such as cleaner energy and more sustainable transport systems–that will also bring immediate health benefits.

Together, we must act to reduce the impact of climate change, for healthy populations and a healthy planet.

Margaret Chan, Director General,
WHO *Statement on World Environment Day,*
June 5, 2007.

Background

DESPITE THE IMPORTANCE of environmental conditions on health and sanitation issues, historically most environmental health problems have led to specific risks in a local context. In the past, the symptoms of human impact on the environment were industrial urban air pollution, chemical pollution of rivers, and manifestations of waste in rich and poor countries.

Hazards that originate in the environment are responsible for a quarter of the burden of disease in the world according to the World Health Organization (Prüss-Üstün and Corvalan, 2006). In addition, many risk factors associated with major disease, such as water unfit for consumption, pollution, poor sanitation, and malnutrition are related to the environment.

To these local risks, others have been added due to changes that some of the major biophysical and ecological systems are experimenting, which pose additional health problems on a large scale. We are eliminating or altering many geophysical and ecological systems, thus causing important changes in natural resources and services provided by nature to purify our air, maintain soil fertility, pollinate plants, decompose waste, provide fresh water, food, and burning fuels for transportation, etc. Various human activities have led to a wide variety of forms of global environmental change, affecting different groups of people at all latitudes, such as biodiversity loss, deforestation, desertification, ozone layer depletion, water scarcity, and climate change.

Climate change is considered one of the most serious threats to sustainable development, with adverse impacts on the environment, human health, food security, natural resources, and physical infrastructure. Some characteristics of modern society, such as social conditions and economic priorities, processes and technological choices, underlie the problem of climate change and exacerbate health inequities. All these elements are responsible for the vulnerability of populations which are facing climate change. For example, many Latin American countries have different conditions in common, such as tropical climate, poor water and food security, low socioeconomic status, and political instability, which make them more vulnerable to the effects of climate change, creating serious risks to the health and well-being of their people.

The effects of climate change in developed countries are different from those suffered by developing countries, where not all groups are affected in the same manner and intensity. Development is rarely fair and it is always the poorest members who are more vulnerable to the various projected effects. For example, the poorest communities are among the most vulnerable to the different impacts of climate change, as in the case of hydrometeorological disasters.

Health impacts

It is recognized that there is poor awareness of the impacts of climate change in the health sector as well as other sectors. There is a serious burden of major diseases in developing countries due to climate-sensitive diseases such as malaria, diarrhea, and malnutrition. In addition, there are difficulties in attributing the observed changes in disease patterns to climate change and there is an underestimation of the impacts of extreme events (IISD, 2007). In low-income countries, the loss of life is repeatedly shown to be disproportionately higher among children, women and the elderly, especially among the poor during extreme events.

The World Health Organization (WHO) and the Intergovernmental Panel on Climate Change (IPCC) have done analyses which indicate that climate change is responsible for many diseases affecting a large number of people, and premature deaths. Generally, there is an increase in the number of people who suffer from illnesses and injuries due to heat waves, floods, storms, landslides, fires, and droughts; the burden of diarrheal diseases and the frequency of cardio-respiratory diseases due to ozone concentrations also increase.

Furthermore, it changes the distribution of vector-borne diseases where rainfall is the limiting factor (e.g. malaria, dengue); temperature and humidity can affect some species of pollen that cause allergies; and it is very important to note the increased risk of death due to heat waves, particularly among the elderly. In addition, climate changes affect food and water-related diseases, inasmuch as it diminishes food production, and affect the quality and quantity of drinking water.

Some urban areas suffer from poor air quality due to weather patterns that disrupt the chemical balance of the atmosphere and its contaminants. In some places the topography can increase or decrease their concentration, which in turn impacts the health of the population. The effects on air quality are a topic of great interest and concern, as the increase in temperature can exacerbate ozone pollution. This contaminant has been associated with increased hospital admissions for lower respiratory tract infections and asthma in children.

A warmer climate may cause the transmission of diseases due to the consumption of unsafe water and contaminated food; it may also threaten agriculture in some of the least developed countries; and there is an increment of the dangers from exposure to extreme temperatures (e.g. heat waves) as well, which is responsible for high mortality rates in the most vulnerable groups. For example, each year about 1.2 million people die from causes related to urban air pollution; diarrheal diseases are responsible for 2.2 million, due in large part to the lack of access to potable water and sanitation, and to poor hygiene; 3.5 million die due to malnutrition; and natural disasters can cause approximately 60 000 deaths (WHO, 2009a).

Health effects of climate change in developing countries are very closely related to the vulnerability of a group and the social inequalities it suffers. Certain population groups are potentially more vulnerable than others. The variables involved are poverty, education, population density, economic development, food availability, income, local environmental conditions, health status, quality and availability of health services, and availability of early warning systems.

Climate change will progressively affect populations in vulnerable areas, with unpredictable effects on sudden migration or temporary displacement. Migration due to extreme events, such as droughts, floods, and hurricanes has been increasing in the last years. Migration (even temporary) and resettlement around the world are triggers for infectious diseases and noncommunicable diseases, including cardiovascular disease and diabetes. People who are displaced not only appear to be more vulnerable to these diseases, but their course is also worse than those who have not migrated; one reason being that they usually do not have the same access to health services than non-migrants, and often do not receive care that could help them. Psychosocial problems also arise because migration is always a stressful process (Carballo *et al.*, 2008).

Although there is not enough hard data about the impacts of climate change on children's health, floods, cyclones or hurricanes, droughts, heat stress, and an expansion in the range of various disease vectors are recognized as environmental stresses to children (Bartlett, 2008) (table 1). Children are also known to be particularly susceptible to injuries of various kinds. Burns and falls, along with drowning, disproportionately affect children under five (Bartlett, 2002). Children are curious and driven to explore, yet lack the capacity to understand and respond well to danger. Malnutrition, malaria, respiratory infections, and diarrhea are very common illnesses related to climate change, but more important is the huge potential that exists for death and injury in the face of extreme events (Bartlett, 2008).

It is expected that climate change will exacerbate current gender inequalities. The decline of natural resources and agricultural productivity could increase pressure on the health of women, and reduce the time to participate in decision-making processes, as well as activities that allow them to produce income. It has been determined that weather disasters have serious consequences for households headed by women, particularly where the heads of households have fewer opportunities to rebuild (Samaniego, 2009).

Impacts in some Latin American countries

It is likely that by 2020, health professionals in Latin America will encounter patients with a diverse range of diseases that are related to climate. Among these are: heat stress, other heat-related diseases (affecting the blood vessels and heart); physical trauma, food and water related diseases due to extreme events; emerging and re-emerging diseases, as well as changes in distribution; vector borne diseases; respiratory diseases, including problems such as allergies. In certain areas affected by disasters whose impact can be long term, people may experience more distress and mental illnesses such as depression and post-traumatic stress-related disorders.

This section presents information obtained from national reports from Latin American countries which presented information regarding health impacts to the United Nations Framework Convention on Climate Change. It also includes some information from other international agencies and academic papers.

Table 1. Some likely impacts of climate change and implications for children

Change	Impact on natural systems, agriculture, water	Impact on urban areas	Impact on health and household coping	Implications for children
Warm spells and heat waves Frequency up in most land areas	Reduced crop yields in warmer regions, wildfire risk up; wider range for disease vectors	Heat islands with higher temperatures (up to 10° higher); often large concentrations of vulnerable people; air pollution worsened	Increased risk of heat-related mortality and morbidity; more vector-borne disease; impacts for those doing strenuous labour; increased respiratory disease where air pollution worsens; food shortages	Greatest vulnerability to heat stress for young children; high vulnerability to respiratory diseases, vector-borne diseases, highest vulnerability to malnutrition with long term implications
Heavy precipitation events frequency up in most areas	Damage to crops, soil erosion, water-logging, water quality problems	Floods and landslide risks up; disruption to livelihoods and city economies, damage to homes, possessions, businesses and to transport and infrastructure; loss of income and assets; often large displacements of population, with risks to social networks and assets	Deaths, injuries, increased food and both water-washed diseases; more malaria from standing water; decreased mobility with implications for livelihoods; dislocations; food shortages; risks to mental health, especially associated with displacement	Higher risk of death and injury than adults; more vulnerable to water borne/water washed illness, and to malaria; risk of acute malnutrition; reduced options for play and social interaction; likelihood of being removed from school/ put into work as income is lost; higher risk of neglect, abuse and maltreatment associated with household stress and/or displacement, long-term risks for development and future prospects
Intense tropical cyclone activity increases	Damage to crops, soil erosion, water-logging, water quality problems			
Increased area affected by **drought**	Land degradation, lower crop yields, livestock deaths, wildfire risks and water stress up	Water shortages, distress migration into urban centres, hydro-electric constraints, lower rural demand for goods/ services, higher food prices	Increased food and water shortages, malnutrition and food and waterborne diseases up; risk of mental health problems from wildfires	Young children at highest health risk from inadequate water supplies; at highest risk of malnutrition, with long-term implications for overall development; risk of early entry into work, exploitation
Increased incidence of **extremely high sea level**	Salinization of water sources	Loss of property and enterprises; damage to tourism, damage to buildings from rising water table	Coastal flooding, increasing risk of death and injuries; loss of livelihoods; health problems from salinated water	Highest rates of death for children; highest health risks from salinization of water supplies, long-term developmental implications

Source: Bartlett, 2008: 2.

Argentina

The distribution of the rodent responsible for hantavirus pulmonary syndrome was affected by the rates of temperature and precipitation changes during the period from 1967 and 1998 in certain areas of the Argentine Patagonia. Based on a model, it is predicted that if climate trends in the 21st century continue at the same rates as observed during the last decades of the 20th century, significant changes in colilargo (vector) presence probability would be expected in certain areas 30 years from now, and more extensively in 60 years (Carbajo *et al.*, 2009). In Buenos Aires roughly 10% of deaths that occur during the summer may be associated with thermal stress caused by the "heat island" effect (De Garín and Bejarán, 2003).

Bolivia

Human health is already affected by climate change. Dengue, Chagas disease, malaria, and other vector-borne diseases, show a growing trend and can become a major threat to the population in the next five to ten years. From December 2007 to February 2008, the whole country was affected by flooding causing accented effects of climate variability, on the basis of climate change, causing serious problems due to the number of cases of dengue, hemorrhagic dengue, malaria, acute respiratory infections, diarrhea, skin diseases, musculoskeletal problems, and instances of leptospirosis cases (Government of Bolivia, 2009).

Aparicio and Ortiz (2000) have concluded that climate change may favor by 11.3% the development of new cases of malaria caused by *Plasmodium vivax*, and 43.6% of cases caused by *Plasmodium falciparum*, with an average of 30% for both (Government of Bolivia, 2009). The Vice-Ministry of the Environment, Natural Resources and Forestry (2000) has reported an intensification of leishmaniasis transmission.

Brazil

Brazil has a geographic location and continental size that can make it vulnerable to important climate changes and its consequent socio-environmental impacts. Some of these impacts are related to vector-borne diseases, extreme events, and air pollution.

Malaria and dengue are among the most significant infectious diseases in Brazil that are related to climate change. Their incidence can decrease or increase, depending on certain regional conditions. The biggest problem of these maladies is mainly linked to their incidence and difficulty to control, as well as the known sensitivity to climate factors. Global climate change can also have an effect on the increase in cases of schistosomiasis (Government of Brazil, 2010).

Extreme events, such as drought, can trigger human population migration processes, causing spatial redistribution of endemic population and increased vulnerability of communities. Prolonged droughts in semiarid north-eastern Brazil have provoked rural-urban migration of subsistence farmers, and a re-emergence of visceral leishmaniasis (Confalonieri, 2003).

States in the northeast region are the most vulnerable to climate impacts on health, which include water shortages capable of affecting the epidemiological scenario of diseases associated to poor hygiene, as well as worsen food security situations that cause malnutrition. In years of severe drought associated with the phenomenon known as El Niño, a significant increase in child mortality rates caused by diarrheic diseases was ascertained (Government of Brazil, 2010).

Some examples of extreme events are the smoke from burning fields which has caused several diseases due to the exposure to particles. Flash floods and mudslides can cause death and destruction (e.g. Rio de Janeiro, 2010); and there is a risk of leptospirosis epidemics in floodable areas poorly served by waste collection (Government of Brazil, 2010).

The increment in temperature can be responsible for mortality in children. In São Paulo, it was found that for every increase in degrees above 20°C, there was a 2.6% increase in overall mortality in children under 15 –very similar to the increase found in those over 65 years of age (2.5%). For younger children, this increase is likely to be higher (Gouveia *et al.*, 2003).

Particularly in tropical cities, deterioration in the air quality is predicted, causing more impacts on health related to air pollution, such as an increase in hospital admissions (particularly those with respiratory problems and heart disease), neonatal deaths, and neurological, ophthalmological, hematological and dermatological problems. This mainly occurs in periods of dry weather, especially in the winter, in cities in the southeast and south regions (Government of Brazil, 2010).

Based on a General Vulnerability Index developed by the Government of Brazil, there is a consensus that Mexico City and all southern states are among the least vulnerable. The worst situations were represented by the northeastern states; although there is less consensus with this conclusion (Government of Brazil, 2010).

Colombia

The significant increase in the incidence of classic dengue and hemorrhagic dengue focuses on the poorest municipalities, located below 1 800 meters of elevation, and located on the banks of major rivers, where there are preconditions of endemicity and who were affected by a decrease of water supply, during the El Niño event. Nonetheless, it can be expected that with warming, dengue and malaria can expand to higher areas of the country (Government of Colombia, 2010).

Malaria presents an annual cycle strongly related to hydroclimatic cycles. Incidence of dengue will depend on temperature and the effect on the vector cycle, mainly in the cities of the Andean region (750-1 500 m) (Government of Colombia, 2010).

Cárdenas *et al.* (2006) reported the impact of El Niño Southern Oscillation (ENSO) climatic fluctuations during 1985–2002, in the occurrence of cases of leishmaniasis in two northeastern provinces of Colombia. They found that during the El Niño event, cases of leishmaniasis increased, whereas during La Niña phases, leishmaniasis cases decreased.

The results suggested that an increased frequency of droughts, as expected under climate change scenarios for Colombia, is likely to increase the incidence of leishmaniasis in the region (Government of Colombia, 2010).

Costa Rica

During El Niño (ENSO warm phase) the incidence of dengue increases in the provinces of Pacific influence. In Limón, the fluctuation of the rate is inversely associated with the cold phase of ENSO, La Niña.

There are relationships with temperature and precipitation and the incidence of malaria, although it seems that there is not a consistent correlation with ENSO variables. Based on the latest results of future climate projections for Costa Rica, central parts of the Caribbean (areas of highest incidence of malaria at present), would experience an increase in precipitation and new highs in maximum and minimum temperatures. These conditions can affect the physiology of vectors and change the incidence and distribution of the disease.

Chaves and Pascual (2006) have linked temperature with cutaneous leishmaniasis and based on linear models they are able to succesfully predict the dynamics of the incidence up to 12 months in advance (Government of Costa Rica, 2009).

It has been reported that respiratory problems are present throughout the year, but between May and June are exacerbated by the arrival of the rainy season, changes in temperature expected due to seasonality, and a greater presence of allergens. Changes in temperature in extremely humid and hot environmental conditions are conducive to produce asthma (*idem.*).

It seems that temperature and seasonality are important factors in the monthly distribution of diarrheal cases in the province of San José. There is also evidence that wet years can cause outbreaks of diarrhea in some parts of the country. In fact, the national rate increases during years of La Niña events, compared with El Niño events. During La Niña there are more than twice the amount of cases of diarrhea than during an El Niño event. Changes in precipitation based on projections of climate change might cause impacts in the incidence of diarrhea in children and adults, and outbreaks in rural areas (*idem.*).

There is a correlation between rainfall and the prevalence of angiostrongilosis. During the dry season (January-May) 33% of cases occur, while 67% occur from June to December, although this information is preliminary (*idem.*).

Ecuador

Some projections regarding a rise of 2.5°C and 40 percent in daily precipitation have been made. These changes could cause between 58 000 and 130 000 new cases of malaria, and between 8 200 and 10 200 new cases of dengue at the end of the century, depending on the global climate scenario. It would also shift the epidemic to new altitudinal thresholds in rural and urban areas (ECLAC, 2010).

For the health sector, the costs of prevention, treatment, and loss of productivity due to malaria and dengue cases related to climate change could lead to a yearly increase in public and private spending of between US$14.9 million in scenario B2, and US$29.3 million in scenario A2 by the end of the century (*idem.*).

Ecuador has some areas that are vulnerable to landslides and floods, some 31 200 km^2 are highly vulnerable, and another 15 percent of the territory is moderately vulnerable (*idem.*).

Honduras

One of the impacts on children due to extreme events was well documented after Hurricane Mitch. Similarly, children in shelters and resettlement camps were found to be significantly more malnourished than exposed children who had not been resettled. It is possible, however, that this finding could be related, at least in part, to the very poor levels of sanitation that existed in many temporary shelters. Also at higher risk were children in households where adults were ill (Barrios *et al.*, 2000).

Mexico

Climate events related to health problems among the Mexican population are related to temperatures and extreme humidity conditions that are conducive to the outbreak of illnesses such as heat stroke, vector-borne diseases, and food and waterborne diseases.

Regarding the impacts due to heat stress, deaths from heat stroke have been reported, especially in states with extreme temperatures in the northern part of the country. For example, in the state of Sonora (northern), increases of 1°C lead to significant increases in mortality from heat stroke of about 1.2%, while in Baja California (northern) the average increase is almost 1.3% (INE-SEMARNAT, 2006).

There has been an increase of dengue cases more than 600% between 2001 and 2007 (Barclay, 2008). Thus, there is some research trying to associate the changes in temperature and rainfall to the increments. In some states, an increase in vector-borne diseases (dengue and malarial fevers) is associated with an increase in temperatures, with precipitation as a covariable. In the case of malaria, the effect of the increase in temperature of 1°C is related to increases of 1.15%

and 1.06% in the occurrence of cases in the states of Chiapas and Sinaloa, respectively (INE-SEMARNAT, 2006).

An increase in the ambient temperature of 1°C produces an average increase of 1.07% in morbidity from acute diarrheal illness in some states. There is a consistent, positive relationship between morbidity from acute diarrheal diseases and the maximum temperature (INE-SEMARNAT, 2009). There is also a correlation between the minimum temperature and sea surface temperature; and for every increase / decrease by 1°C there is an increase / decrease in five percent of diarrheal cases, and for every change of 10 mm in rainfall, cases vary by five percent (*idem.*).

Based on some studies, the government has concluded that human settlements will be more vulnerable because of their requirements for food, water, and fuel consumption in regulating the temperature of homes and industries, particularly in semiarid regions. Vulnerable groups may be affected directly, as in the case of heat stroke, and indirectly, through alterations in the life cycle of vectors and parasites, as in the case of dengue fever and diarrheal illnesses (INE-SEMARNAT, 2006).

Climate change could be responsible for an increment in 2030 to approximately five percent of annual cases of dengue and diarrheal infections (INE, 2009).

For the period 2008-2050, the estimated economic impact in the health sector would result in additional expenditure of approximately 45 billion Mexican pesos for the sector, under the A2 scenario (*idem.*).

Nicaragua

As malaria is a very important disease affecting the Nicaraguan society, the government made a study regarding climate change variables, such as temperature and precipitation. The study found the rate of malaria cases increases exponentially with increasing temperature. This indicates that a small increase in temperature has a significant effect on the increase malaria index. A decrease in precipitation may cause an increment or a decrease in the likelihood of malaria cases, depending on the initial level of precipitation and magnitude of the decline. Scenarios of temperature increment showed an increase of between 38 and 150% in the rate of malaria, depending on the scenario and the region (Government of Nicaragua, 2001).

Annual variations in dengue/dengue hemorrhagic fever in Nicaragua appear to be related to climate-driven fluctuations in the vector densities (temperature, humidity, solar radiation and rainfall) (Patz *et al.*, 2005).

Peru

A relationship between the incidence of acute respiratory infections and low temperatures has been reported. In the future, it is expected that lack of rainfall will increase the amount of days with clear skies, which would have an impact on higher levels of UV radiation over the basin; this situation would result in an increase in diseases related to the radiation exposure, both in the skin and eyes (Government of Peru, 2010).

Malaria has been linked to climate variables, such as temperature, relative humidity and precipitation. Ramal *et al.* (2009) have described the correlation between climate and malaria explored over 13 years. A significant negative correlation was found between temperature and cases of malaria for five years; river level for four years; and humidity for three years. No link was found with rainfall.

An autochthonous disease, Carrion's disease (*Bartonella bacilliformis*) has been linked also to climate variability (Huarcaya *et al.*, 2004).

The health of the Andean populations can be affected due to climate change, particularly by diseases related to quality and availability of water and food, vector-borne diseases, respiratory infections, and other illnesses associated with extreme climate events (Ganten *et al.*, 2010).

Suriname

The Suriname cutaneous leishmaniasis is a seasonal disease. Rainy seasons stretch from November to January and from May to July. Van der Meide *et al.* (2008) made a study and found that most patients with this disease were registered during the short dry season in March.

Venezuela

Cabaniel *et al.* (2005) have reported a link between climate variability of the incidence of cutaneous leishmaniasis in an endemic area of Venezuela, during three important El Niño phases. Based on higher Southern Oscillation Index (SOI) values, models showed a reduced incidence of cutaneous leishmaniasis; the increase with respect to the average trend in rain was associated with increases in trends for cutaneous leishmaniasis in the period from 1994 to 2003.

In November 1999, there was an outbreak of malaria in an Andean area of Venezuela with altitudes up to 2200 meters above sea level. This area historically had been classified as free of malaria cases, but during the course of that year there was an intense rainfall that could explain this occurrence of highland malaria (Benítez *et al.*, 2004).

There is a study in Caracas between 1998 and 2004 regarding the link between dengue hospital morbidity and climate variability. On one hand, the report found that the highest incidence had a climatic correlation with La Niña. On the

Table 2. Main health effects in Latin American countries due to climate variability

Countries	Malaria	Dengue	Diarrhea	Leptospirosis	Hantavirus	Leishmaniasis	Respiratory Diseases	Heat stroke
Argentina 2003, 2009					✓			✓
Bolivia 2007	✓	✓	✓	✓		✓	✓	
Brazil 2003, 2010, 2011	✓	✓	✓	✓		✓	✓	✓
Colombia 2006, 2010	✓	✓				✓		
Costa Rica 2006, 2009	✓	✓	✓			✓	✓	
Ecuador 2010	✓	✓						
Mexico 2007, 2008, 2009	✓	✓	✓					✓
Nicaragua 2005	✓	✓						
Peru 2009, 2010	✓		✓				✓	
Suriname 2008						✓		
Venezuela 2004, 2005	✓	✓				✓		

Source: Elaborated by the author.

other hand, there was a reduction in the number of cases compared with the mean values, when the phenomenon of El Niño occurred. A statistically significant link was found between dengue fever and rainfall abnormalities in Caracas, and with maximum temperatures recorded (Rifakis *et al.*, 2005).

Some evidence suggests that onchocerciasis (river blindness) (Botto *et al.*, 2005) and ascariasis are related to climate (Benítez *et al.*, 2005).

Table 2 shows a summary of the main health effects in Latin American countries due to climate variability.

Challenges

The complexity of the challenges of global change has led to a call for a comprehensive approach. The challenges for the entire population to have access to clean domestic energy, drinking water, sanitation, and education are compounded by the increased prevalence of diseases related to chronic poverty and the severity of natural disasters; and conditions are often concurrent.

It is essential that intersectoral collaboration and coordination among various ministries (including Education, Health, Environment, Social Needs, Agriculture and Finance) work to identify and solve particular needs, considering vulnerabilities of all human groups, especially children, women, and Amerindian populations. Intersectoral and multidisciplinary work is needed also as many policies that are implemented in other sectors (water, agriculture, social, and natural resource management) will have a direct or indirect impact on the health of the population.

Participatory approaches focused on gender activities, including water and energy management, environmental education, food security, and disaster risk reduction, will create economic opportunities, reduce vulnerability and empower marginalized populations to create a sustainable society.

To tackle climate change, key partnerships are essential. The vast complexity of climate change is too big for one institution to handle. Thus, a cooperative partnership between government, civil society, international organizations, donors, private sector, media, academic, and individual levels (even taking into account age and gender) is necessary to reduce and mitigate risk at all levels. It is essential to be clear about vulnerable populations and national security because they would be the biggest victims of climate change impacts. At the same time, they are powerful actors of change that help to contribute significantly to the collective effort to mitigate climate change and its effects.

Research

It is necessary to adopt a new methodological approach to research. Research should focus on how climate changee is affecting the patterns of illness and death related to extreme events (floods, droughts, heat waves, forest fires); vector-borne diseases (e.g. malaria, dengue, hantavirus, schistosomiasis, leishmaniasis, Chagas disease), waterborne and foodborne infectious diseases (gastroenteritis), and respiratory diseases in urban areas (e.g. asthma, allergies).

There is a need to reinforce an effective epidemiological surveillance to detect emerging and re-emerging diseases at local and national levels, and enhance operational effectiveness and early warning. It is also necessary to develop scenarios focused on health for various Latin American regions.

Beneficiaries and decision-makers need to be included from the beginning of the process if the results are expected to be useful to any of them. Moreover, taking into account the complexity of the phenomenon of climate change, an interdisciplinary approach is considered a necessity for all research initiatives.

It is important to do research to understand the dynamics of migration in cultural, social, economic, environmental, and mental and physical health. As extreme events are more frequent with climate change producing migration as a consequence, research should assess the impact of internal and external migration to and from large urban centers amongst vulnerable populations; as well as the possibility of disease spread and new demands of health services, as they face emerging and re-emerging diseases linked to migration.

Research should be directed to design effective processes for building resilience and survival strategies for vulnerable groups, particularly those who are most at risk, such as women and children (mainly poor and indigenous).

It is also important to evaluate some environmental and social consequences of extreme events, such as forest fires and prolonged droughts. For example, droughts increase vulnerability to fire haze, dust and respiratory diseases, and malnutrition due to food scarcity and high costs; not to mention the burden of disease associated with the poor quality or lack of water, and possible changes in risky behavior (e.g. smoking, alcohol consumption, self-medication).

There is little information on how the increase in temperature can interact with air pollution and impact the health of the population. Making an assessment of how the number of cases of asthma can be affected when secondary ozone levels increase with higher temperature, is particularly important in cities such as Mexico City, São Paulo, and Santiago, Chile. Research is needed to find out how climate change may affect exposures to pollutants, particularly airborne allergens and particulates from the slash and burn which comes from forest fires in rural areas of Latin America. It is suggested to promote research focus on how built environment interventions both affect the health of vulnerable populations and reduce climate change.

We also need to promote research focused on ways to improve early warning systems to protect the health and well-being of the exposed population. In order to reach this goal, various stages of prevention should be considered: primary (e.g. build flood levees); secondary (early identification of damage); and tertiary impacts involving the face of the situation (preparation of health services to treat diseases that can be exacerbated by the extreme event).

Scientists should work towards a greater understanding of gender issues, as they play an important role in health issues. In the case of women, many of them living below the poverty line, their complex roles and social identity (in terms of reproductive, productive, social, psychological, and cultural variables) are very influential in the way that they can be affected by the different manifestations of climate change. Some examples of research are shown in table 3.

Table 3. Research topics on Global Environmental Change and Human Health

Research Domain	Examples
Understanding the health effects of global environmental change	Identification of key health indicators to monitor Empirical studies of current health effects, taking advantage of circumstances (extreme weather events) and localities (environmental hotspots) where these effects already manifest themselves Scenario analyses of future health effects, combining theoretical insights, empirical data, and quantitative and qualitative modeling exercises Integrated assessment analyses of current and future health effects, comparing different environmental changes to facilitate priority setting
Adaptation to reduce the health effects of global environmental change	Development of more-effective methods for the health management of heat waves, floods, and other extreme weather events Development of more-effective methods to control emerging infectious diseases, such as vector control, vaccination, and pharmacological treatment Development of diets that are nutritious, palatable, and affordable and do not require unsustainable food production and transportation methods Economic analyses of various adaptation strategies, including health costs and benefits
Understanding the contribution of the health sector to global environmental change	Assessment of the environmental effect (“footprinting”) of health sector resource use and waste generation Development of health sector practices that are sustainable in terms of resource use and waste generation

Communication research	Assessment of public and policymaker knowledge, attitudes, and behaviors with respect to climate change and identifying audience segments Testing of various communication strategies regarding climate change

Source: Frumkin *et al.*, 2008: 441.

WHO (2008) has proposed five priorities of research topics:

1) identify effective measures to enhance public health systems to address all environmental health risks;
2) assess the impact of policy decisions made by non-health sectors;
3) compare the effectiveness of short-term interventions (e.g. heat waves);
4) characterize the indirect effects of climate change (e.g. the risk of conflict); and
5) assess how the effects of climate change interact with other determinants (e.g. urbanization).

We can identify five applied research topics on the linkages between climate, policies addressing climate change, and health outcomes (WHO, 2009a):

1) health vulnerability to climate change and scale and nature thereof;
2) health protection strategies and measures relating to climate change and their effectiveness, including cost-effectiveness;
3) the health impacts of potential adaptation and mitigation measures in other sectors, such as water resources, land use and transport, in particular where these could have positive benefits for health protection;
4) decision support and other tools, such as surveillance and monitoring, for assessing vulnerability and health impacts, and targeting measures appropriately; and
5) assessment of the likely financial costs and other resources necessary for health protection from climate change.

A new methodological approach to research needs to be adopted. This methodological approach should have health, environmental, social, and physical indicators, that will allow for a comprehensive review and be clear about how climate change impacts modify these indicators.

Finally, in order to face all these challenges it is important to strengthen research capacity, particularly in developing countries where both the health impacts and opportunities for health improvements are likely to be greatest, facing limitations in research, and human, economic, and technological resources. Capacity building activities should include opportunities for all stages of career development, technical, and university graduate and postgraduate levels (WHO, 2009a).

Beneficiaries and decision-makers need to be included right from the outset of the process if results are expected to be useful to any of them. Also, considering the complexity of the climate change phenomenon, an interdisciplinary approach is considered a must in all research initiatives.

Adaptation measures

Adaptive measures should be established to identify and scientifically evaluate, where possible, measures, technologies, and most appropriate and effective policies better suited to climate change issues of information technology, health services, infrastructure, equity, and financial resources. Such studies should be carried out in different places (different exposure profiles, adaptive capacity, vulnerability), using the same protocol.

In order to identify and implement policies to protect human health from climate variability and climate change impacts, health vulnerability and climate adaptation assessment should be implemented to face future risks. Local circumstances, socioeconomic conditions, and regulatory frameworks should be taken into account to define context, structure, and content of the assessment. Social, academic, and official sectors must have the proper knowledge regarding health impacts due to climate change, as well as be aware of the vulnerability of regions and specific groups. Policy-makers, stakeholders, and the public should understand the health risks and adaptation and mitigation measures to address the impacts of climate change (Berry *et al.*, 2011).

Public health professionals have an opportunity to correct the commonly held misperception that climate change is solely an environmental problem. In order to demonstrate that climate change is not exclusively an environmental problem, it is equally important to communicate: the ways in which public health professionals are engaged in local needs regarding health vulnerability and climate adaptation assessment, adaptation and mitigation actions to confront human health impacts due to climate vulnerability, and the need for climate change prevention and preparedness. These messages will likely enhance public engagement and readiness to enact policies that will help communities adapt to climate change (Maibach, 2011).

An important issue is to be aware of the inadequacies of health systems at regional and national levels, as they should be able to protect vulnerable groups facing different health risks. One of the main challenges is to develop different adaptation strategies in order to cover primary, secondary, and tertiary prevention (McMichael *et al.*, 2009). Figure 1 shows different pathways of the impact climate change can have on health, and potential primary health care adaptive strategies.

The experience of the General Vulnerability Index, developed by Brazilian researchers, should be considered in order to allow establishing adaptation strategies and resources necessary to reduce vulnerability.

Adaptation measures in the health sector should take into account vulnerable groups, such as women, children, and the elderly, considering their possible impacts. These measures should focus on diminishing their vulnerability and reducing morbidity and mortality. For example, figure 2 shows different adaptation actions, including the level of vulnerability, the most vulnerable populations, effectiveness ratings, and evidence ratings. Table 4 shows some essential services of public health, with climate change examples that governments, at regional and local levels, should consider to confront the impacts on climate change.

Establishing climate change and human health observatories based on reliable information systems, including coordination of a regional network, should be considered. Surveillance to identify outbreaks of climate-related disease in its early stages, as emerging and re-emerging diseases daily, must be enhanced. Some examples of primary health care adaptation measures are shown in table 5.

There is some evidence that suggests that the costs of treating additional cases of diseases resulting from climate change may be important and much higher than the current budgets in most developing countries. A big effort to estimate adaptation costs, including simulation and sensitivity analysis to describe how the multiple sources of uncertainty affect estimates of the costs and benefits, needs to be made (WHO, 2009a).

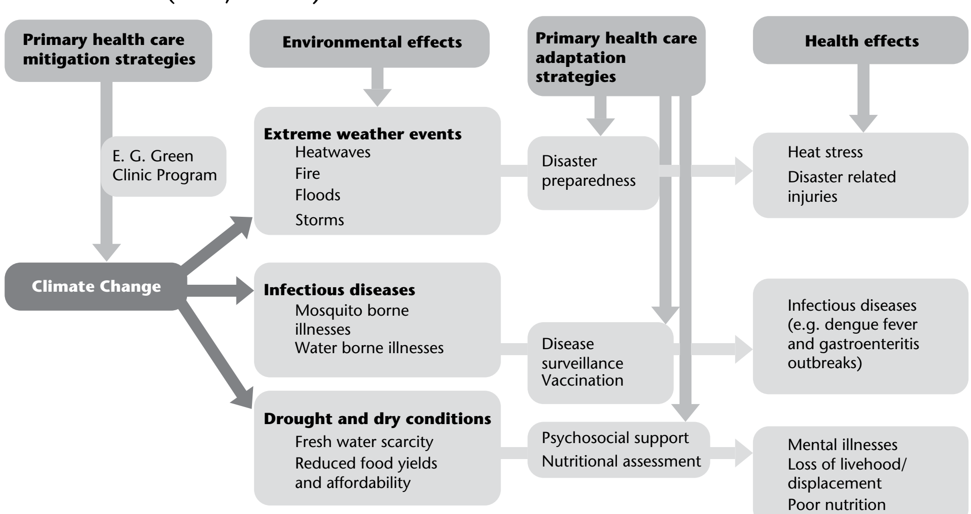

Figure 1. Pathways by which climate change can impact on health, and potential primary health care adaptive strategies

Source: Blashki *et al.*, 2007: 987.

	ACTION SET	VULNERABILITIES	MOST VULNERABLE POPULATIONS	EFFECTIVENESS RATING	EVIDENCE RATING
1	CHILD SURVIVAL PROGRAMME WITH NUTRITION COMPONENT	Malnutrition		Very High	Medium
2	SCHOOL HEALTH AND NUTRITION PROGRAMMES	Malnutrition		Very High	High
3	BREASTFEEDING PROMOTION	Diarrhea Malnutrition		High	High
4	ORAL REHYDRATATION THERAPY AND ZINC SUPPLEMENTATION	Diarrhea		Very High	High
5	IMMUNIZATION PROGRAMMES (ROTAVIRUS, HIB, HEPATITIS B, PNEUMOCOCCAL)	Diarrhea Acute respiratory infections		High	High
6	IMPROVED WATER SUPPLY INFRASTRUCTURE	Diarrhea		Very High	Medium
7	BASIC SANITATION FACILITIES	Diarrhea Waterborne diseases		Very High	High
8	INSECTICIDE-TREATED BED NETS	Malaria Dengue, other vector borne diseases		Very High	High
9	INDOOR RESIDUAL SPRAYING	Malaria		Very High	High
10	EXCESSIVE HEAT EVENT NOTIFICATION AND RESPONSE PROGRAMMES	Cardiovascuar and respiratory diseases		High	High

Infants Children Adolescents Adults Elderly Population in poor halth Medium High Very High

Figure 2. Adaptation actions, vulnerabilities, most vulnerable populations, effectiveness rating and evidence rating

Source: DARA/The Climate Vulnerable Forum, 2010: 114.

Table 4. The 10 Essential services of public health, with climate change examples

Service	Climate Change Example
Monitor health status to identify and solve community health problems	Tracking of diseases and trends related to climate change
Diagnose and investigate health problems and health hazards in the community	Investigation of infectious water-, food-, and vector-borne disease outbreaks
Inform, educate, and empower people about health issues	Informing the public and policy makers about health impacts of climate change
Mobilize community partnerships and action to identify and solve health efforts	Public health partnerships with industry, other professional groups, faith community, and others, to craft and implement solutions
Develop policies and plans that support individual and community health efforts	Municipal heat-wave preparedness plans
Enforce laws and regulations that protect health and ensure safety	(Little role for public health)
Link people to needed personal health services and ensure the provision of health care when otherwise unavailable	Health care service provision following disasters
Ensure competent public and personal health care workforce	Training of health care providers on health aspects of climate change
Evaluate effectiveness, accessibility, and quality of personal and population-based health services	Program assessment of preparedness efforts such as heat-wave plans
Research for new insights and innovative solutions to health problems	Research on health effects of climate change, including innovative techniques such as modeling, and research on optimal adaptation strategies

Source: Frumkin *et al.*, 2008: 438.

Table 5. Primary health care adaptation strategies

- Public education and awareness
- Early alert systems: impending weather extremes, infectious disease outbreaks
- Disaster preparedness, including increasing the health system's "surge" capacity to respond to emergencies
- Enhanced infectious disease control programs
  - food safety, vaccine programs, vector control, case detection and treatment

- Improved surveillance
  - risk indicators (e.g. mosquito numbers, aeroallergen concentration)
  - health outcomes (e.g. infectious diseases outbreaks, rural suicides, seasonal asthma peaks)

- Appropriate health workforce training, including mid-career development (e.g. updated understanding of climatic influences on health, training in public health)

Source: Blashki *et al.*, 2007: 988.

Mitigation measures

Reliable evidence suggests that many climate mitigation strategies can yield both immediate and more sustained global public health benefits – in rich and poor societies, temperate or tropical, urban and rural. Friel *et al.* (2008) have pointed out that the mitigation of climate change is a prerequisite in order to prevent the health inequity gap from widening. This is particularly important in Latin American countries, where inequity in society is a very important issue.

The health sector is responsible for significant GHGs emissions, particularly in developed countries, but increasing in importance in developing countries. For this reason, this sector must commit to establish mitigation measures, in order to join the efforts in health, economic, and social co-benefits (Maryon-Davis, 2011). In response to this interest, WHO (2009b) has outlined seven elements of a 'climate-friendly hospital' (or other health facility) in order to diminish its own significant climate footprint:

- *Energy efficiency*: Reduce hospital energy consumption and costs through efficiency and conservation measures.
- *Green building design*: Build hospitals that are responsive to local climate conditions and optimized for reduced energy and resource demands.
- *Alternative energy generation*: Produce and/or consume clean, renewable energy onsite to ensure reliable and resilient operation.
- *Transportation*: Use alternative fuels for hospital vehicle fleets; encourage walking and cycling to the facility; promote staff, patient and community use of public transport; site healthcare buildings to minimize the need for staff and patient transportation.
- *Food*: Provide sustainably grown local food for staff and patients.
- *Waste*: Reduce, re-use, recycle, compost; employ alternatives to waste incineration.
- *Water*: Conserve water; avoid bottled water when safer alternatives exist.

Human health can be affected due to transportation (the largest end-use consumer of energy), water usage, electricity, agriculture, forestry and land use, among other activities. So, working across sectors promoting changes in policies and behaviors can help reduce GHGs emissions on one hand, and on the other, improve public health. For example, transportation infrastructure affects physical activity. Trails offer multiple co-benefits, providing alternative transportation routes, promoting physical activity and preserving green space. Walking, bicycling, and using mass transit would increase physical activity which reduces risks of mortality, colon cancer, diabetes mellitus, stroke, cardiovascular disease, and depression, and enhances psychological well-being (Younger *et al.*, 2008).

Because the built environment affects health, public health professionals should be included in land use and transportation decision-making processes. A multidisciplinary approach can help maximize the positive health impacts of infrastructure changes and reduce their negative effects (*idem.*).

Developing risk perception studies for different social groups is part of gathering knowledge of the people we are dealing with (civil society, students, NGOs, policy makers, academics, media). Response to adaptation and mitigation actions will depend on this perception. This information will be the basis for a hazard communication program which clearly defines the groups towards which this communication should be transmitted (e.g. students, media, industrial decision-makers, NGOs, opinion leaders, etc.). These programs should be evaluated at various stages.

At the international and domestic policy-making levels, the public health benefits of mitigation measures should be more prominent (Ganten *et al.*, 2010). For example, the health co-benefits resulting from such measures can help address existing global health priorities, such as ischaemic heart disease in adults, child mortality from acute respiratory infections, and other noncommunicable diseases.

Decision-making support

Decision making mainly focuses on adaptation and mitigation measures, so that better qualification of the effects of GHGs mitigation policies on health will contribute to evidence-based policy making, assessing the magnitude of potential near-term health benefits (or harmful effects) associated to a specific measure (Haines *et al.*, 2009).

There is an important gap regarding information at different levels and sectors that should support analyses, assessments, and policies. For example, multi-threat vulnerability maps, especially focused on water availability, are not available in the region. There is a need to develop models for integrated management of vulnerable areas, in order to include health, food security, water resources, energy, and economics. This would be an important tool for the decision-making process. Improved risk assessment is needed to inform decision makers about a broad range of health impacts due to climate change at the regional, national, and international levels (WHO, 2009a).

Since health can be affected by alterations in many environmental components, it is suggested as a cross-cutting theme in all other sectors, such as water, agriculture and livestock, forestry, transportation, sanitation, safety, civil protection, etc. This will not only reinforce the analysis of health impacts and vulnerability, but it will also be seen as a key element in adaptation measures in other sectors in which it is proposed. Thus, health ministries should become more involved and active in decisions on climate change. The recommendation should be that the health, transport, agriculture, energy, industry, and scientific sectors should collaborate to study and implement climate change mitigation and adaptation measures that benefit health (Ganten *et al.*, 2010).

Research should focus on the assessment of costs (economic and social) of the health effects of climate change in order to provide inputs for decision making.

There is a wave of interest in "green" economic development among UN and multi-lateral aid agencies, national governments, and industry (Neira, 2010). As a response to this interest, WHO has published a series of *Health in the green economy* (2011a) with the aim to propose important health co-benefits for sector and health policy makers. The series is looking at climate change mitigation and "green growth" strategies in five economic sectors: transport, housing, health care facilities, household energy in developing countries, and agriculture. The stakeholders are the health sector, the household energy sector (WHO, 2001b), and the transport sector (WHO, 2011c).

It is important to develop specific climate change scenarios to consider: 1) the future age distribution, 2) the future prevalence of heart and respiratory diseases, and 3) any future changes in extrinsic determinants of vulnerability.

Many times one of the most important barriers to decision making is not just the lack of information, but poor knowledge management. There is a failure to ensure that relevant research is presented to different stakeholders in the fashion in which it is needed so that it can be easily understood and incorporated into their decision making processes. The way stakeholders perceive the health risks posed by climate change and the kind of information they need to be able to take actions should be clear.

When we consider climate change and global health equity, there are some overlapping policy areas to be highlighted: economic development, urbanization, and food systems (Friel *et al.*, 2008). In this sense, governments should work taking into account these policy areas in order to consider the way they interact as a whole system, promote cross-sectoral policies, and support the strategies and programs at regional and national levels.

Conclusions

Many developing countries with populations at the greatest risk from climate change are still facing existing public health challenges from treatable conditions such as malnutrition, diarrhea, acute respiratory infections, malaria, dengue, and other infectious diseases. Diverting limited personnel and resources away from these ongoing problems to address future threats from climate change could make things worse.

Health professionals have an urgent responsibility to ensure that the health benefits of environmental policies are understood by the public and by policy-makers. Intersectoral work should be reinforced in order to promote a better understanding of the health impacts and the implementation of successful policies.

Global interdependence and interconnectedness enable the environmental and social determinants of health to be addressed in different ways in order to reduce poverty, increase health equity, and finally build societies that behave responsibly with natural resources and live implementing environmentally sound practices. Latin America should focus on these goals.

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3. Climate Change, Vulnerability, and its Effects on Health: The Situation in Mexico

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CLIMATE CHANGE is the major threat for the 21st century and one which will have very diverse effects on a global scale, both for developed countries as well as for developing countries. In fact, these effects have already become reality.

Climate change shows a variation in climatic conditions linked to human activity and brought about by greenhouse gas emissions, of which the most significant are carbon dioxide, methane, nitrous oxide, perfluoromethane, perfluoroethane, hydrofluorocarbons, and sulfur hexafluoride. All of these alter the composition of the earth's atmosphere and induce warming, adding on to climate's natural variability (IPCC, 2007).

Some of the threats associated with climate change that could potentially have effects on human health and well-being, including mental health, are the following: increasing temperatures, heat waves, intense precipitation, disasters associated with hydro-meteorological phenomena, changes in the reproduction and distribution patterns of microorganisms and vectors, among many others (Kovats *et al.*, 2003).

Nevertheless, it is also recognized that climate change, although it is a generalized, global threat, will have differentiated repercussions in the short and medium term in different regions of the world and among different population groups. Women, the elderly, children, and people with chronic or debilitating illnesses are the groups considered to be most vulnerable to this threat.

In different scenarios potentially resulting from climate change, a group that is vulnerable within a certain context may not be considered vulnerable within another context—and these differences must be taken into account in each case that is examined. The relative weight of each of the diverse factors that create the vulnerability must be determined. That is, there are vulnerability conditions and characteristics which may be viewed as an opportunity to change and improve in some countries, and yet in other countries, the same conditions will exclude, restrict, or impede development. Being a woman, a senior citizen, or a child does not necessarily equate to vulnerability in all cultures and realities.

Worldwide, studies have been conducted that have found evidence of the impact that climate change has on human health and have envisioned scenarios that are anything but optimistic regarding its effects, based on factors recognized as bearing upon the degree of vulnerability and damage. Yet in Mexico, there is a lack of sufficient, systemized, and pertinent information that would allow for adequate decision-making on emerging topics such as climate change and its relation to and impact on people's health and well-being, in order to avert risks and avoid damage in both the present and the future.

This document discusses the threats or dangers that can ensue from climate change, as well as some of its effects on human health. It focuses on those circumstances and characteristics that give rise to greater conditions of vulnerability and, therefore, greater damage.

In addition, analyzing the threat that climate change poses to health and understanding the conditions of vulnerability allows for planning out strategic actions to face the dangers stemming from climate change, thereby anticipating or avoiding damage. Likewise, action is taken at a more favorable time and with greater effectiveness against the conditions that increase the risk of loss of health and well-being, as well as developing adaptation measures that are better suited to Mexico's reality and that of each of its states.

In order to better understand the analysis of health risks as well as proposing plans and strategies, it is worth reiterating the following points.

In the classic approach to environmental health, risk factors are found at the organismal level of individuals and human communities, in the hazardous environmental agents of a biological, chemical, and physical nature, and in the physical environment where such agents are found, that is, in water, air, soil, food, etc.

In the climate factor scenario, this paradigm is modified, making the situation even more complex due to the introduction of two new components. A whole new dimension is added to the context of physical environmental factors. This dimension is related to the danger of a very diverse series of climate conditions which present threats and hazards beyond the analysis and disciplines associated with the three types of hazardous agents mentioned above and which require including new disciplines in the public health approach, such as meteorology, disaster forecasting and prevention, geology, the location of human settlements, and urban planning. A second group of factors in this new scenario are social and economic factors which are determinants of health. While this is nothing new, in public health there has been a historical tendency not to give sufficient consideration to the weight and significance of these latter factors in adverse effects on health resulting from exposure to hazardous environmental agents and conditions, whether in the form of bacteria, toxic substances, floods, hurricanes, etc.

As stated above, a population's vulnerability to dangers related to climate change is heavily determined by the community's social and economic risk factors, which in turn depend largely on the political context.

Climate change as a threat to a population's health

All threats, regardless of their causes, have the potential to cause damage, whether immediately or in the long term. It is known that the damage produced is magnified by the exposed group's conditions of vulnerability. The starting point is the assumption that there are biological and social characteristics and conditions that increase vulnerability to climate change.

To better understand this context, a "threat" or "hazard" is defined as "a potentially damaging physical event, phenomenon, or human activity that may cause the loss of life or injury, property damage, social and economic disruption, or environmental degradation. Hazards can include latent conditions that may or may not become future threats and can have different origins: natural (geological, hydro-meteorological, and biological) or induced by human processes (environmental degradation and technological hazards)" (ONU/EIRD, 2004). It is important to mention that threats induced by human processes can be classified into public health threats (epidemics, pollution), chemical-technological threats (explosions, fires, leakage or seepage, spills) and social-organizational threats (interruptions or breakdowns in the operation of vital services and systems, wars, violence, social conflict).

Likewise, vulnerability is defined as the condition, susceptibility, or predisposition of a community, group, or person to suffer damage or injury when submitted or exposed to a threat or hazard or any adverse change in the environment (ONU/EIRD, 2005). Such damage may be biological, psychological, or economic in nature, although it is not limited to these categories.

Social vulnerability is a consequence of different factors, all of a varying nature. It is related to a community's geographic, climatic, demographic, economic, cultural, political, structural, psychological, and organizational characteristics and conditions, infrastructure and services the community has access to and may use, along with the measures it takes to prevent, reduce, and avoid damage from threats or hazards present in its environment. The biological risk factors of an individual's organism also contribute significantly and synergistically to generating social vulnerability depending on the degree to which they are immersed in more or less adverse conditions associated with the aforementioned social factors.

A threatening or hazardous event generally has a greater impact on the most vulnerable individuals, as they are the ones with the least capacity and strategies to face such events. Therefore, they are the ones who suffer the most damage, in terms of both frequency and severity. Climate change is considered a threat to health and well-being, and therefore, strategies are required to increase response capacity and implement adaptation measures against this threat, considering the magnitude of the impact it will have on different population groups—particularly those who are most vulnerable. It has been acknowledged that climate change has had and will have differentiated effects according to the world's different regions and their inhabitants' generation, age group, income level, occupation, and gender (IPCC, 2007).

The Intergovernmental Panel on Climate Change, based on historic temperature records, has pointed out that eleven of the hottest years ever have occurred during the last twelve years (beginning in the mid-1990s). This marks a tendency towards accelerated warming and a 0.2°C increase in temperature per decade if greenhouse gas emissions continue to be produced at the same rate or higher than the current levels. According to the projections of this group of experts under different scenarios, a one-degree increase in temperature will result in greater morbidity and mortality from heat waves, an increase in cardiac, respiratory, and infectious diseases, diarrhea, floods and droughts, changes in the dynamics and distribution of certain disease vectors, and an increasing demand for health services. The repercussions, as indicated by the group's projections, will depend on the temperature's rate of change, the social and economic conditions of the exposed groups, and the population's adaptive capacity (*idem.*). Based on this information, two important aspects can be identified from a risk and damage perspective: the exposure to climate change hazards and the population's ability to respond to such threats. The challenge lies in reducing the vulnerability of the exposed groups and increasing their resilience and adaptive capacity.

Temperature increase and heat waves

Temperature increase is recognized as an indicator of climate change. In some regions of the world, it will bring about a higher incidence of heat waves, hotter summers, and milder winters.[1] And, although this last factor is considered positive for some countries, the general outlook is that the effects on natural habitats, socio-economic systems, and health and well-being will be more negative than positive.

1 Particularly in countries with warm climates, as in countries with colder climates, these have shown a tendency to be even more critical, as is the case in Europe and the United States of America, which have registered record snowfalls like the ones recorded in 2010.

A heat wave is defined as an adverse meteorological phenomenon associated with a significant and stressful increase in temperature within a geographic area that causes temporary adjustments in the population's way of life and creates hazardous conditions for the health of certain groups within that population. A heat wave occurs when, for three or more consecutive days, the maximum recorded temperatures are equal to or above the 95th percentile. These conditions may last for several days if the heat wave is very powerful (OMM, 2009; Aparicio, 2005; Ballester, 1996). Some authors point out that a heat wave is determined when temperatures reach or exceed 32 degrees centigrade (DGOI, 2009; Ballester, 1996); nevertheless, the threshold in this study shall be established at maximum daily temperatures that reach above the 95th percentile for each region, country, or location being analyzed, as other studies specify temperatures at which heat waves are declared that range from 30.3 to 36.5°C; and at such temperatures, already significant effects on mortality are reported (Díaz-Jiménez, 2005).

Heat waves are produced by an intense heating of the air and are associated with a sudden and abrupt atmospheric phenomenon caused by the expansion of polar and arctic or tropical air masses which extend over a large expanse and provoke alterations in the normal rhythm of temperatures. Considering the current scenario and its tendency toward population growth, higher consumption of fossil fuels, an increase in the use of energy, greater production of farm foods, and higher deforestation rates, it is anticipated that higher emissions of greenhouse gases, increasing temperature, and heat waves will bring about serious threats to human health, with greater consequences for vulnerable groups.

Increasing temperatures and heat waves have caused disasters[2] worldwide. A study of the disasters and deaths throughout the world caused by heat waves from 1900 to 2009 reported on cases recorded as early as 1936 and found a significant rise in the number of events and deaths as of the 1990s, and a tragic situation during the year 2003 with 18 such events resulting in 73 722 deaths. In order of importance, the most critical years were 2003, 2006 (3 737 deaths in 10 events), 1998 (2 723 deaths in 2 events), 1936 (1 693 deaths in 2 events), 1980 (1 310 deaths in 2 events), and 1995 (1 228 deaths in 3 events) (figure 1).

Deaths due to heat waves from 1936 to 2009 totaled 93 641, showing a great difference in their effects among the continents. The greatest number of deaths occurred in Europe with 76 631 deaths, followed, in rank order, by Asia with 10 643 cases, America with 5 898, Oceania with 347, and Africa with 122. Asia ranks first with respect to the number of disasters due to heat waves, with 40 events, followed by America with 28, Europe with 27, Africa with 4, and Oceania with 1.

2 According to the criteria established in the UN Program for the Environment, an event is considered a disaster when it causes 20 or more deaths.

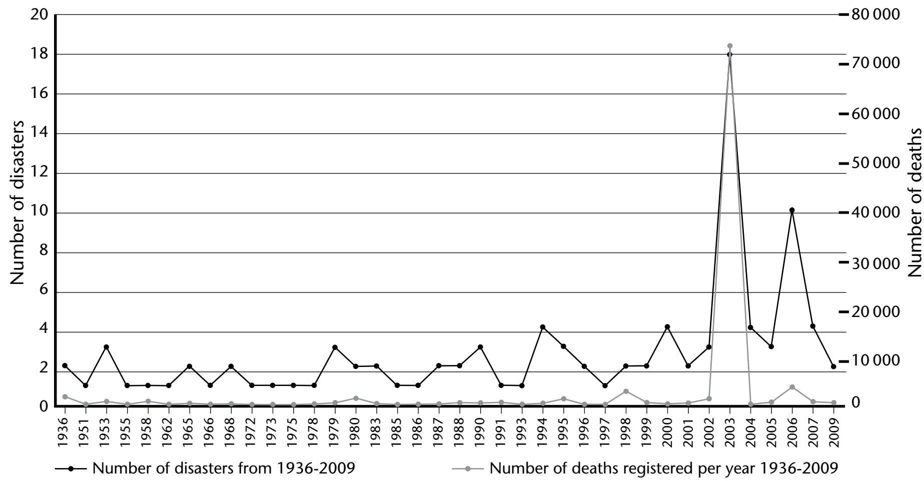

Figure 1. Disasters and number of deaths due to heat waves in different regions of the world, from 1936 to 2009

Source: EM-DAT: The OFDA/CRED International Disaster Database. Consulted on: http://www.emdat.be. Brussels: Université Catholique de Louvain.

The worst heat wave disaster occurred in Europe during the summer of 2003, leaving a total of 72 210 dead. The countries that suffered the greatest loss of life were Italy (20 089), France (19 490), Spain (15 090), and Germany (9 355). On the American continent, the United States stands out with 18 events (4469 deaths), followed by Mexico with 3 events (479 deaths), Brazil with 2 (169 deaths), Canada and Argentina with one event each and 500 and 100 deaths, respectively (EM-DAT, 2011).

The deaths that occurred from 2000 to 2009 amount to 86.5% of the total number of deaths recorded due to this cause. During this period, we can observe a marked difference in the number of events and deaths in comparison to earlier decades (table 1).

Table 1. Disasters and number of deaths worldwide due to heat waves from 1900 to 2009, by decade

Decade	Number of disasters	Number of deaths
2000-2009	50	81 032
1990-1999	19	5 796
1980-1989	10	2 296
1970-1979	7	565
1960-1969	6	1 015
1950-1959	6	1 471
1940-1949	0	0
1930-1939	2	1 693
Total	**100**	**93 641**

Source: Elaborated by the author.

Mexico's Third National Communication within the United Nations Framework Convention on Climate Change states that, from 1979 to 2003, 8 heat waves were recorded in Mexico, causing 35 deaths. The worst-hit states were Baja California and Sonora with 88% of all deaths; risk of death due to heat waves is expected to rise in such states. Likewise, 1998 has been identified as one of the hottest years in the last decades, with a higher increase in deaths due to heat stroke; it has been established that the population's most vulnerable groups consist of persons over 65 years old and those suffering from prior illnesses (INE-SEMARNAT, 2006).

Air pollution

Around the world, one of the greatest problems in cities that is linked to climate change is the increase in air pollution, mainly due to organic compounds produced during the combustion of hydrocarbons and biomass, classic pollutants such as particulate matter, sulfur dioxide, nitrogen dioxide, ozone, nitrous oxides, and inorganic pollutants such as mercury, nickel, lead, chrome, cadmium, asbestos, manganese, and several others, which in many cases exceed the safety limits for humans established by the World Health Organization.

The damage that air pollutants cause in the human body is determined by a) the dangers associated with the substance, as determined by its physical-chemical nature, concentration, frequency, and length of exposure (Gutiérrez *et al.*, 1997), and b) among other factors, the biological characteristics, health conditions, age, and nutritional state of the individual exposed to pollutants.

Pollutants generated by the incomplete combustion of fossil fuels (coal, petroleum, gas) have become a critical problem due to their role in maximizing the greenhouse effect, acid rain, and air, soil, and water pollution. Their contaminating effects are associated to their combustion and the highly toxic byproducts they generate, particularly organic compounds.

Fires, as well as the still-prevalent practice of cooking with wood in homes in many countries, worsen air pollution problems, presenting a threat to the population by exposing people to high concentrations of organic compounds–such as methane, benzene, toluene, xylene, styrene, benzo-alpha-pyrene, acetonitrile, and methyl chloride—as well as gases and inorganic compounds, all of which are linked to an increase in mortality from acute and chronic respiratory illnesses and cardiovascular disease (Gutiérrez *et al.*, 1997; OMS, 2003; Michelozzi *et al.*, 2007; IPCC, 2007; Feria-Velasco and De Celis-Carrillo, 2007; Ayres *et al.*, 2009).

Some studies indicate that there is a synergistic effect between air pollution and increasing temperatures, identifying ozone, particulate matter, and sulfur anhydride as being responsible for the increase in health risks, in that these variables are linked to an escalation in respiratory and cardiovascular disease (Ballester, 1996; Katsouyanni *et al.*, 1993).

Factors and conditions that increase a population's vulnerability to climate change

In this document, as stated above, a population's vulnerability is defined as a state, condition, susceptibility, or predisposition that confers upon such individuals a greater possibility of suffering damage from a threat when they are exposed to it. This vulnerability "is related to characteristics inherent to the exposed element and the individual's response capacity when faced with the threat" (Cardona and Sarmiento, 1989). To a large degree, vulnerability develops over time and is determined by biological, demographic, geographic, cultural, social, economic, educational, political, institutional, and psychological factors (Wilches-Chaux, 1993), which play a decisive role in a person's or a community's daily life, health, and its possibilities for development. Vulnerability is recognized to be a condition linked to a threat which puts an individual or a community at a disadvantage when faced with adverse, distorting, or dangerous situations and changes to which it cannot adapt. Additionally, the vulnerability may be modified if the causes which give rise to it are acted upon (Maskrey, 1998).

Some factors which have been identified as contributing to a population's greater vulnerability and which have been shown to have negative repercussions on health are age, gender, poverty, schooling, little or no access to basic services, quality of housing, genetic load, physical and hormonal nature, nutritional state, the existence of chronic illnesses, dependence upon and access to resources, and social networks (Garibay-Chavez, 2008; D'Ippolit *et al.*, 2007; Michelozzi *et al.*, 2007; UICN, 2007; Ishigami *et al.*, 2007; INE-SEMARNAT, 2006; Díaz-Jiménez *et al.*, 2005; Bifani, 2003; Ballester, 1996; Cardona and Sarmiento, 1989; Rose, 1985).

Biological characteristics, health/illness conditions, social circumstances such as performing certain roles, stress, poverty and social inequality, access to water, electricity, and health services, dependence on natural resources threatened by climate change, being marginalized from technological innovations, limited participation in decision making, and inability to respond and adapt to climate change all confer a greater predisposition to experiencing the effects of a threat or hazard in a differentiated manner upon the population's groups and sectors (Garibay-Chavez, 2008). In this context, it is considered that, when faced with a specific climatic phenomenon such as an increase in temperature and heat waves, some population groups will exhibit greater vulnerability.

It is important to specifically point out some of the most marked social conditions that are considered to be vulnerable and often highly vulnerable, such as women, small children, the elderly, marginalized groups, the poor, indigenous groups, migrants and displaced people, individuals who live alone, the disabled, the undernourished, and persons with chronic diseases—particularly respiratory, cardiovascular, or debilitating diseases. These conditions also include people who live in regions with high climate variability and extreme temperatures.

The following are some of the factors that differentiate and determine a population's vulnerability to climate change.

An individual's biological characteristics

Genetic load, anatomical features, hormonal differences, body temperature, bodily factors such as humidity, pH level, surface area, water and fat content, as well as enzymatic processes and protein linkage (Rose, 1985), and the person's general health condition have significant implications and produce different vulnerability conditions for each individual when faced with environmental hazards, and particularly, climate change. These variations among individuals or groups can produce significant differences in the impact that the exposure to high temperatures may have upon their health, when gender and age substrata are considered.

Geographic location

The geographical variety within Mexico determines that the country is affected by middle latitude meteorological systems in the winter or tropical systems in the summer. Climate variations are brought about to a considerable extent by the occurrence of the El Niño phenomenon, and the diversity in climate regions found throughout the country produces certain particularities that influence temperature, humidity, and rain and wind patterns (INE-SEMARNAT, 2009).

Living in certain municipalities and states in the country determines the condition of greater or lesser exposure to high temperatures. Likewise, there are different degrees of exposure for people who reside in urban areas and people who live in rural areas. This also implies that they are under the influence of certain environmental factors that interact with temperature, such as some air pollutants, thus increasing the risk of contracting specific diseases.

Geographic location also influences a population's vulnerability if it is isolated, confined, or suffers from marginalization and poverty.

Socio-demographic characteristics

Social differences among individuals and communities which determine different degrees of vulnerability are the result of the cultural context, demographic characteristics, roles performed as a group, access, control, and equity. Some socio-demographic variables associated to a population's vulnerability are:

- Age. Senior citizens, women of childbearing age or who are pregnant, children under five years old, and persons with chronic diseases are considered to be vulnerable groups, whether due to their biological characteristics, elements of dependence, or because they demand specific attention.
- Gender. Some studies have shown that women have a greater mortality rate from heat waves (Aguilar, 2009), although there are diverging opinions on the subject. While research conducted in Europe reports a marked bias towards feminine mortality among senior citizens when faced with heat waves (Michelozzi *et al.,* 2007; D'Ippolit *et al.,* 2007), in the United States, in contrast, mortality is found to be higher among men (Kilbourne, 1992).
- Schooling. A low educational level limits a person's possibility for development and is a marginalizing factor in many areas of social, cultural, economic, scientific-technological, and political life. It is acknowledged that the lower the individual's schooling level, the higher the acceptance of risk and the lower the possibilities of changing his or her condition of vulnerability.
- Financial income and poverty. It has been established that low income populations who live on one dollar or less per day show greater disadvantages and marginalization—and thus vulnerability—have more difficulty securing certain basic necessities, have less access to health and education services, are more susceptible to suffering damage and have a lower capacity to recover after an illness. Financial dependence results in higher vulnerability. Differences regarding the availability of financial resources influence people's ability to respond to global changes, particularly with respect to access to information, basic food supplies, markets, medical services, infrastructure, and technologies which have lower costs and greater efficiency, especially considering that the latter are essential for adaptation (Leary and Kulkarni, 2007; OIT, 2005; Denton, 2002; ONU, 2000).
- Inequity and social inequality. The discriminatory and non-equitable treatment by society of some population groups creates a situation of vulnerability for such groups. There have been different levels of progress in the achievement of political and social rights for the population, particularly with respect to basic human rights related to health, nourishment, and housing, among others. The imbalance in power relationships between men and women with respect to access to resources, control, and the benefits obtained from resources, as well as equal pay, produces inequality and uncertainty, which will have greater effects on those who show higher levels of dependence on such resources (ONU, 2010; UICN, 2007; ONU, 1995).
- Participation and representation in decision-making processes. A very small percentage of the population is involved in decision-making or is taken into account strategically when decisions are made. The population's involvement

in establishing policies is still very limited. In the context of climate change scenarios, it is considered that the different groups within a population should actively participate in decision-making and their problems and concerns must be heard, as this is essential to creating adaptation strategies consistent with the diverse realities of such groups and sectors, particularly those which have been identified as the most vulnerable (ONU, 1992).

- Low perception of the risks posed by climate change and high levels of acceptance thereof. The assumption is that a low perception of risk or high levels of acceptance of a threat by a part of the population results in greater vulnerability (Urbina, 2006). The fact that climate change has not yet been clearly identified as a threat and that the population perceives itself as not vulnerable to such change, and furthermore, that it views climate change as a distant matter that does not affect it at present, makes a person or a community more vulnerable. When a population considers that the effects of climate change will become evident only in the long term, or it does not visualize such changes as something that affects it in a direct manner, it is recommended that measures be taken to bring about a higher perception of the threats such changes entail, of the risk level they imply, and to decrease the degree of acceptance.

Health conditions

There are differences with respect to the type of diseases and deaths by gender, age group, geographic sector, social class, type of work activity, and the frequency and impact that such diseases have on their daily life. Health conditions predispose individuals to suffer greater damage due to certain threats and environmental changes. This has been widely demonstrated by research conducted over the years in the field of environmental health, both in Mexico and abroad. According to some authors, having a chronic disease (cardiovascular, respiratory, metabolic) increases the probability of suffering damage due to an increase in temperature or climate variability in comparison to individuals who are in optimal health conditions (Díaz-Jiménez *et al.*, 2005; Ballester, 1996).

Responsiveness with respect to adapting to climate change (determined by the needs and demand for care and resources available)

The consequences attributed to the increase in temperature and the population's limited ability to respond in terms of adaptation are creating greater inequalities; thus, it is important to take these differences into account in the adaptation strategies followed in each country, region, or sector.

Social and support networks are decisive to a particular group's responsiveness and resilience, and play a significant role in daily life, in the opportunities

Figure 2. Mexican states and their location

Source: INEGI, 2011a. *Entidades federativas de México y su localización.*

for and possibilities of development, quality of life, and health conditions. The premise is that the higher the number of support networks, the less vulnerable the group will be when faced with threatening situations (Garibay-Chavez, 2008; Garibay-Chavez *et al.,* 2002).

This interaction of the varied factors and conditions mentioned above determine an individual's conditions of vulnerability to climate change hazards and the magnitude of their consequences. Knowing a population's current level of vulnerability allows for prevention and opens a pathway for taking steps to develop adaptation measures that impede or reduce damage and increase resilience.

Temperature systems and health conditions of the population of selected municipalities: an assessment of Mexico

Mexico has 32 states (figure 2) and 2 454 municipalities (INEGI, 2008) and a population of 112.3 million people according to the 2010 census. Of these, 77% of the population lives in cities, and 62% of this figure resides in urban areas with

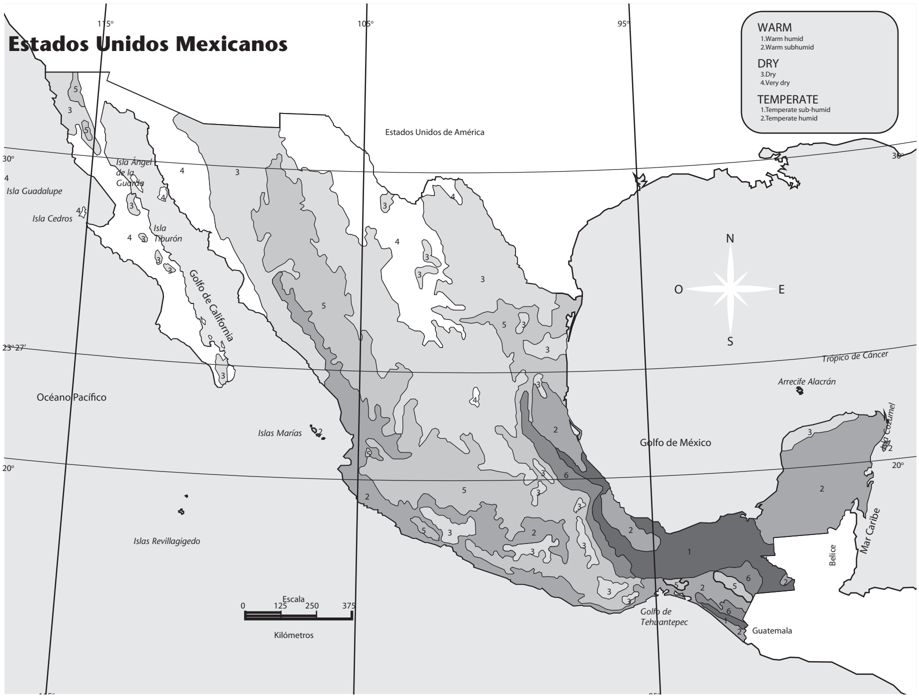

Figure 3. Types of climate in Mexico

Source: INEGI, 2011b. *Mapa de principales tipos de climas.*

more than 100 000 inhabitants (INEGI, 2010a; 2010b). With respect to Mexico's economic conditions, the latest figures released by the UN Development Program indicate that 17.6% of the population lives in extreme poverty, and in 2007, 4.8% had a daily income of two dollars (PNUD, 2009).

Mexico is a nation characterized by great climate diversity, which is the result of its geographic location and complex topography. This complexity determines its precipitation and temperature systems at the regional level (Davydova, 2010). Its varied climate regions range from areas with arid climates, covering 51% of its surface, to warm climate zones totaling 25.9% of its territory, mild climates in 23%, and cold climates with temperatures below 10ºC in less than 1% of its territory (INE-SEMARNAT, 2009). The annual mean temperature varies between 10 and 26ºC throughout most of the country (93%). It can be said that Mexico is a tropical country, with frequent temperatures above 18ºC as the annual mean, which vary according to altitude (figure 3).

Climate in Mexico is influenced by middle-latitude meteorological systems in winter and tropical systems in summer. It is determined by factors such as altitude, latitude, atmospheric conditions, rain, humidity, and land use. An analysis of temperatures throughout its territory from 1970 to 2008, presented during the Fourth National Communication before the United Nations Framework Convention on Climatic Change (INE-SEMARNAT, 2009), found that: a) the historical average mean temperature during this period was 20.9°C, increasing as of the 1990s, and in the last 10 years, showing an accelerated increase in temperature of 0.7°C; b) the annual mean for the maximum temperature was 28.4°C, which likewise, increased as of 1990; the years showing the greatest increases were 1995, 1998, and 2007; and c) the annual mean for the minimum temperature was 13.2°C which also registers—as of the 1990s—a tendency towards temperatures above the registered mean.

Considering the projections for Mexico in 2050 stated in the above-mentioned Fourth Convention (*idem.*), under a scenario catalogued as B2, which assumes that there will be greater local development at a social and environmental level, population growth, and moderate economic development, it is expected that there will be a reduction in precipitation, higher evapotranspiration, scarcity of available water, climate changes, and specifically, an increase in the annual mean temperature of up to 2°C. The highest temperatures are expected in northwestern Mexico and the Gulf of Baja California and these variations will entail serious repercussions on health (Gutiérrez and Espinoza, 2010).

The dynamics observed in annual mean temperatures with regard to oscillations between warming and cooling can be explained in part by the El Niño and La Niña phenomena (Magaña *et al.*, 1999); but this variability may also have been determined at the local level by human activities, changes in land use, concentration of activities, loss of vegetation cover, and recorded fires.

In Mexico, only recently has there been an interest in analyzing the impact that the increase in temperature, heat waves, and climate variability will have on the population's health and well-being. Research is needed to establish how the different climate change scenarios will affect the population's health. It is also important to understand the implications that global and local changes will have, particularly on groups with greater vulnerability due to their living conditions and characteristics.

This document analyzes 64 municipalities in Mexico, two for each state: that with the *highest average maximum temperatures* and that with the *lowest average maximum temperatures*, for the month of May during the period extending from 1950 to 2000 (May is the month in which the average maximum temperatures are recorded in most states in the country). In this study, ischemic heart disease mortality was used as the basic element for analyzing health, as it is a type of disease that different authors associate with high temperatures. The analysis focused on the potential relationship between temperatures and ischemic heart disease mortality in the municipalities included in the study, taking Mexico's different climate and altitude zones into account.

Average maximum temperatures during 1950-2000 in the study's municipalities by state

With respect to the predominant climate type in the study's municipalities, in rank order, 31.7% have hot climates with average maximum temperatures ranging from 29 to 38ºC, 22.2% have arid and semiarid climates with average maximum temperatures ranging from 20 to 37.5ºC, 17.5% have temperate climates with average maximum temperatures ranging from 22 to 32ºC, 12.6% have semi-tropical climates with average maximum temperatures ranging from 20 to 36ºC; 7.9% have very arid climates with average maximum temperatures ranging from 16 to 37ºC, 7.9% have cold climates with average maximum temperatures ranging from 19 to 26.5ºC. No information was available for one municipality. The average maximum temperatures in the municipalities included in the study show that 45% (29 out of 64) had average maximum temperatures above 32ºC, 50% between 20 and 30ºC (32 out of 64), and three municipalities (4%) had temperatures below 20ºC (table 2).

Table 2. Municipalities in Mexico, climate and average maximum temperatures, 1950-2000

State	**Highest average maximum t°**			**Lowest average maximum t°**		
	Municipality with the highest average maximum t° (°C)	Types of climate Percentage distribution (%)	Highest ave max t° (°C)	Municipality with the lowest average maximum t° (°C)	Types of climate Percentage distribution (%)	Lowest ave max t° (°C)
Aguascalientes	Calvillo	Temperate semiarid (35.4), semiarid semitropical (33.4) and temperate subhumid with summer rains, less humidity (29.5) and temperate subhumid with summer rains, medium humidity (1.7)	35	San José de Gracia	Temperate semiarid (47.2), temperate subhumid with summer rains, less humidity (32.8), temperate subhumid with summer rains, medium humidity (20)	28
Baja California	Mexicali	Very arid, tropical and warm climates (51.6), very arid semitropical (34.7), very arid temperate (9.2), semi-cold subhumid with winter rains (3.6), dry Mediterranean temperate (0.8) and temperate subhumid with winter rains (0.1)	37	Playas de Rosarito	Dry Mediterranean temperate (100)	22.5
Baja California Sur	Los Cabos	Very arid, tropical and warm climates (49.6), arid semitropical (23.3), arid very hot and tropical (9.4), temperate subhumid with summer rains, higher humidity (6.4), semiarid semitropical (5.7), temperate subhumid with summer rains, medium humidity (4.8) and very arid semitropical (0.9)	26	La Paz	Very arid semihot (43.4), very arid very hot and tropical (43.1), dry semihot (10.4), semiarid semitropical (1.4), temperate subhumid with summer rains, less humidity (1.3) and temperate subhumid with summer rains, medium humidity (0.1)	16
Campeche	Calkini	Hot subhumid with summer rains, less humidity (98.4) and semiarid, very hot and tropical (1.6)	36	Calakmul	Tropical subhumid with summer rains, medium humidity (64.5), tropical subhumid with summer rains, less humidity (25.1) and tropical subhumid with summer rains, higher humidity (10.4)	34.5

State	Highest average maximum t°			Lowest average maximum t°		
	Municipality with the highest average maximum t° (°C)	Types of climate Percentage distribution (%)	Highest ave max t° (°C)	Municipality with the lowest average maximum t° (°C)	Types of climate Percentage distribution (%)	Lowest ave max t° (°C)
Chihuahua	Batopilas	Temperate subhumid with summer rains, medium humidity (26.8), semiarid very hot and tropical (24.8), semiarid semitropical (15.9), temperate subhumid with summer rains, less humidity (12.9), semihot subhumid with summer rains, less humidity (12.1), temperate subhumid with summer rains, higher humidity (5.4) and semihot subhumid with summer rains, medium humidity (2.1)	32.5	Bacoyna	Semi-cold subhumid with summer rains, higher humidity (82.5), temperate subhumid with summer rains, medium humidity (9.3), semi-cold subhumid with summer rains, medium humidity (6.7), temperate subhumid with summer rains, less humidity (1) and semitropical subhumid with summer rains, less humidity (0.5)	24.5
Chiapas	Catazaja	Tropical humid with year-round rain (57.4) and tropical humid with plentiful rain in summer (42.6)	36	Chamula	Temperate subhumid with summer rains (66.7), temperate humid with plentiful rain in summer (29.9), semitropical subhumid with summer rains (2.4) and semitropical humid with plentiful rain in summer (1)	22
Coahuila de Zaragoza	Torreón	Very arid semitropical (89) and arid temperate (11)	36.5	Ramos Arizpe	Very arid semitropical (50), arid semitropical (30.8), semiarid temperate (13), dry temperate (6) and temperate subhumid with scarce rainfall throughout the year (0.2)	26.5
Colima	Villa de Álvarez	Tropical subhumid with summer rains, less humidity (48.6), tropical subhumid with summer rains, medium humidity (29.9), semitropical subhumid with summer rains, medium humidity (6.9), tropical subhumid with summer rains, higher humidity (5.5), semitropical subhumid with summer rains, higher humidity (5.1) and semitropical subhumid with summer rains, medium humidity (3.9)	32	Minatitlán	Semitropical subhumid with summer rains, higher humidity (32.1), tropical subhumid with summer rains, higher humidity (24.4), tropical subhumid with summer rains, medium humidity (21.2), temperate subhumid with summer rains, higher humidity (9.6), tropical subhumid with summer rains, less humidity (6.6) and semitropical subhumid with summer rains, medium humidity (6.1)	30

State	Highest average maximum t°			Lowest average maximum t°		
	Municipality with the highest average maximum t° (ºC)	Types of climate Percentage distribution (%)	Highest ave max t° (°C)	Municipality with the lowest average maximum t° (ºC)	Types of climate Percentage distribution (%)	Lowest ave max t° (°C)
Mexico City	Venustiano Carranza	Dry semiarid with summer rains (91) and temperate subhumid with summer rains, less humidity (9)	28	Cuajimalpa de Morelos	Temperate subhumid with summer rains, greater humidity (49), semi-cold subhumid with summer rains, higher humidity (45) and semi-cold humid with plentiful rains in summer (6)	22
Durango	Rodeo	Dry semitropical with summer rains (67.4), semiarid temperate with summer rains (19.8), arid temperate with summer rains (10.8) and semiarid semitropical with summer rains (2)	35.5	Guanaceví	Semi-cold subhumid with summer rains, higher humidity (50.1), temperate subhumid with summer rains, less humidity (22.6), temperate subhumid with summer rains, medium humidity (12.6), semiarid temperate (9.9), temperate subhumid with summer rains, higher humidity (3.9), semi-cold subhumid with summer rains, medium humidity (0.7) and semitropical subhumid with summer rains, medium humidity (0.1)	26.5
Guanajuato	Xichu	Semiarid semitropical (60.8), semitropical subhumid with summer rains, less humidity (16.9), temperate subhumid with summer rains, less humidity (11.1), semiarid very hot and tropical (8), semiarid temperate (2.1) and temperate subhumid and summer rainfall with medium humidity (1.1)	31	Jerécuaro	Temperate subhumid with summer rains, medium humidity (80.7), temperate subhumid with summer rains, less humidity (10.7), semitropical subhumid with summer rains, less humidity (8.4) and semi-cold subhumid with summer rains, higher humidity (0.2)	27
Guerrero	Tlalchapa	Tropical subhumid with summer rains, less humidity (100)	37.5	Cutzamala de Pinzón	Tropical subhumid with summer rains, less humidity (97.5), semitropical subhumid with summer rains, less humidity (2.4)	36
Hidalgo	San Felipe Orizatlán	Semitropical humid with plentiful rain in summer (71) and semitropical humid with year-round rain (29)	35	Mineral del Monte	Semi-cold subhumid with summer rains, higher humidity (58), temperate subhumid with summer rains, higher humidity (36) and temperate subhumid with summer rains, less humidity (6)	21.5

State	Highest average maximum t°			Lowest average maximum t°		
	Municipality with the highest average maximum t° (°C)	Types of climate Percentage distribution (%)	Highest ave max t° (°C)	Municipality with the lowest average maximum t° (°C)	Types of climate Percentage distribution (%)	Lowest ave max t° (°C)
Jalisco	Jilotlán de los Dolores	Tropical subhumid with summer rains, less humidity (53.2), semiarid very hot and tropical (34.6), tropical subhumid with summer rains, medium humidity (8.6), semitropical subhumid with summer rains, medium humidity (2.6), semitropical subhumid with summer rains, higher humidity (0.6), temperate subhumid with summer rains, higher humidity (0.3) and arid very hot and tropical (0.02)	31.5	Manzanilla de la Paz	Temperate subhumid with summer rains, medium humidity (92.4) and temperate subhumid with summer rains, higher humidity (7.6)	25
Estado de México	Luvianos	Tropical subhumid with summer rains, less humidity (48.1), semitropical subhumid with summer rains, higher humidity (22.1), semitropical subhumid with medium-humidity summer rains, (15.2), tropical subhumid with summer rains, medium humidity (10.5), and tropical subhumid with summer rains, medium humidity (4.2)	35	Toluca	Temperate subhumid with summer rains, higher humidity (73.8), semi-cold subhumid with summer rains, higher humidity (23.2) and high-altitude cold with sharp winters (3)	19.5
Michoacán de Ocampo	Huétamo	Semiarid very hot and tropical (59.3), tropical subhumid with summer rains, less humidity (23.1) and arid, very hot (17.6)	36.5	Tancítaro	Semitropical subhumid with summer rains, medium humidity (39.1), temperate subhumid with summer rains, higher humidity (16.5), semitropical subhumid with summer rains, less humidity (12.5), tropical subhumid with summer rainfall, less humidity (12.4), temperate humid with plentiful rain in summer (9.7), semi-cold humid with plentiful rainfall in summer (7.2), semitropical subhumid with summer rain, higher humidity(2.4) and semiarid very hot and tropical (0.1)	20

State	Highest average maximum t°			Lowest average maximum t°		
	Municipality with the highest average maximum t° (°C)	Types of climate Percentage distribution (%)	Highest ave max t° (°C)	Municipality with the lowest average maximum t° (°C)	Types of climate Percentage distribution (%)	Lowest ave max t° (°C)
Morelos	Jojutla	Tropical subhumid with summer rains, less humidity (100)	37.5	Tetela del Volcán	Temperate subhumid with summer rains, higher humidity (73.4), semi-cold subhumid with summer rain, medium humidity (6.5) and high-altitude cold with sharp winters (0.7)	23
Nayarit	La Yesca	Semitropical subhumid with summer rains, less humidity (35.4), semitropical subhumid with summer rains, medium humidity (17), temperate subhumid with summer rains, medium humidity (13.6), tropical subhumid with summer rains, less humidity (10.6), semiarid very hot and tropical (9.9), temperate subhumid with summer rains, higher humidity (7.6) and tropical subhumid with summer rains, medium humidity (5.9)	34	El Nayar	Tropical subhumid with summer rains, and less humidity (28.1), semitropical subhumid with summer rains, less humidity (21.1), tropical subhumid with summer rains, medium humidity (13.8), semitropical subhumid with summer rains, medium humidity (10.5), temperate subhumid with summer rains, higher humidity (7), semitropical subhumid with summer rains, higher humidity(5.8), tropical subhumid with summer rains, higher humidity(5.8) and temperate subhumid with summer rains, medium humidity (4.7)	20

State	Highest average maximum t°			Lowest average maximum t°		
	Municipality with the highest average maximum t° (°C)	Types of climate Percentage distribution (%)	Highest ave max t° (°C)	Municipality with the lowest average maximum t° (°C)	Types of climate Percentage distribution (%)	Lowest ave max t° (°C)
Nuevo León	China	Semitropical subhumid with scarce rainfall throughout the year (53), semiarid very hot and tropical (41) and arid very hot and tropical (6)	34.5	General Zaragoza	Temperate subhumid with summer rains, medium humidity (37), temperate subhumid with summer rains, higher humidity (25), temperate subhumid with scarce rainfall throughout the year (8), semi-cold subhumid with summer rains, higher humidity (5), arid temperate (4), semiarid temperate (4), semi-cold subhumid with summer rains, medium humidity (4), temperate subhumid with summer rains, less humidity (3), semitropical subhumid with summer rains, less humidity (3), semitropical subhumid with summer rains, medium humidity (3), semiarid semitropical (2) and arid semitropical (2)	24.5
Oaxaca	Santiago Llano Grande	Tropical subhumid with summer rains, medium humidity (52.8) and tropical subhumid with summer rains, more humid (47.2)	38	San Pedro Mixtepec	Semi-cold subhumid with summer rains (50), temperate subhumid with summer rains, more humid (38.1), temperate subhumid with summer rains, medium humidity (11.5) and semitropical subhumid with summer rains (0.4)	19
Puebla	Jolalpan	Tropical subhumid with summer rains (100)	36	Tlachichuca	No data available	17
Querétaro	Arroyo Seco	Semitropical subhumid with summer rains, less humidity (78.4), tropical subhumid with summer rains, less humidity (19.8), semiarid semitropical (1.3), temperate subhumid with summer rains, medium humidity (0.4) and semiarid tropical (0.1)	31.5	Cadereyta de Montes	Temperate semiarid (60.2), temperate subhumid with summer rains, higher humidity(16.8), semiarid semitropical (9.7), temperate subhumid with summer rains, less humidity (7.5), semitropical subhumid with summer rains, less humidity (2.7), arid semitropical (2) and semitropical subhumid with summer rains, medium humidity (1.1)	27.5

State	Highest average maximum t°			Lowest average maximum t°		
	Municipality with the highest average maximum t° (°C)	Types of climate Percentage distribution (%)	Highest ave max t° (°C)	Municipality with the lowest average maximum t° (°C)	Types of climate Percentage distribution (%)	Lowest ave max t° (°C)
Quintana Roo	José María Morelos	Tropical subhumid with summer rains, medium humidity (100)	35.5	Othón P. Blanco	Tropical subhumid with summer rains, medium humidity (75.8), tropical subhumid with summer rains, higher humidity (21.7) and tropical subhumid with summer rains, less humidity (2.5)	33.5
San Luis Potosí	Axtla de Terrazas	Semitropical humid with plentiful rain in summer (100)	36	Catorce	Arid temperate (76.8), semiarid temperate (10.2), temperate subhumid with summer rains, less humidity (10.8), arid semitropical (1.8) and semi-cold subhumid with summer rains, medium humidity (0.4)	27.5
Sinaloa	El Fuerte	Arid very hot and tropical (41.2), semiarid very hot and tropical (32.3), very arid very hot and tropical (13.7), tropical subhumid with summer rains less humidity (11), semitropical subhumid with summer rains less humidity (1) and arid semitropical (0.7)	37.5	Concordia	Tropical subhumid with summer rains, less humidity (44.1), tropical subhumid with summer rains, medium humidity (24.1), semitropical subhumid with summer rains, higher humidity (15), tropical subhumid with summer rains, higher humidity (13.2) and temperate subhumid with summer rains, higher humidity (3.6).	29
Sonora	Álamos	Semiarid very hot and tropical (41.8), semitropical subhumid with summer rains, less humidity (19.9), arid very hot and tropical (15.2), semiarid semitropical (8.4), tropical subhumid with summer rains, less humidity (6.8), temperate subhumid with summer rains, medium humidity (4.2), arid semitropical (1.9), semitropical subhumid with summer rains, medium humidity (1.3), temperate subhumid with summer rains, less humidity (0.5) and semiarid temperate (0.05)	35	Cananea	Temperate semiarid (91.3), arid temperate (7.9) and temperate subhumid with summer rains, less humidity (0.8)	26

State	Highest average maximum t°			Lowest average maximum t°		
	Municipality with the highest average maximum t° (°C)	Types of climate Percentage distribution (%)	Highest ave max t° (°C)	Municipality with the lowest average maximum t° (°C)	Types of climate Percentage distribution (%)	Lowest ave max t° (°C)
Tabasco	Emiliano Zapata	Tropical humid with plentiful rain in summer (90.5) and tropical humid with year-round rain (9.4)	36	Tacotalpa	Tropical humid with year-round rain (100)	34
Tamaulipas	Xicoténcatl	Tropical subhumid with summer rains, less humidity (82), semitropical subhumid with summer rains, medium humidity (7), semiarid very hot and tropical (6) and tropical subhumid with summer rains, medium humidity (5)	35.5	Maquihuana	Temperate subhumid with scarce rainfall throughout the year (25), semi-cold subhumid with summer rains (15), arid semitropical (13), semiarid temperate (12), temperate subhumid with summer rains, higher humidity (11), temperate subhumid with summer rains, less humidity (9), temperate subhumid with summer rains, medium humidity (5), arid temperate (5), semiarid semitropical (4) and semitropical subhumid with summer rains, less humidity (1)	26.5
Tlaxcala	Zacatelco	Temperate subhumid with summer rains, medium humidity (51) and temperate subhumid with summer rains, higher humidity (49)	27	San Francisco Tetlanohcan	Semi-cold subhumid with summer rains, higher humidity (63), temperate subhumid with summer rains, higher humidity (19), temperate subhumid with summer rains, medium humidity (17) and cold (1)	20
Veracruz	Tierra Blanca	Tropical subhumid with summer rains, higher humidity (91), tropical subhumid with summer rains, medium humidity (8) and tropical humid with plentiful rain in summer (1)	35.5	Perote	Temperate semiarid (52), temperate subhumid with summer rains, less humidity (19), semi-cold subhumid with summer rains, higher humidity (13), temperate subhumid with summer rains, medium humidity (6), temperate subhumid with summer rains, higher humidity (4), semi-cold subhumid with summer rains, medium humidity (3), temperate humid with plentiful rain in summer (1), semi-cold humid with plentiful rain in summer (1) and cold (1)	20

State	Highest average maximum t°			Lowest average maximum t°		
	Municipality with the highest average maximum t° (°C)	Types of climate Percentage distribution (%)	Highest ave max t° (°C)	Municipality with the lowest average maximum t° (°C)	Types of climate Percentage distribution (%)	Lowest ave max t° (°C)
Yucatán	Santa Elena	Tropical subhumid with summer rains, less humidity (100)	36.5	Progreso	Arid very hot and tropical (66.7) and semiarid very hot and tropical (33.3)	31.5
Zacatecas	Moyahua de Estrada	Semitropical subhumid with summer rains, less humidity (48.8), semiarid very hot and tropical (32.5), semiarid semitropical (5.7), temperate subhumid with summer rains, medium humidity (5.3), semitropical subhumid with summer rains, medium humidity (5) and tropical subhumid with summer rains, less humidity (2.7)	33.5	Valparaíso	Temperate subhumid with summer rains, less humidity (42.5), semiarid temperate with summer rains (23.2), temperate subhumid with summer rains, medium humidity (14.2), semiarid semitropical with summer rains (13.4), semitropical subhumid with summer rains, less humidity (5.4), semiarid very hot and tropical with summer rains (1.3)	29

Source: CCA-UNAM 2011. Temperatura. *Atlas climático digital de México. Climatología mensual de la temperatura máxima promedio 1950-2000*.
INEGI, 2009a. Clima *Prontuario de información geográfica municipal de los Estados Unidos Mexicanos.*

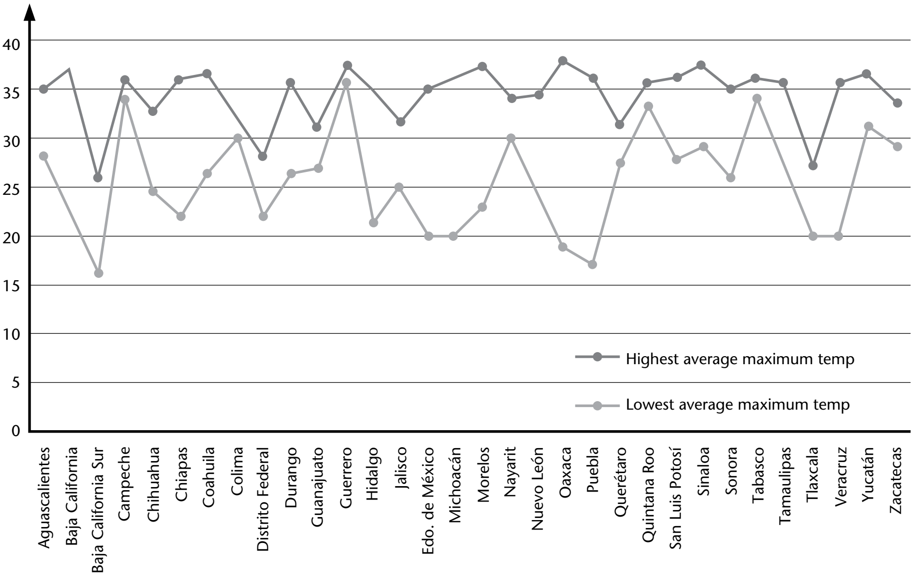

Figure 4. States of Mexico and highest and lowest average maximum temperatures of the selected municipalities

Source: Elaborated by the author, based on CCA-UNAM 2011. *Atlas climático digital de México*.

Figure 4 shows the highest and lowest average maximum temperatures in the municipalities included in the study, from 1950 to 2000. The states with municipalities that recorded the greatest variation between the highest and lowest average maximum temperatures are: Baja California, Baja California Sur, Chiapas, Coahuila, Hidalgo, Estado de México, Michoacán, Estado de Morelos, Nuevo León, Oaxaca, and Veracruz, where the difference in some cases exceeds 10 degrees.

Forty-seven percent of the municipalities show average maximum temperatures ranging from 32 to 38ºC. Santiago Llano Grande in Oaxaca stands out with the highest average maximum temperature. Municipalities which recorded average maximum temperatures of 32 ºC and above are listed in table 3.

Table 3. Municipalities of the states of Mexico which recorded the highest average maximum temperatures from 1950 to 2000 (32°C and above)

State	Municipality	Average maximum temperature recorded in 1950-2000 (ºC)
Oaxaca	Santiago Llano Grande	38
Guerrero	Tlalchapa	37.5
Sinaloa	El Fuerte	37.5

Morelos	Jojutla	37.5
Baja California	Mexicali	37
Michoacán	Huetamo	36.5
Coahuila	Torreón	36.5
Yucatán	Santa Elena	36.5
Campeche	Calkini	36
Chiapas	Catazaja	36
Guerrero	Cutzamala de Pinzón	36
Puebla	Jolalpan	36
Tabasco	Emiliano Zapata	36
Tamaulipas	Xicoténcatl	35.5
Zacatecas	Valparaíso	35.5
Veracruz	Tierra Blanca	35.5
Durango	Rodeo	35.5
Quintana Roo	José María Morelos	35.5
Sonora	Álamos	35
Aguascalientes	Calvillo	35
Hidalgo	San Felipe Orizatlán	35
Estado de México	Luvianos	35
Nuevo León	China	34.5
Campeche	Calakmul	34.5
Tabasco	Tacotalpa	34
Nayarit	La Yesca	34
Quintana Roo	Othón P. Blanco	33.5
Zacatecas	Moyahua de Estrada	33.5
Chihuahua	Batopilas	32.5
Colima	Villa de Álvarez	32

Source: Elaborated by the author, based on CCD/UNAM, 2011.

State of health: main causes of mortality among the general population and mortality related to an increase in temperature

General mortality among the population

On a global scale, noncommunicable diseases are the principal cause of mortality. In 2008 alone they caused 36 million deaths. The distribution of the causal subgroups is as follows: cardiovascular diseases, 48%; cancer, 21%; chronic respiratory diseases, 12%, and diabetes, 3% (WHO, 2011). People who suffer from these diseases are especially susceptible to suffering from worsening health conditions, and eventually, death when subjected to extreme climate conditions, especially if such conditions appear suddenly. In this sense, heat waves have been found to be particularly lethal.

In Mexico, the three main causes of mortality, in rank order, are: 1) diabetes mellitus, 2) malignant tumors, and 3) ischemic heart disease. Liver disease in men and cerebrovascular disease in women rank fourth, while cerebrovascular disease in men and chronic lower airway disease in women rank fifth. Ischemic heart disease and chronic lower airway disease show fairly equal percentages with respect to men and women; for ischemic disease, 11% among men and 10.7% among women and for chronic lower airway diseases, 4.2% among men and 4.1% among women. With respect to cerebrovascular diseases, women show higher mortality rates than men (table 4).

Table 4. Main causes of general mortality among men and women in Mexico in 2007, percentage distribution

Rank	Cause of death	Men (%)	Rank	Cause of death	Women (%)
1	Diabetes mellitus	11.7	1	Diabetes mellitus	16.2
2	Malignant tumors	11.1	2	Malignant tumors	14.6
3	Ischemic heart disease	11	3	Ischemic heart disease	10.7
4	Liver diseases	7.9	4	Cerebrovascular diseases	6.7
5	Cerebrovascular diseases	4.9	5	Chronic lower airway diseases	4.1
6	Transportation accidents	4.3	6	Liver diseases	3.5
7	Chronic lower airway diseases	4.2	7	Transportation accidents	1.5

Source: INEGI, 2007b. *Estadísticas vitales*. Base de datos.

Mortality related to an increase in temperature: ischemic heart disease

According to several authors worldwide, ischemic heart disease is one of the causes of mortality related to an increase in temperature.

Ischemic heart disease is the first cause of death worldwide and ranks third in Mexico. This disease is characterized by a "decrease in the delivery of oxygen to the heart as a consequence of the obstruction and/or stenosis of the coronary arteries, which can result in a heart attack and the death of the individuals affected" (SS, 2007).

The states which recorded the highest percentage of deaths among the general population, in rank order, were: Sonora (30.6%), Sinaloa (30.4%), Nuevo León (30.3%), Tamaulipas (29%), and Durango (28.7%) (INEGI, 2007b). For women, the highest mortality rate was recorded in Sinaloa (15.6%), Sonora (14.1%), Mexico City (14.1%), Durango (13.9%), Nuevo León (13.9%), and Tamaulipas (13.6%). For men: Sonora (16.5%), Nuevo León (16.4%), Tamaulipas (15.4%), Sinaloa (14.8%), Durango (14.8%), and Coahuila de Zaragoza (14.6%) (figure 5).

In 2009, ischemic heart disease caused 60 445 deaths in Mexico, with a specific observed mortality rate of 56 deaths per 100 000 inhabitants. In general, mortality due to this cause is higher in men than in women: 63.9 per 100 000 inhabitants and 48.7 per 100 thousand inhabitants, respectively (SS, 2010).

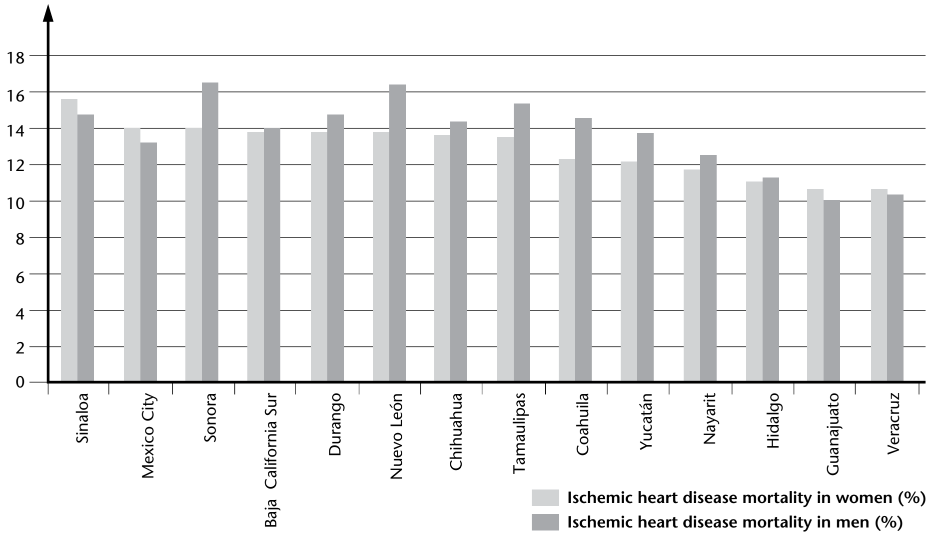

Figure 5. States in Mexico which registered the highest mortality due to ischemic heart disease, taking into account the national median, 2007

Source: INEGI, 2007a. *Estadísticas vitales*. Base de datos.

Although there are many factors which have a bearing upon ischemic heart disease mortality, with respect to climate change scenarios, further studies are necessary in Mexico to determine what percentage of such deaths can be linked to an increase in temperature, especially when we consider the research and findings reported in other countries and that 21.7% of the total number of deaths in Mexico in 2007 were caused by ischemic heart disease—a percentage which shows an upward trend. Among men, deaths due to this cause account for 11% of the total number, and for women, 10.7% of the total.

Among the elderly (60 years old and above), ischemic heart disease ranks first as the cause of death in that age group; for men, the rate is 15.2%, while it is second for women, at 13.9%. As a significant associated morbid condition, half of all men over 60 suffer from high blood pressure, as do 60% of all women in this age group (INEGI, 2007a).

Cerebrovascular disease

Cerebrovascular disease is the second cause of death worldwide and ranks fourth in Mexico (representing 11.6% of all deaths). This disease group is "characterized by the lack of oxygen delivery to the brain due to a hemorrhage or obstruction of an artery; such events are usually very serious and frequently result in the death of the person affected. More than 70% of deaths due to this type of complication occurs in individuals over 60 years of age and is also the cause for the majority of disabilities suffered by this age group" (SS, 2007).

In the context of a gender analysis, this type of disease ranks fourth among women, with a rate of 28.6 deaths per 100 000 inhabitants and fifth among men, with a rate of 26.7 deaths per 100 000 inhabitants. For women, this represents is 6.7% of the general mortality rate, and for men, this figure is 4.9%.

The states which report the highest mortality rates due to this cause, taking the national average as a reference point (4.8% in men and 6.5% in women), are: Hidalgo (8.2%), Baja California (7.9%), Yucatán (7.5%), Oaxaca (7.3%), Querétaro (7.3%), and Veracruz (7.2%). In all of these states, the highest average numbers are for women. For women, fifty-nine percent of all states record figures above the national median, and this figure is 46% for men.

The link between ambient temperature and ischemic heart disease mortality in Mexican municipalities

Ischemic heart disease mortality trends from 1990 to 2009 in the municipalities included in the study

Between 1990 and 2009, there has been an increase in the average annual mortality rate related to ischemic heart disease in the 64 municipalities included in this study. In 1990, it was 30 deaths per 100 000 inhabitants, in 1995 it grew to 38, in 2000 the number was 42, in 2005 it was 51, and in 2009 it climbed to 60. In 1990, 7.8% of the municipalities reported mortality rates above the annual observed median for the municipality; in 1995 it was 9.3%, in 2000 it was 12.5%, in 2005 it was 29.6%, and in 2009 it rose to 45.3% (DGIS-SS, 2011).

The highest observed average mortality rate due to ischemic heart disease occurred in the municipality of China in Nuevo León, with 119 deaths per 100 000 inhabitants, followed by Miquihuana, Tamaulipas, with 104; Venustiano Carranza, Mexico City, with 91; Xicoténcatl, Tamaulipas, with 90; and Valparaíso, Zacatecas, with 86.

Temperature and mortality at the municipal level due to ischemic heart disease

Taking the findings reported by some authors worldwide pertaining to the relationship between an increase in temperatures and mortality due to cardiovascular diseases as the point of reference, an analysis was conducted of each state's municipalities that showed a difference between the highest average maximum temperatures and the lowest average maximum temperatures, in order to identify contrasts between average ischemic heart disease mortality rates during the 1990-2009 period.

Not all municipalities which registered average maximum temperatures above 32°C exhibited high mortality rates due to ischemic heart disease. The findings showed that 65.6% of the states display differences among their municipalities with respect to average ischemic heart disease mortality rates; the municipality that registered the highest temperatures also registered the highest rates (table 5). Within that 65.6%, when the climate differences are larger among the municipalities within the same state, there are marked differences in mortality rates; with less difference in temperatures between the municipality with the highest average maximum temperature and the municipality with the lowest average maximum temperature; see the following cases (table 5):

1) Mexico City with Venustiano Carranza, which has an arid-semiarid climate and a 28°C average maximum temperature, and the municipality of Cuajimalpa, with a temperate subhumid climate and an average maximum temperature of 22°C (the difference between their ischemic heart disease mortality rates is 57 points).
2) Durango with Rodeo, which has an arid semitropical climate and an average maximum temperature of 35.5°C, and the municipality of Guanaceví, with a semi-cold subhumid climate and an average maximum temperature of 26.5°C (the difference between their ischemic heart disease mortality rates is 39.9 points).
3) Nuevo León with the municipality of China, which has a semitropical subhumid climate with 34.5°C, and the municipality of General Zaragoza, with a temperate subhumid climate and an average maximum temperature of 24.5°C (the difference between their ischemic heart disease mortality rates is 83.3 points).

Differences in mortality rates can also be observed when the municipalities within the same state exhibit different climate types and the difference between the average maximum temperatures registered in such municipalities is greater than 14 degrees. The following are noteworthy:

1) Baja California with Mexicali, which has a very arid climate and an average maximum temperature of 37°C, and Playas de Rosarito, with an arid climate and an average maximum temperature of 22.5°C (the difference between their average ischemic heart disease mortality rates is 35.4 points).
2) Chiapas with Catazaja, which has a tropical humid climate and an average maximum temperature of 36°C and the municipality of Chamula, with a temperate subhumid climate and average maximum temperature of 22°C (the difference between their average ischemic heart disease mortality rates is 32.9 points).

3) Oaxaca with the municipality of Santiago Llano Grande, which has a tropical subhumid climate and an average maximum temperature of 38°C and the municipality of San Pedro Mixtepec, with a semi-cold subhumid climate and an average maximum temperature of 19°C (the difference between their average ischemic heart disease mortality rates is 27.3 points).
4) Veracruz with the municipality of Tierra Blanca, with a tropical subhumid climate and an average maximum temperature of 35.5°C and the municipality of Perote, with a semiarid temperate climate and an average maximum temperature of 20°C (the difference between their average ischemic heart disease mortality rates is 54.3 points) (table 5).

26.5% of the municipalities included in the study showed ischemic heart disease mortality rates above the national median (56 per 100 000 inhabitants). Of this percentage, 15% exhibited average maximum temperatures of 33.5 to 37.5°C, and the remaining 10.9% registered average maximum temperatures within a range from 16 to 31.5°C (table 5).

Table 5. Ischemic heart disease mortality in municipalities within each Mexican state and average maximum temperature from 1950 to 2000

State	Municipality with the highest average maximum t° (°C)	Highest average maximum t° (°C)	Average ischemic heart disease mortality rate from 1990-2009 *	Municipality with the lowest average maximum t° (°C)	Lowest average maximum t° (°C)	Average ischemic heart disease mortality rate from 1990-2009*
Aguascalientes	Calvillo	35	51.5	San José de Gracia	28	31.9
Baja California	Mexicali	37	67.3	Playas de Rosarito	22.5	31.9
Baja California Sur	Los Cabos	26	37.1	La Paz	16	58.1
Campeche	Calkini	36	41.5	Calakmul	34.5	8.2
Chihuahua	Batopilas	32.5	13.6	Bocoyna	24.5	47
Chiapas	Catazaja	36	41.2	Chamula	22	8.2
Coahuila	Torreón	36.5	55.6	Ramos Arizpe	26.5	55.6
Colima	Villa de Álvarez	32	31.3	Minatitlán	30	14.8
Durango	Rodeo	35.5	76.4	Guanaceví	26.5	36.5
Guanajuato	Xichu	31	25.9	Jerécuaro	27	35.2

State	Municipality with the highest average maximum t° (°C)	Highest average maximum t° (°C)	Average ischemic heart disease mortality rate from 1990-2009 *	Municipality with the lowest average maximum t° (°C)	Lowest average maximum t° (°C)	Average ischemic heart disease mortality rate from 1990-2009*
Guerrero	Tlalchapa	37.5	33.3	Cutzamala de Pinzón	36	34.1
Hidalgo	San Felipe Orizatlán	35	30.7	Mineral del Monte	21.5	22.5
Jalisco	Jilotlán de los Dolores	31.5	54.7	Manzanilla de la Paz	25	51.7
Mexico City	Venustiano Carranza	28	91.8	Cuajimalpa	22	34.7
Estado de México	Luvianos	35	13.5	Toluca	20	26.8
Michoacán	Huetamo	36.5	36.3	Tancítaro	20	52.1
Estado de Morelos	Jojutla	37.5	58.4	Tetela del Volcán	23	43.4
Nayarit	La Yesca	34	22.0	El Nayar	30	5.8
Nuevo León	China	34.5	117.1	General Zaragoza	24.5	33.8
Oaxaca	Santiago Llano Grande	38	31.1	San Pedro Mixtepec	19	3.8
Puebla	Jolalpan	36	76.9	Tlachichuca	17	24.7
Querétaro	Arroyo Seco	31.5	44.5	Cadereyta de Montes	27.5	32.2
Quintana Roo	José María Morelos	35.5	17.7	Othón P. Blanco	33.5	27.3
San Luis Potosí	Axtla de Terrazas	36	34	Catorce	27.5	51.3
Sinaloa	El Fuerte	37.5	68.7	Concordia	29	60.3
Sonora	Álamos	35	84.4	Cananea	26	83.6
Tabasco	Emiliano Zapata	36	34.6	Tacotalpa	34	22.3
Tamaulipas	Xicoténcatl	35.5	90.4	Miquihuana	26.5	101.7
Tlaxcala	Zacatelco	27	30	San Francisco Tetlanohcan	20	27.9
Veracruz	Tierra Blanca	35.5	81.3	Perote	20	26.9
Yucatán	Santa Elena	36.5	27.5	Progreso	31.5	58
Zacatecas	Moyahua de Estrada	33.5	70.3	Valparaíso	29	86.7

*Average mortality rate per 100 000 inhabitants

Source: Elaborated by the author, based on CCA-UNAM, 2011 *Atlas climático digital de México*.

DGIS-SS (2011). *Base de datos de defunciones 1979-2007*.

A general analysis of the relationship between climate type and average ischemic heart disease mortality rates shows that the lowest mortality rates are found in semi-cold and arid Mediterranean climates, where temperatures between 19 and 26.5ºC are recorded; in semitropical humid, tropical humid, and semiarid semitropical climates, although temperatures are high—from 31 to 36ºC—mortality rates are low (ranging from 22.3 to 44.5), in comparison to what is observed for other climate types. High mortality rates with a narrow range are observed in arid, very hot and tropical climates with temperatures from 31.5 to 37.5ºC and in arid, semitropical climates with temperatures of 35.5ºC (table 6).

Table 6. Types of climates in the municipalities included in the study, ischemic heart disease mortality rates for the 1990-2009 period and average maximum temperature registered between 1950 and 2000

Climate type	Climate subtype	Range of Average ischemic heart disease mortality rate from 1990-2009.*	Average maximum temperature range (ºC)
Semi-cold	Subhumid	3.8 to 47	19 and 26.5
Temperate	Subhumid	8.2 to 101.7	22 and 32.5
Semitropical	Subhumid	14.8 to 117.1	20 to 34.5
	Humid	30.7 to 44.5	31.5 to 36
Tropical	Subhumid	5.8 to 90.4	29 to 38
	Humid	22.3 to 41.2	34 to 36
Arid	Very hot and tropical	58 to 68.7	31.5 to 37.5
	Semitropical	76.4	35.5
	Temperate	51.3	27.5
	Mediterranean	31.9	22.5
	Semiarid	91.8	28
Semiarid	Very hot and tropical	36.3 to 84.4	35 to 36.5
	Semitropical	25.9	31
	Temperate	26.9 to 83.6	20 to 35
Very arid	Very hot	37.1 to 67.3	26 to 37
	Semitropical	55.6 to 58.1	16 to 36.5

* Rate per 100 000 inhabitants.

Source: Elaborated by the author.

The municipalities which had the highest ischemic heart disease mortality rates for 1990-2009 registered average maximum temperatures from 33.5 to 36ºC. The five municipalities which had the highest mortality rates during the period from 1990 to 2009 are shown (table 7).

The highest ischemic heart disease mortality rate observed in 2009 occurred in the municipality of Tierra Blanca, Veracruz with 182 deaths per 100 000 inhabitants, followed by Xicoténcatl, Tamaulipas, with 181; Valparaíso, Zacatecas, with 139; China, Nuevo León, with 136; and Jolalpan, Puebla, with 127 (table 7).

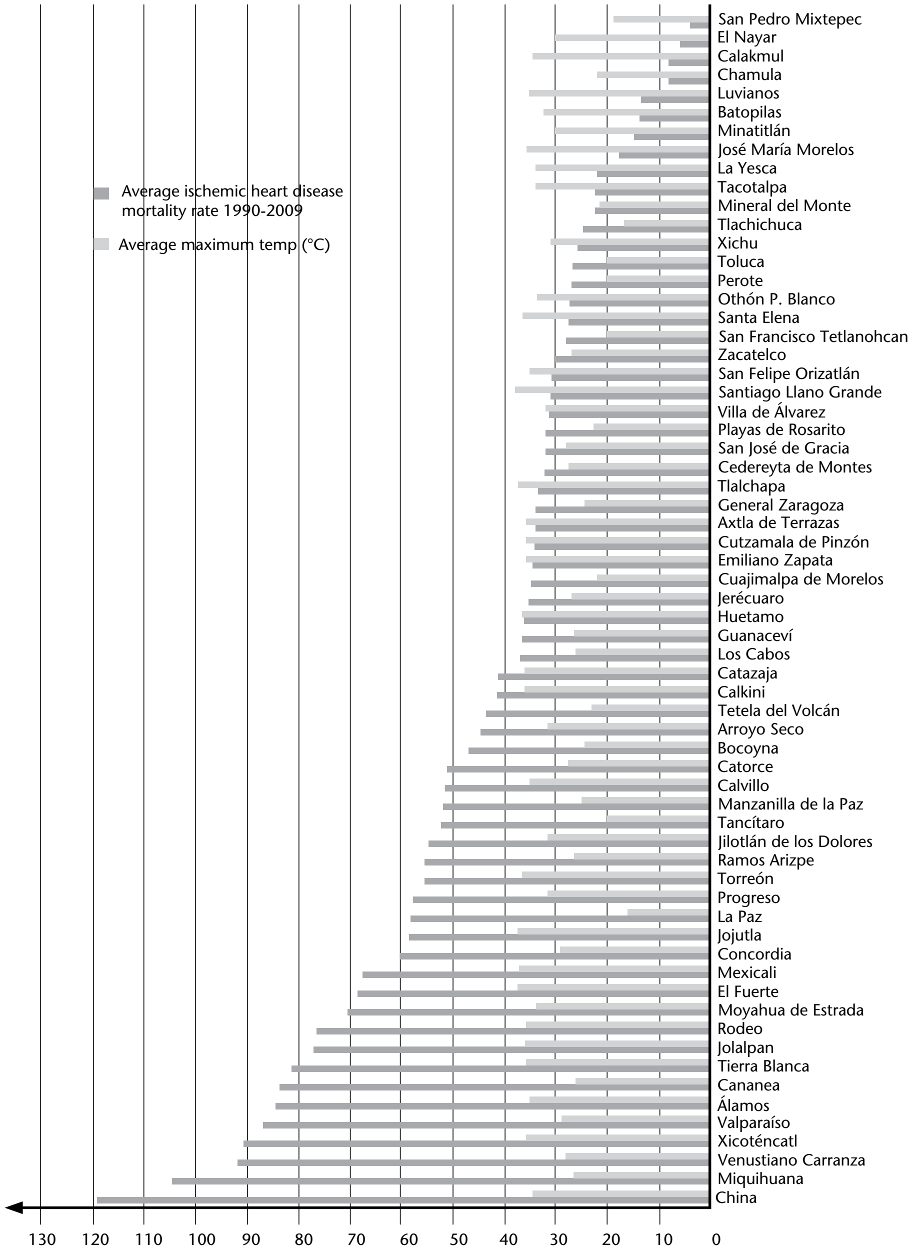

Figure 6. Average mortality rates for ischemic heart disease from 1990 to 2009 and maximum average temperatures from 1950 to 2000 in the municipalities studied

Source: Elaborated by the author.

Table 7. Municipalities with the highest ischemic heart disease mortality rates from 1990-2009 and the average maximum temperatures registered for 1950-2000

Year and t°	Municipalities and ischemic heart disease mortality rates per 100 000 inhabitants.				
1990	Miquihuana, Tamaulipas (167)	Tancítaro, Michoacán (83)	China, Nuevo León (78)	Jilotlán de los Dolores, Jalisco (76)	Venustiano Carranza, Mexico City (66)
Average maximum temperature	26.5°C	20°C	34.5°C	31.5°C	28°C
1995	China, Nuevo León (138)	Valparaíso, Zacatecas (112)	Manzanilla de la Paz, Jalisco (88)	Cananea, Sonora (85)	Venustiano Carranza, Mexico City (81)
Average maximum temperature	34.5°C	29°C	25°C	26°C	28°C
2000	Miquihuana, Tamaulipas (187)	China, Nuevo León (131)	Catorce, San Luis Potosí (90)	Venustiano Carranza, Mexico City (89)	Moyahua de Estrada, Zacatecas (87)
Average maximum temperature	26.5°C	34.5°C	27.5°C	28°C	33.5°C
2005	Cananea, Sonora (143)	Álamos, Sonora (124)	Rodeo, Durango (121)	Venustiano Carranza, Mexico City (113)	China, Nuevo León (109)
Average maximum temperature	26°C	35°C	35.5°C	28°C	34.5°C
2009	Tierra Blanca, Veracruz (182)	Xicoténcatl, Tamaulipas (181)	Valparaíso, Zacatecas (139)	China, Nuevo León (136)	Jolalpan, Puebla (127)
Average maximum temperature	35.5°C	35.5°C	29°C	34.5°C	36°C

Source: Elaborated by the author.

Although generally ischemic heart disease mortality in Mexico is still higher among men, there is an accelerated increase among women, with a rate of 22 per 100 000 inhabitants in 1990, increasing in 2009 to 52 per 100 000. In climate change scenarios, this is a critical issue and the repercussions of climate variability, increasing temperatures, and heat waves in some of the nation's municipalities need to be studied in greater detail.

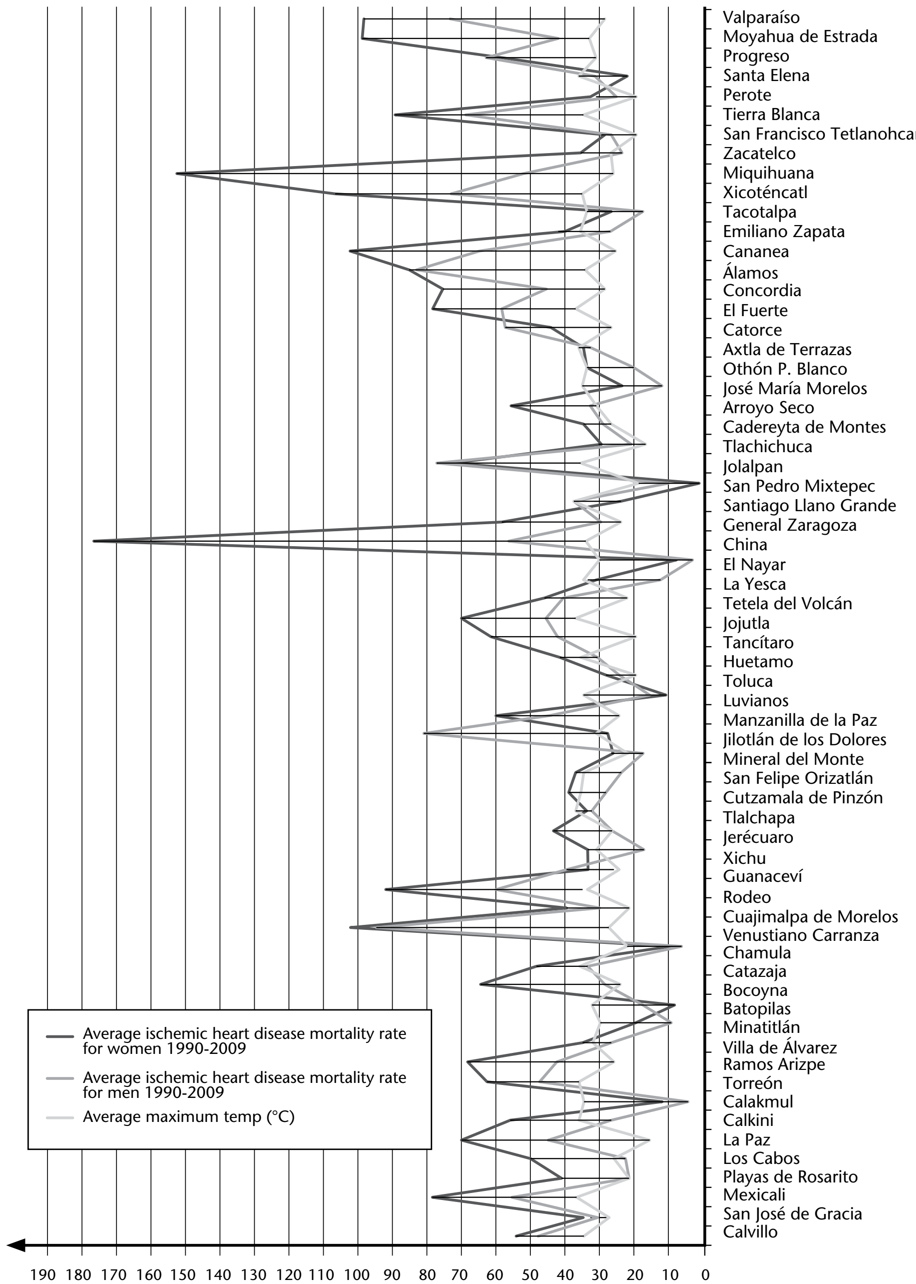

Figure 7. Average ischemic heart disease mortality by gender and average maximum temperatures in the municipalities included in the study; rates per 100 000 inhabitants

Source: Elaborated by the author.

The municipalities that had the highest average mortality rates among women from 1990 to 2009 were, per 100 000 inhabitants: Venustiano Carranza, Mexico City (88), Álamos, Sonora (83), Jilotlán de los Dolores, Jalisco (81), Jolalpan, Puebla (77), Valparaíso, Zacatecas (74), Xicoténcatl, Tamaulipas (74), Tierra Blanca, Veracruz (72), Cananea, Sonora (64), Progreso, Yucatán (64), and Rodeo, Durango (60) (figure 7).

In men, the highest average rates per 100 000 inhabitants occurred in the municipalities of China, Nuevo León (176), Miquihuana, Tamaulipas (152), Xicoténcatl, Tamaulipas (106), Cananea, Sonora (102), Moyahua de Estrada, Zacatecas (99), Valparaíso, Zacatecas (98), Venustiano Carranza, Mexico City (94), and Rodeo, Durango (92) (figure 7).

Conclusions

Heat waves are considered high-risk conditions worldwide and one of the most important threats to health and well-being in the 21st century, due to the social, financial, and environmental costs they entail in terms of disease, deaths, disability, disasters, damage to productive activities, loss of species, and altering environments and their functions.

The increase in temperature and heat waves has been significant as of the 1990s; 50% of all related events worldwide and 86.5% of all deaths associated with such causes occurred from 2000 to 2009.

Asia is the region where the majority of disasters due to heat waves have occurred, followed by America, and then Europe. In terms of number of deaths, Europe has been the hardest hit, followed by Asia, America, Oceania, and Africa. The heat waves suffered by Europe in 2003 are considered to be the worst disaster of this type.

It is well-known that some regions and groups are more vulnerable to climate change hazards and particularly to an increase in temperature and the occurrence of heat waves. A greater impact on the population's health and well-being is anticipated due to an upward trend in increasing climate variability, extreme climate events, and more frequent heat waves.

There are factors and conditions which augment a population's exposure and vulnerability to increasing temperatures, heat waves, and climate extremes: a) biological characteristics: anatomic, hormonal differences, and body fat; b) socio-demographic variables: gender and age (the elderly are considered more susceptible to an increase in temperatures and to damage when exposed to these conditions); c) suffering from certain chronic diseases is directly related to a higher risk of becoming ill and dying due to exposure to high temperatures and heat waves; d) economic, educational, and equality levels which restrict or allow access to basic services and possibilities for development; and e) responsiveness in adapting to climate change and reducing vulnerability.

In addition to the factors mentioned above, there are other aspects which increase Mexico's vulnerability to climate change as a country, among them a lack of policies and measures by the healthcare sector, scarce research on the topic of climate change and its effects on the population's health and vulnerability, limited development of plans and programs to monitor diseases which are sensitive to climate change, and adaptation measures for the population, as well as nonexistent systematization of useful and quality information which would allow for the development of studies and adequate decision-making regarding prevention and adaptation, especially with respect to temperature humidity, precipitation, daily morbidity and mortality for sensitive diseases, daily hospital admissions, health costs, air pollutant ratings, frequency, intensity, and damage from extreme events and disasters, emergency response capacity based on the population's demands, and availability of resources, among others.

Mexico is a country with great climate diversity and these variations determine a greater exposure, vulnerability, and risk associated with high temperatures, heat waves, and other climate extremes, according to the state and municipality of residence. Nevertheless, although median temperatures (10 to 26°C) are not extreme like in other regions of the world, we can consider that they present a danger for health, as an upward trend is observed with respect to such increasing temperatures and the occurrence of climate extremes, especially regarding sudden changes or changes that continue over several days.

The municipalities that recorded the highest average maximum temperatures are Santiago Llano Grande in Oaxaca (38ºC), Tlalchapa, Guerrero (37.5ºC), El Fuerte, Sinaloa (37.5ºC), Jojutla, Morelos (37.5ºC), and Mexicali, Baja California (37ºC).

The average annual mortality rate for ischemic heart disease is on the rise. When analyzing the municipalities included in the study in Mexico, in 1990 the rate was 30 deaths per 100 000 inhabitants, in 2000 it was 42, and by 2009, it had increased to 60; that is, it doubled in 20 years. The states with the highest percentage of deaths were those in the northern part of the country: Sonora, Sinaloa, Nuevo León, Tamaulipas, and Durango.

Results show that when climate differences are greater in municipalities within the same state, very different average mortality rates are observed, with lesser differences in temperature (6 to 10 degrees) and when the difference in the average maximum temperature recorded in such municipalities is greater than 14 degrees.

Fifty-five percent of the municipalities with the highest average mortality rates registered temperatures between 33.5 and 36ºC. The climate types where such high rates were observed were arid, very hot and tropical, and arid, semitropical with temperatures ranging from 31.5 to 37.5°C, and in semiarid climates with temperatures of 28°C.

The lowest average ischemic heart disease mortality rates were recorded in municipalities with semi-cold, arid Mediterranean climate where temperatures ranged from 19 to 26.5°C. Likewise, low rates were observed in semitropical humid, tropical humid, and semiarid semitropical climates, even though the recorded temperatures were high, between 31 and 36°C.

Taking into account previous findings by scientific literature which indicate that extreme temperatures—both high and low—, high altitudes which bring about low oxygen tension, and extreme climates with respect to the air's relative humidity are considered risk factors that trigger heart attacks, it was expected that the study would find a link between these variables in the municipalities included in the study. Using available information at the municipal level on the highest and lowest maximum temperatures, ischemic heart disease mortality rates and predominant climate types, a correlation analysis was conducted, obtaining results that are not significant upon confronting such variables, as the values obtained neared zero ($r = 0.18$).

Considering the resulting low correlation, it is clear that the mortality rates in such municipalities are being influenced by other factors with a greater relative weight which were not considered in this study, such as gender, age, occupation, air pollution, lifestyle, predisposing morbidities, and timely medical attention, among others. It is important to conduct specific studies which will determine the weight of diverse factors as causes of death in ischemic heart disease. It is also necessary to achieve a greater degree of disaggregation in mortality rates in order to obtain new results that contribute to a better understanding of the role played by climate variables in triggering ischemic heart death, especially the synergism between climatic variables and those factors already recognized as risks.

The information available allowed us to obtain evidence that lent clarity to the importance and need for further research on the relationship between climate variables and ischemic heart disease mortality in climate change scenarios, and to transform it into a tool we can use to prevent health damage. Interdisciplinary research in the fields of climate change and health is relevant when we consider the regional differences we find in Mexico with respect to climate types, temperature increase, heat waves and occurrence of thermal extremes, exposure levels, and groups with greater vulnerability and risks.

The population's ability to adapt to climate change will depend on how its vulnerability conditions are served and overcome, as these conditions are contributing to a higher degree of damage to health and well-being.

Proposals to reduce the population's vulnerability to climate change

1. Any proposal to reduce human vulnerability when faced with adverse effects associated with climate change must be based on the scientific data obtained from clinical and epidemiological studies on the main effects on health as indicated in this document. Likewise, monitoring and surveillance of the environmental variables involved must be encouraged, so that records can be available that will allow for evaluating trends and establishing their relation to effects on health.
2. A stronger commitment from the healthcare sector is necessary in assessing the effects that increasing temperatures and heat waves are having on morbidity and mortality, especially among the population's most vulnerable groups. It is also necessary to produce more detailed information that will provide a basis for conducting further research and making the correct decisions. Focusing on risks is a highly recommended approach for such tasks.
3. The studies on vulnerability and adapting to climate change conducted in Mexican states take into account, in all of their assessments and proposals, their diverse climates, the role of changes in land use in the increase in temperatures at the local level and in the greater exposure to threats derived from climate change, as well as identifying the vulnerable groups among the local population and gender differences with regard to the effects of climate change.
4. Reducing Mexico's vulnerability to climate change in the medium and long term will imply re-thinking and changing the way in which human settlements, and particularly cities, are established, as well as responding to the structural base-causes which contribute to and maximize the negative effects of threats arising from climate change on the population's health and well-being. The "Cities and Climate Change Initiative" within the framework of the UN-Habitat (ONU, 2011) offers an opportunity for local governments to promote measures to help cities adapt to and lessen the impact of climate change.
5. In the development of public policy and strategies concerning adaptation, priority should be placed on those states which exhibit the highest maximum temperatures (>32ºC), higher ischemic heart disease mortality rates (above the national average), and greater vulnerability to climate change due to their own type of climate.
6. Establish national and international cooperation measures to analyze health risks associated with climate change and to increase monitoring and surveillance capacities of those diseases associated with temperature increases and heat waves, with early-warning systems, to improve the response by health services as well as to train medical personnel.

7. Establish a permanent education and communication plan for the population on critical heat wave periods, which will publicize measures to be taken for the general population and specific vulnerable groups: children, the elderly, the malnourished, and people who suffer from cardiovascular, respiratory, and metabolic diseases.
8. Create improved environmental health indicators to assess the progress on topics related to climate change and health.
9. Determine specific projects for diseases associated with a rise in temperature, heat waves, extreme climates, and air pollution.
10. In all climate change adaptation plans, incorporate measures that include urban planning, using efficient technological innovations, adapting housing, and educating and communicating with the population in order to reduce vulnerability.
11. Proposals geared toward reducing or mitigating the effects of climate change on the population's health must also consider long-term approaches for socio-economic development activities, where defining preventive measures against associated risks is recommended. This requires inter-sector coordination on topics related to climatology, location of industrial zones, urban development, human settlements, and restricting housing in areas of potential danger, among many other measures. Research in these areas must be encouraged in order for the reduction in vulnerability to be based on scientific criteria in addition to economic, social, and political considerations, which will necessarily play an important role.

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4. Climatic Change, Civilizing Expectation

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Threats or development?

NATURAL DISASTERS have accompanied humanity's existence since its origin and, throughout the process of cultural evolution, humans have adapted to their occurrence. The earliest events recorded by history are the same type of events that continue to occur decade after decade and year after year because they are a product of the geological forces that have determined the changes of the planet's surface since its origins and which are associated to the mutation and permanence of life. These aggradations, which have included volcanic eruptions, earthquakes, and tsunamis, cause a heavy loss of life and property damage, but they also have given rise to a variety of surface relief such as mountains, ranges, valleys, canyons, and gorges. These, in turn, help determine climate patterns and vegetation diversity that make for abundant and diverse life forms, natural resources, and ecosystem services. These geological forces also produced fertile soils that allowed humans to become sedentary, as they were able to grow their food and develop their culture without having to move. For example, the materials released by volcanoes—once decomposed in the sand and broken down into clay by rain and changing temperatures—release nutrients that sustain wild plants and crops, and nourishment for multiple species, among them, our own.

Ultimately, life as we know it and the sources of energy we use were made possible by those geological forces which are perceived as threats because we cannot alter or control them through technology. These forces have conditioned how we plan land use, regarding the territory where we live, work, and enjoy our leisure time, in order to reduce the loss of human life and physical damage, and procure safe areas. Paradoxically, the technology we have trusted and the manner in which populations have concentrated in cities have exposed us to new disasters and suffering, instead of enhancing the well-being sought by human ingenuity. This need for more certainty in development for the years to come has supported the idea of a new civilizing order coupled with a new international economic order, a need expressed since 1974 (UN, 1974).

Threats test our capacity of sensory perception, our interpretation of signals, and our ability to avoid future disasters by reducing our exposure to such superior forces. The visible manifestations of volcanic activity make the risk quite obvious, but in recent history not all threats have been perceivable, either due to their sudden materialization outside all probabilistic logic, the slow pace in which they manifest themselves and cause us to incorporate them into our daily lives disregarding the effects of chronic deterioration, or because of their dimension, which falls beyond the usual scope of our thinking process.

The vulnerability of humans increases as a result of the lack of understanding of the consequences wrought by the effects on the planet's vital systems, whose symptoms are often unpredictable. At the same time, the dominant belief that places other than our own are more exposed to danger, adds to the growing vulnerability of human populations. Another lesson we can learn from natural disasters is that the greatest loss of human life does not necessarily happen where the threats appear with intense magnitude, but rather where vulnerability is greater.

Natural disasters during centuries of progress

If we analyze the behavior of those disasters that the United Nations calls "natural disasters", particularly those which have taken place on our planet during the 20th century and from the beginning of the 21st century to date, we find that the impact of the worst of such disasters, such as volcanic eruptions, epidemics, and floods, were reported in the first half of the 20th century (EM-DAT, 2011). Epidemics have surpassed, in terms of loss of life, the effects of disasters caused by geological forces by a 4:1 ratio, and during the last 110 years, have averaged 955 000 deaths per decade. The period that suffered the greatest damage took place between 1901 and 1926, when 10 pandemic events occured. The worst epidemics have been caused by bacteria specific to unsanitary environments, in addition to those transmitted by fleas and mosquitos, vectors which frequently overtake a population's preventive measures and overwhelm the adjustment systems of the surrounding ecosystems. This type of disaster is expected to increase during this century as a result of climate change (Githeko *et al.*, 2000).

Floods rank third among natural disasters that cause the loss of human lives, averaging 336 000 deaths per decade, with the most catastrophic floods occurring during the period from 1930 to 1939. As with epidemics, the number of floods is anticipated to increase in the future due to climate change and improper land use that modifies the infiltration/runoff ratio (Patz and Christenson, 2010).

Volcanic eruptions are last among the disasters causing the most damage at the beginning of the 20th century. They average 10 000 deaths per decade. The period of greatest damage due to volcanic activity occurred between 1902 and 1909 when the greatest loss of life was suffered, equivalent to 40% of all loss of life recorded in the 20th century and so far this century. It would seem that vulnerability to this type of threats has diminished, perhaps because early warning systems have been put into place after we learned to interpret the signs and symptoms of this force which become apparent prior to a great eruption, reducing exposure to this type of danger.

There are other types of disasters that have caused the greatest damage mainly during the second half of the 20th century. Such is the case of hurricanes, which have caused 121 000 deaths per decade, with the most damaging events taking place between 1960 and 1969 (EM-DAT, 2011). The intensity of these meteorological phenomena has increased because of climate change, and the damage they cause is expected to increase during this century (UN HABITAT, 2011).

The disaster that caused the greatest number of deaths in the world during the 20th century was drought, with an average of 1.17 million deaths per decade. Thus, lack of water is the cause of the worst damage wrought on humanity, more than epidemics or geological forces. The period of time that encompasses the 10 worst drought disasters is broader, spanning from 1900 to 1983. A notable fact is that the four countries that have suffered the most due to drought (China, Bangladesh, India, and the former Soviet Union), are the same countries which have suffered the most damage from epidemics.

Finally, the disasters that have caused the worst consequences in the 21st century are earthquakes, tsunamis, and extreme temperatures (EM-DAT, 2011).

Earthquakes are the leading geological threat to the planet, on account of their frequency, averaging 198 000 deaths per decade. Notwithstanding their constant occurrence during the 20th century, 40% of the most disastrous earthquakes in history took place between 2004 and 2010, and this planetary force is expected to continue taking human lives if we do not experience a radical change in the level of vulnerability of cities that, as they spread in a disorderly manner, disrupt ecosystems, the city itself, and its traditional social organizations. The damage caused by an earthquake has been shown to depend not on the magnitude of the geological phenomenon, but rather on the exposed communities' vulnerability; which is why it only takes a 5.1 earthquake to cause a disaster in China, whereas in Japan only earthquakes above 6.5 tend to cause damage. In the Americas, an earth tremor with a 6.3 magnitude causes a disaster in Peru, while in Mexico this occurs at magnitudes above 6.6. One of the factors of vulnerability specific to this threat is the unexpected nature of its occurrence.

Tsunamis, linked to seaquakes, have had the greatest impact on loss of life (30%) between 2004 and 2011. An element of vulnerability related to tsunamis is attributed to the fact that a great number of the people who have died in tsunamis were tourists, who tend to have scarce knowledge of the territory they are visiting; Another factor is the misguided belief that the damage will not be so great once a population has implemented certain security systems which, in the end, prove to be inadequate in view of the ever-increasing magnitude of this type of phenomenon. The average number of deaths per decade caused by this type of force has been 25 000.

Extreme temperatures (the great majority of which were heat waves) (OECD, 2010) are the only type of disaster where 80% of the deaths occurred from 2003 to the present during the period of reference (1900 to 2011). Europe is the most vulnerable continent (in contrast to Asia and the Americas where the greatest effects of the other types of disasters have occurred), totaling 123 844 deaths from the beginning of the 21st century to date. More people have died worldwide due to heat waves in the last 30 years, than due to volcanic eruptions in the last 110 years.

A chain of disasters

Advances in climate change sciences tell us that the rise in the planet's temperature is expected to result in more disasters caused by epidemics, droughts, floods, hurricanes, and extreme temperatures, in addition to air pollution—all of which will increase the disasters experienced by the planet's human population, infrastructure, and biodiversity.

Due to the way in which development has been carried out, climate change triggers a series of disasters. Thus, a drought will bring about undernourishment and heat waves will increase metabolic and mental illnesses (Chand and Murthy, 2008). Not only the poorest will be affected; the richest, accustomed to abundance, will also suffer. Intense rains will not only cause more floods, but also soil erosion. As erosive rains increase, this chronic disaster will have the worst consequences for humanity, as it makes the food system—the foundation of culture—more vulnerable.

Thus, the linear models used by science and technological development are no longer adequate to tackle a phenomenon which knows no physical boundaries, has no defined objects or subjects, and has manifested a wider range of probabilities.

Ours is a unique generation that has witnessed planetary changes within a human—and not geological—time frame. Climate change is a change in the planet's vital system. Although disasters always cause damage, they always also provide some benefits. It is believed that climate change will bring advantages to the northern countries, as warming will allow different crops to grow and increase agricultural productivity (paying little attention to the quantification of the loss of ecosystems and their services due to changes in land use). But the greatest benefit this change can provide us, in an objective manner, is to make us modify our way of thinking that has reduced Nature to resources valued by economic criteria and its usefulness.

Climate change, which is a planetary change, may give us the opportunity to change the course of the cultural forces which have led to a state of decline in the vital planetary fabric and social fabric.

Climate change offers us a chance to learn and to make a civilizing change in pressing issues, among them, recognizing errors (and asking for forgiveness) for having opted to use, as our main source of energy, petroleum extracted from under the ground—a choice which has reverted the quality of the atmosphere instead of opting to use solar energy, provided by the very same star that gave life to us.

We must recognize that the linear path that we have followed during the second industrial revolution has led us to become the subject of study of a planetary experiment, the most dangerous humanity has ever faced.

What is most important is that climate change has allowed us to visualize and build possible scenarios of what the world will be like in the near future. Our capacity to embark on a new path, motivated by new ideas, will enable us to change the effects of inevitable disaster, and our own degree of vulnerability, as well as allow us to build on a new understanding.

We are the first generation to have become aware of how a vital planetary layer has been altered with incalculable magnitude and speed. Ten thousand years ago, uncertainty about access to food brought about the invention of farming, and with it a great leap for humanity that has benefitted 400 generations. Likewise, this uncertainty of multiple dimensions, which now lies before us due to climate change, is a call for a new creative leap forward.

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5. Climate Change in Syria

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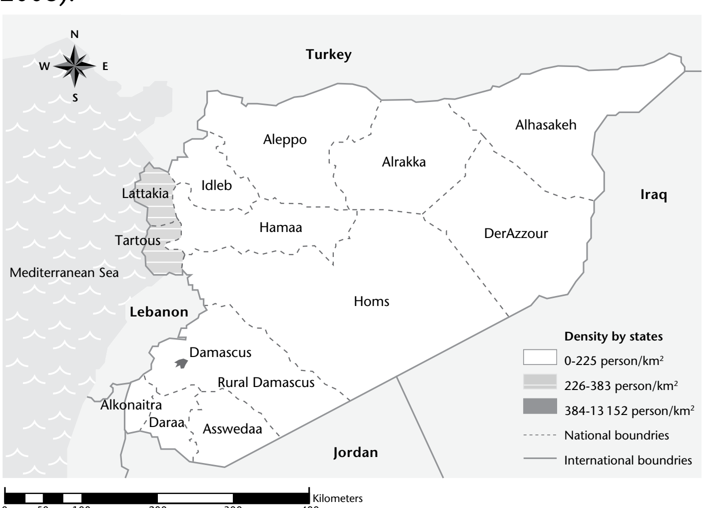
Background

Syria's location

THE SYRIAN ARAB REPUBLIC lies in western Asia, on the eastern shores of the Mediterranean Sea between latitudes of 32° 19′ and 37° 25′ north, longitudes 35° 43′and 42° 25′ east. Syria is bordered in the north by Turkey, in the east by Iraq, in the south by Jordan and Palestine, and in the west by Lebanon and the Mediterranean Sea. The land surface area is 185 180 km^2; one-third of which is fertile lands and forests. The remainder is desert-like and mountainous terrains (Meslmani *et al.*, 2008).



Syrian Arab Republic

Figure 1. Map of Syrian Arab Republic showing its governorates and borders

The Syrian population

Syria has witnessed rapid population growth in the twentieth century. The number of people living in the Syrian Arab Republic was estimated at 20.367 million at the end of 2009. The population has doubled once from 1922 to 2006, with an average annual increase of 222 820. The annual population growth rates diverged in the last fifty years to varying degrees; in the 1970s, the population growth rate reached 3.35%, whereas it remained at 3.3% from 1991 through 1994 (Meslmani *et al.*, 2008).

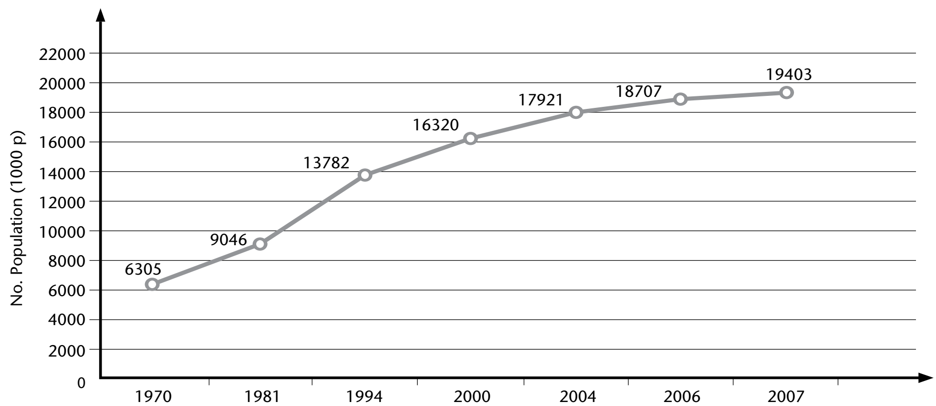


Figure 2. Annual population increase in Syria (in thousands of people)

Source: Statistical Abstracts of Syrian Arab Republic.

Syrian efforts on climate change

Syria, convinced of the importance and seriousness of climatic changes, ratified the United Nations Framework Convention on Climate Change (UNFCCC) in 1995. On 4 September 2005, the Kyoto Protocol was also signed. The Ministry of State for Environmental Affairs (MSEA) became the national focal point for climate change issues. As a non–annex1 party to the convention, Syria has no quantitative commitments toward the reduction of Green House Gases (GHGs) emissions. However, article 12 of the convention obligates countries to prepare National Communications to the Conference of Parties (COP) of the UNFCCC with the support of the Global Environmental Facility (GEF), build awareness of climate change issues, and increase the national consensus and willingness to take action against climate change. Further obligations include providing the international community with information on the inventory and trends of sources and sinks of GHGs emissions in the country.

The country started its efforts within the UNFCCC in 2007 with a program supported by the (GEF) and managed by the United Nations Development Programme (UNDP). The program was aimed at building national capacity in documenting national emissions of greenhouse gases and preparing Syria's Initial National Communication (INC-SY) to the UNFCCC. INC-SY was submitted to the secretariat of the UNFCCC in December 2010. The goal of the report was to provide support for the government of Syria in preparing the first communication report on climate change according to a methodology followed by all member countries and to submit it to the conference of COP. In addition to enhancing the national capacity for the synergistic implementation of the UN Framework Convention, the report was also aimed at:

- Identifying challenges hindering adaptation to climate change.
- Identifying national constraints limiting proper implementation of the activities related to the UN Framework Convention on Climate Change.
- Providing a practical framework to enhance the national capacity for the synergistic implementation of the UN Framework Convention on Climate Change.
- Streamlining the commitments and obligations entailed in the global environmental management system and convert them into national policies.

The preparation of INC-SY on Climate Change included the following four main themes:

- Identifying national circumstances (Meslmani, 2010).
- An inventory of greenhouse gas emissions (Meslmani and Khorfan, 2009).
- Programs to measure adaptation to climate change (Meslmani and Abido, 2009).
- Programs to measure the mitigation of greenhouse gas emissions (Meslmani and Kordab, 2010).

All studies were conducted by the project's management in cooperation with national experts from different stakeholders and under the direct supervision of the MSEA.

The INC-SY report also established a national GHGs inventory, assessed Syria's vulnerability to climate change, and helped make a preliminary assessment of some specific mitigation measures and opportunities to reduce GHGs emissions in various sectors. The enabling activities for preparation of INC-SY were fully conducted and the report also submitted (Meslmani *et al.*, 2008).

In order to continue to fulfill commitments to UNFCC in accordance with the relevant decisions of the COP, the first GHGs inventory of Syria's current emissions of authorized GHGs was conducted using IPCC guidelines. This inventory also provided information on emissions of non-direct GHGs, such as CO and NMVOC. It also provided statistics on emissions of SOx. The GHGs inventory also gave information on main sectors of the economy, such as energy, agriculture, industry, transport, and waste, which further enabled the country to deal with other environmental issues. It also provided data on economic and social development, which play a helpful role in planning and management (Meslmani and Khorfan, 2009).

The GHGs inventory considered the year 1994 as the benchmark year for calculation, as recommended by the COP. The calculations were carried out for the years spanning between 1994 and 2005, in order to evaluate trends and time series of GHGs emissions. They were presented within the context of the economic and social progress taking place in the country. The calculations can provide sound basis for evaluating reduction policies and measures. They can also provide a useful tool for developing future scenarios.

As a result of the project called "Enabling activities for the preparation of Syria's Initial National Communication", the reports of the national circumstances, the GHGs inventory, and programs for adaptation and vulnerability to climate change have been defined and analyzed. Therefore, the measures to mitigate the increase of GHGs have been suggested.

The most important National Adaptation Plan of Action (NAPA) which was proposed by INC-SY was adopted in the 11th five-year plan of the country by the State Planning Commission (SPC). The implementation and sustainability aspects of the NAPA were taken into consideration while designing the action plan, as well as proper and effective management and follow-up tools in MSEA and other institutions related to implementing the INC-SY Action Plan (Meslmani and Wardeh, 2010).

NAPA is designed on the basis of the following principles:

1. Develop sustainable institutional coordination mechanisms.
2. Develop clear and systematic integration of the UNFCCC concepts in national policy and legislation.
3. Advance the sustainable development of agricultural and water resources.
4. Generate capacity development, knowledge management, networking, outreach, and awareness.
5. Develop means for technology transfer.
6. Spark local communities' empowerment and participation.

A review of potential evaluation criteria focused on the NAPA Annotated guidelines as well as on the 10th and 11th five-year Socio-Economic Development Plans, the National Environmental Policy presented at the Copenhagen Conference on Climate Change (December 2009), the National Environmental Action Plan for Conserving Biodiversity, and the National Action Plan for Combating

Desertification. Stakeholders were consulted for finalizing the following set of evaluation criteria by which to evaluate each proposed adaptation measure:

- Contribution to sustainable development.
- Livelihood security of local communities.
- Poverty reduction to enhance adaptive capacity.
- Synergy with other multilateral environmental agreements.
- Cost-effectiveness.

NAPA Includes the following 16 projects within the above-listed six principles:

1. Develop a sustainable coordination mechanism among institutions implementing the NAPA.
2. Strengthen the technical capacity of the UNFCCC focal point at the MSEA.
3. Develop a regulatory framework for the systematic integration of the concepts of UNFCCC in national policy and legislation.
4. Develop a policy system for assessing the impact of the economic and trade agreements on the environment.
5. Develop integrated agricultural production.
6. Promote conservation and rational use of water resources including modern irrigation.
7. Develop and implement easily accessible drought forecast and drought monitoring information systems to improve drought preparedness.
8. Develop the investment environment in agriculture and agribusiness.
9. Develop sustainable awareness on adaptation to climate change.
10. Establish and maintain a climate change database.
11. Develop agricultural and water research and extension.
12. Develop knowledge management and networking.
13. Develop a technology transfer system and capacity building for energy efficiency and renewable energy.
14. Develop linkages between policy-making and research, and national policies on technology transfer at the regional and international levels.
15. Create an environment for renewable energy and develop capacity for rational and efficient uses of energy.
16. Develop and implement a comprehensive capacity-building and innovation program for community natural-resource management based on traditional knowledge.

There is a range of challenges that could threaten the ultimate implementation of the priority adaptation activities identified by the NAPA process. Potential challenges stem from various sources, including technical, economic, financial, and institutional aspects at different levels. Therefore, mechanisms for implementing, monitoring, and evaluating NAPA have been developed. Stakeholders agreed that further delay in adaptation would significantly increase the vulnerability of the other sectors and/or lead to much higher adaptation costs in the future. MSEA is considering how to obtain high-level commitment and endorsement of this action plan to help integrate the issue of climate change into the strategies and plans of the relevant main sectors—especially with regard to water and agriculture.

Current domestic mitigation strategies to reduce greenhouse gas (GHGs) emissions in Syria

Review of GHGs emissions in Syria

Emissions by sector

The share of GHGs emissions in key sectors such as energy, agriculture, industry, and waste are presented in figure 3, which shows that the energy sector is the largest contributor with 72% in 1994 and 74% in 2005. The total emissions of GHGs from the energy sector increased from 38.23k ton/year in 1994 to 58.35k ton/year in 2005. GHGs emissions in the agriculture sector increased from 9.47k ton/year in 1994 to 13.93k ton/year in 2005. The share of agriculture and industry decreased slightly only 1%. This means that the energy sector has grown the fastest.

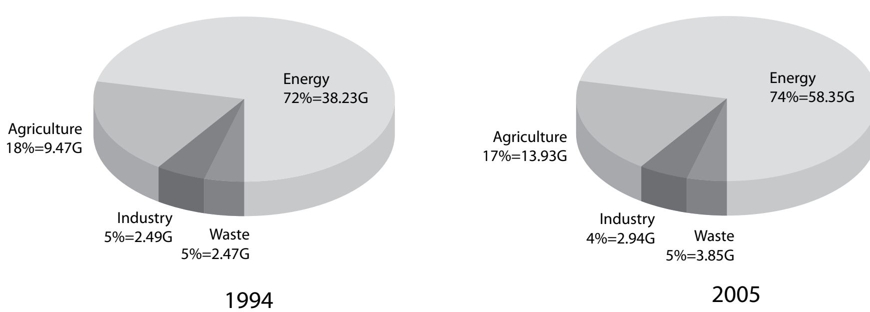


Figure 3. GHGs Emissions by sector in CO_2 for the Years 1994 and 2005

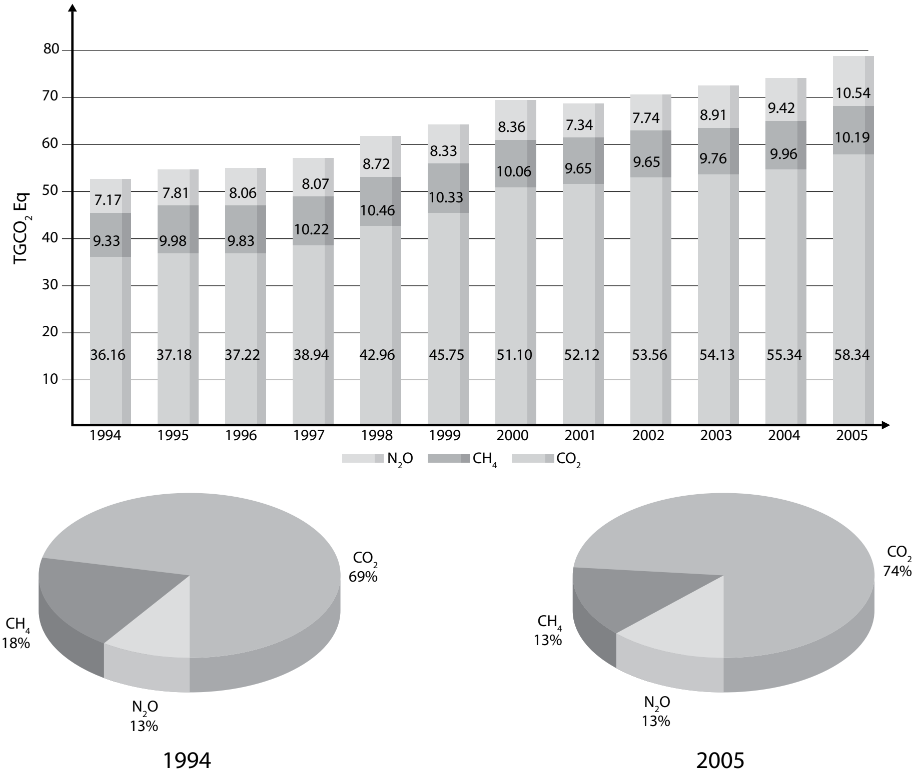


Figure 4. Share of each GHGs from total emissions from 1994 to 2005

Figure 4 shows the share of each GHGs in total emissions. It is clear that the share of CO_2 is the highest: it increased from 69% in 1994 to 74% in 2005, due to the increase in the use of oil and gas for energy (since most CO_2 comes from burning fossil fuels in the energy sector). The share of CH_4 decreased from 18% in 1994 to 13% in 2005, while stay the share of N_2O (13%) during both periods. This could be explained by the high increase in the share of total emissions for GHGs released through the generation of electricity (Meslmani and Khorfan, 2009).

Figure 5 also shows GHGs emissions for the years 1994-2005, by sector. It is clear that emissions from the energy sector have risen steadily and fast, while agriculture's share has remained constant; the same can be said of the waste sector, while industry's contribution has slightly increased from 2.49k ton/year in 1994 to 2.94k ton/year in 2005. This slight increase translates to a decrease in the share of industry in total GHGs emissions from 5% to in 1994 to 4% in 2005, as shown in figure 5.

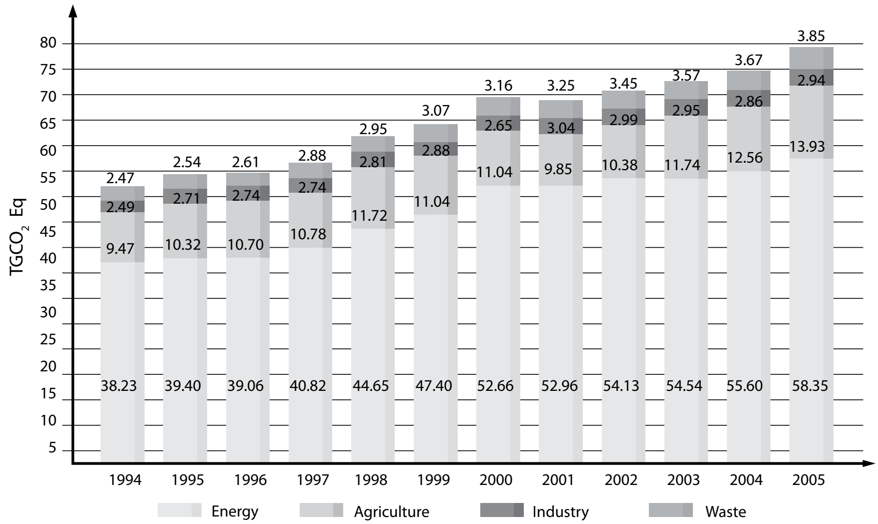


Figure 5. GHGS Emissions according to Sector from 1994 to 2005

Strategies implemented (to be implemented) within Syria to mitigate climate change

Mitigation

Any targets for reducing emissions must take into account (Meslmani, 2011):

- The principle of inclusiveness and mutual vulnerability. In this context, ambitious reduction targets are required to limit the dangers of climate change. This requires dealing with all types of emissions, relevant economic sectors, and all sources of absorption (sinks). Any effective policy must be comprehensive and shall balance the benefits and costs of actions taken.
- The principles of equity and common but differentiated responsibilities and respective capabilities. This implies acknowledgement of historical differences in the contributions of developed and developing countries to global climate change and differences in countries' capacity to tackle its causes and impacts. Hence, a balanced approach is required for distributing burden in an explicit and equitable manner. In this regard, developed countries should take the lead in response measures and not place any new burdens on developing countries. Furthermore, economic mitigation measures should be just and fair and take into account the national circumstances of developing countries.
- The responsibility for the actions taken. Developed countries taking measures in response to climate change should take into account the potential impacts trig-

gered by unilateral measures (including international trade systems) on developing countries. Developed countries must commit themselves to providing compensation to developing countries that are adversely affected by such measures.

In this context, the Syrian Arab Republic believes that the following issues are important and must be emphasized:

1. Reductions of global emissions must be calculated on the basis of historical responsibility. All developed countries should be included in mitigation commitments and also demonstrate their leadership in reducing emissions of greenhouse gases due to their historical, current, and direct responsibilities.
2. Developed countries should commit to reducing greenhouse gas emissions by 2050 in order to achieve a minimum level of stability in the global climate. Therefore, post-Kyoto emissions reduction commitments should be no less than 40% below 1990 levels by 2020.
3. Developed countries should meet their national-level emissions reductions either in cooperation or coordination among them, and support the efforts of developing countries for a voluntary shift towards a low-carbon economy. Low-carbon development plans need to be based on each country's respective responsibility and capability, and their development should be financially and technologically supported by developed countries.
4. Any reductions in GHGs emissions in developing countries should be voluntary (non-binding). Voluntary initiatives include, among other things, Nationally Appropriate Mitigation Actions (NAMS), provided that there is access to adequate financial and technological support and assistance in capacity building from developed countries.
5. Developed countries should provide funding and technological support to developing countries to cover the full incremental cost of measurable, reportable, and verifiable (MRV) NAMAs. This must include the costs of monitoring and evaluating progress in mitigation measures for future commitment periods, within a transparent mechanism and an agreed-upon scope. In this context, the quantified obligations of developed countries must be MRV.
6. National action plans may include purely national mitigation procedures and other measures to move to a low-carbon economy through agreed NAMAs, enhanced and supported by adequate funding, appropriate technology, and capacity-building from developed countries. These measures may include market measures, increasing the efficiency of energy production and use, rationalization of consumption, and enacting laws for energy conservation. On the other hand, developed countries should not offset their full obligations as a result of voluntary reductions from developing countries.

7. Developed countries must be responsible for negative impacts resulting from implementation of response measures. Actions taken must not adversely affect sustainable development in developing countries. Developed countries shall not resort to any form of unilateral actions to reduce GHGs emissions, including emissions from the maritime and aviation sectors.
8. Facilitating access to a Clean Development Mechanism (CDM), and providing funding and capacity-building for the preparation and submission of project proposals under the CDM. In this context, carbon capture and storage (CCS) projects should be included under the CDM arrangement.

While preparing INC-SY to the UNFCCC, various national reports related to mitigation actions in several important sectors within Syria such as the energy, renewable energies, transportation, and building sectors were drafted, which served as basic material to subsequently identify the possible opportunity to propose a Framework for the NAMAs-Syria (Meslmani, Housami and Tannous, 2010; Meslmani and Kherfan, 2010; Meslmani and Hainoun, 2010; Meslmani and Zein, 2010a; Meslmani and Zein, 2010b; Meslmani and Al Shaar, 2010; Meslmani, Asfari and Daoud, 2010).

Therefore, the work of INC was to include GHGs emmission reduction opportunities and possibilities for different economic sectors, as well as the increasing of sinks. The potentials of utilizing significant renewable energy sources will be highlighted in the country (hydro, geothermal heat, biomass, solar, and wind), in addition to other alternative energy resources such as natural gas. Furthermore, cost-effective means of addressing low energy efficiency will be considered (Antipolis *et al.*, 2001).

In order to do so, activities to study mitigation possibilities either have been or are going to be performed; which include the following:

- Identifying priority sectors for financing analyses with regard to GHGs key source analyses.
- Establishing database systems for each priority sector and for macroeconomic parameters of the country.
- Selecting methodology and detailing the level of GHGs projected for each sector, and identifying uncertainties.
- Analyzing options to reduce GHGs emissions increases and to enhance removal by sinks.
- Elaborating GHGs mitigation measures for priority sectors (power, transport, industry), assessing the feasibility of their implementation, and facilitating integration of these measures in national programs and strategies.

- Preparing mitigation report including assessing financial obstacles for each priority sector.
- developing national action plan for climate change mitigation measures.

The type and the source of GHGs emissions, as well as mitigation measures for each sector, were described as shown below:

Table 1. The type and sources of GHGs emissions, as well as the mitigation measures for each sector

Sector	GHGs emissions	Sources of emission	Mitigation Measures
Waste	CH_4, CO_2, H_2S	Landfill, solid waste, incinerators, domestic and industrial wastewater treatment plants	◗ implement solid waste minimization principle and encourage solid waste recycling ◗ implement the national strategy for solid waste management, enforce laws and regulations
Transportation	CO, CO_2, NO, NO_2, SO_2, (VOC)S	Transportation facilities small, medium, heavy	◗ vehicle specifications: modify engine to be environmentally friendly, implement periodic emission monitoring programs on vehicles ◗ reduce fuel consumption by improving transportation systems and encouraging public transportation and car pooling ◗ reduce emissions from heavy vehicles by improving regional transportation system through the development of a train system ◗ increase public awareness ◗ distribute peak hours by implementing different working schedules among agencies
Energy	CH_4, NOx, CO_2	Power generation plants such as refineries	◗ insulate homes and create environmentally designed buildings so that energy needed for lighting and heating is minimal ◗ use of renewable energy sources such as wind energy, bio-energy, and hydropower ◗ encourage energy conservation and efficiency
Agriculture and forestry	N_2O, CH_4, CO_2	◗ Animal product facilities ◗ Vegetation cover ◗ Agro-chemical materials (pesticides, fertilizers) ◗ Land use, agricultural wastes	◗ increase and enhancing the vegetation cover ◗ conserve natural resources ◗ plant drought-resistant plants ◗ encourage animal raising in natural range land ◗ minimize the use of chemical material and agricultural waste

Sector	GHGs emissions	Sources of emission	Mitigation Measures
Industry	CO_2, N_2O, CH_4	◗ burning fossil fuel ◗ fertilizer industry ◗ animal waste ◗ wastewater treatment plants ◗ food industry	◗ use water-saving technology in industry, agriculture, and municipal services ◗ reuse treated wastewater ◗ increase energy efficiency utilization
Water	CH_4, CO_2	◗ wastewater ◗ irrigation water in fields and farms ◗ pumping systems in water irrigation projects	◗ water conservation ◗ implement water harvesting techniques ◗ implement desertification prevention measures

Current domestic adaptation strategies related to damage reduction and disaster prevention associated to climate change within Syria

The Mediterranean basin is a highly heterogeneous region where natural phenomena interact in a very complex way, thereby leading to significant inter-annual variability in its climate. Moreover, human activity, which is linked to such variability, has a strong impact on climate at both the local and regional levels (Antipolis *et al.*, 2001). The Mediterranean basin is also very sensitive to interactions with other parts of the world, e.g., influences of the North Atlantic Oscillation (NAO) and the Indian Monsoon. Dust transport from the Sahara to the Atlantic Ocean through the Mediterranean basin has been evidenced. In socio-economical terms, there is a wide spectrum of interactions with natural impacts. This ranges from the influence of invasive imported species on land and marine ecosystems to the footprint of globalization. The economical and socio-cultural impacts are on both local and regional scales. They in turn influence land-use and land-cover practices (*idem.*).

The Syrian climate as a part of the eastern Mediterranean region is determined by dynamic factors that are related to the circulation of the atmosphere and air masses both within and outside the region, including the semi-permanent pressure systems of the cold Siberian high pressure that dominates the winter; the Indian Monsoon low pressure that prevails in summer, and the heat lows of North Africa (Khamaseen). At times, particularly during winter and in the transitional seasons, moving depressions and associated weather, accompanied by the extension of the Sudan trough, affect the area. Topography plays an important role in climate (Meslmani *et al.*, 2008; Antipolis *et al.*, 2001).

Climate monitoring in Syria during the last decade of the 20th century was not adequate and resulted in an overall lack of reliable data on local climate change patterns. In addition, climate change considerations are still poorly integrated into the sectorial and development policies; national capacity for planning and policy development is weak; vulnerability assessment and the development of adaptation measures are almost non-existent; and decision-makers' awareness regarding climate change is also inadequate. Therefore, database construction, based on available historical climate data from the last century and the climate change scenario are the most important tasks of the INC of Syria.

Along with the climate change scenario, a socio-economic scenario of various sectors/systems was developed. Based on future trends in climate change in Syria, the vulnerability and adaptation assessment was conducted for the following sectors: energy, agriculture, forestry, water resources, the coastal zone, natural ecosystems, and human health. The vulnerability assessment identified the most vulnerable systems and regions to climate change in Syria. Based on this assessment, appropriate methodologies will be employed in adaptive capacity needs assessment and in designing an adaptation strategy and policy options.

Integration of climate change issues, including the integration of adaptation measures into the national programs, such as MDGS, NEAP, etc., must be the key methodological approach. Therefore, the ways and means for effective integration of adaptation measures into development and country strategies must be elaborated with particular focus on the procedural and methodological aspects of mainstreaming. For success, coordination among all relevant ministries and government agencies and units during the preparation of adaptation measures must be ensured, along with the maximum participation of stakeholders and transparency of the process (Meslmani, 2007).

Current domestic adaptation strategies (done, to be done):

- Data collection and construction of climate database.
- Assessing climate variability and extreme events (droughts, floods, etc.).
- Selecting appropriate methods and approaches for the development of climate change scenarios.
- Developing scenarios for future climate change and vulnerability in Syria.
- Developing environmental-socio-economic scenarios taking into account the regional, national, and local parameters, priorities, and programs.
- Assessing the vulnerability of agriculture and forestry, water resources, coastal zone, natural ecosystems, and human health for the most critical areas.
- Analyzing policy options and elaborating adaptation measures for all vulnerable sectors/systems.
- Assessing capacity for the implementation of adaptation measures.

- Providing stakeholders involvement in adaptation strategy development.
- Identifying ways and means for effective integration of adaptation measures into the developmental and sectorial national strategies of Syria.
- Preparing an adaptation and vulnerability report to produce awareness-raising material.
- Implementing information, dissemination, and awareness campaigns for both the public as well as for decision-makers.

Expected scenarios of climate change on the Syrian coastline and other areas in Mediterranean zone

As part of the Mediterranean basin, the Syrian coastline with other areas and islands of other countries on the Mediterranean Sea, for example the island of Rhodes, Kastela Bay, the island of Malta and the islands of Cres and Lošinj, were the site of a study conducted in 1996 to apply climate change scenarios, the results can be summarized as follows (Based on Antipolis *et al.*, 2001):

Temperature scenarios

On an annual scale, the temperature sensitivity is generally lower than the global sensitivity evidenced by the simulations, except for the northern part of the island of Cres (+1.1°) and the northern part of the Syrian coastline (+1.2°, these two results corresponding to a 1° global mean temperature increase). On a seasonal scale, the results are generally lower than the mean annual global warming. Katela Bay shows the lowest sensitivity, while the Syrian coastline and the islands of Cres and Lošinj show the highest.

Rainfall scenarios

The island of Rhodes is facing the most favorable change—a rainfall increase in every season. Kastela Bay experiences a rainfall increase in every season, except in autumn. The total rainfall amount is decreasing on the Syrian coastline, while changes are not significant in Malta and the islands of Cres and Lošinj.

Synthesis for these detailed scenarios

Rhodes is the most favorable site, with small temperature changes and a significant rainfall increase. Kastela Bay experiences a rainfall increase (except in autumn) with a temperature increase under the average values. The worse situations are for the islands of Cres and Lošinj, which experience a temperature sensitivity close to the average and no significant rainfall increase, and the Syrian coastline, with a rainfall decrease and a temperature increase close to the mean global change values.

The results show that climate change does not exert just one single effect on a specific country or a region, but rather that its effects span across the globe. On the other hand, it is obvious that in order to face the challenges produced by climate change, efforts must be coordinated regionally, internationally, and globally.

Conclusion

Climate change is the defining challenge of our generation. It is obvious that in order to face the challenges produced by climate change, efforts must be coordinated regionally, internationally, and globally.

Syria is the heart of the Middle East. Therefore, projects to fight climate change at the regional level in the Middle East would be vital. More efforts are needed and more plans that are cooperative must be drafted. On the other hand, the need for cooperation in terms of combating climate change is crucial. Since the effects of climate change will include the Mediterranean Sea and the countries surrounding it, Syria is participating in Mediterranean efforts to reduce the effects of climate change by joining Mediterranean cooperation programs such as the Short and Medium Term Priority Environmental Action Program (SMAP), Mediterranean action Plan (MAP) and all its affiliated centers, etc. Furthermore, Syria is joining the international efforts to combat climate change by signing the UNFCCC and through its work with UNDP and UNEP. However, this does not mean that no more actions and efforts are needed. The need to create a worldwide network is essential and vital in order to be able to deal with worst-case scenario of climate change.

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Declaration on Environmental Health and Climate Change

First International Congress on Environmental Health
Guadalajara-Zapopan, Jalisco, Mexico.

WHEREAS:
The researchers gathered at the First International Congress on Environmental Health in Zapopan, Jalisco, Mexico acknowledge that climate change demands innovative research in order to diminish risks that have multiple repercussions on health and well-being.

We recognize that the socioeconomic development of nations is sustained by the use of diverse technologies, designed under the assumption that natural resources must be exploited, without regard to the costs incurred by the damage inflicted on the environment and the health of present and future generations of humans.

One factor that contributes to the adverse effects of climate change is the lack of appropriate land-use regulation, substituting essential services provided by ecosystems with a rapid and ill-planned urbanization that multiplies and intensifies the stress on the environment and heightens vulnerability.

It is necessary to identify those population groups and areas that are vulnerable to different types of impact resulting from climate change, in order to design adaptive measures to prevent further adverse effects and protect their health.

It is also necessary to include these topics in basic and secondary education curricula, in addition to higher levels that enable interdisciplinary research, as well as in adaptation and mitigation proposals. The foregoing is proposed by virtue of the recognition of health as a cross-sector element for all productive and social sectors.

Likewise, we recognize that, despite the fact that 20 years have passed since the first scientific report on climate change and health, this topic has yet to be included as a matter of priority on institutional agendas, notwithstanding the increase in disasters derived from the surge in the frequency and intensity of extreme temperatures and other climatic phenomena (e.g., droughts and floods) which directly affect the population's health, in addition to several illnesses and diseases sensitive to the effects of climate change, such as malnutrition, diarrhea, and vector-borne diseases.

THEREFORE, we propose the following:
Enact measures geared toward understanding and communicating the effects of climate change on health as a priority.

Assess adaptation measures to face health risks linked to climate change and undertake quantitative and qualitative assessments of their effects on health.

Establish networks of experts to share information, knowledge, skills and tools and produce learning and exchange programs involving members and institutions in order to train high-level researchers in such areas.

Exchange information on climate change and its effects on health, which will contribute to adaptation.

Promote research to assess the effects of climate change on the health of vulnerable population groups, such as young children, the elderly, people with pre-existing conditions, and the poor, especially women and marginalized or displaced rural and urban populations.

Establish guidelines on how to assess vulnerability and adaptation at all levels, prioritizing their vulnerable condition. Such assessments will allow for a better understanding of current and future health risks that result from climate change and the uncertainty related to such risks.

Determine the approach and instruments to be used in quantifying the burden of morbidity attributable to climate change.

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