A CHRISTIAN VIEW ON CLIMATE CHANGE

THE IMPLICATIONS OF CLIMATE CHANGE FOR LIFESTYLES AND EU POLICIES

A Report to the Bishops of COMECE

COMECE

Secretariat of the Commission of the Bishops' Conferences of the European Community

COMECE, NOVEMBER 2011
2 edition

Commission of the Bishops' Conferences
of the European Community
Square de Meeûs, 19/1 – B-1050 Brussels – Belgium
Tel. +32 (0)2 235.05.10 – Fax +32 (0)2 230.33.34
comece@comece.org - www.comece.eu

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INTRODUCTION

Climate change poses an increasing threat to the well-being of humanity both for present and future generations. In fact, it is increasingly understood to have become a question of survival for a large part of mankind. The scientific community is overwhelmingly convinced that ongoing climate change is caused primarily by the increase of man-made greenhouse gas emissions and by the over-consumption of natural resources as a result of the lifestyles of the industrialised societies, the societal and economic systems underlying these lifestyles and the increasing pressure this puts on people and resources in the developing world.

For most of human history there has been a tacit acceptance of the need to exploit our environment to create a world fashioned to suit our needs for food, shelter, transport and technology. Today, technology has enabled us to become dominators of the natural world. We must recognise that the unsustainable, resource-intensive lifestyles of the industrialised world today cannot be made available to all the people of the world and they prejudice the Earth's capacity to support those who come after us.

Independently of whether the oil peak – or as some argue the 'peak everything' – has already been reached or not, the absorption capacity of the atmosphere for greenhouse gases will very soon be reaching its limits and energetic and immediate action will be needed at all levels. If we do not start now to achieve a serious reduction of greenhouse gas emissions, then the costs of mitigation and adaptation will dramatically increase and some of the damage such as the extinction of natural species will be irreversible.

Climate change is an issue of justice for all Creation; it is especially an issue of intra- and inter-generational justice. It is part of Christian belief that the world is a testament to the goodness, beauty and power of God and that we have a responsibility of stewardship for it. Any threat caused by human action to the functioning of our fragile planetary home is therefore a repudiation of our fundamental ethical responsibilities and a danger to the web of life to which we are all intimately connected.

Following earlier publications on the stewardship for Creation, Pope John Paul II, in particular, devoted his 1990 Message of Peace, for example, to the responsibility for Creation. In his Apostolic Letter *Ecclesia in America,* published in 1999, Pope John Paul II listed among the 'Social Sins which Cry to Heaven' the irrational destruction of nature and especially the uncontrolled emission of greenhouse gases and the systematic destruction of rainforests. Pope Benedict XVI in his letter of September 2007 specifically emphasised that: "*The*

preservation of the environment, the promotion of sustainable development and particular attention to climate change are matters of grave concern for the entire human family. No nation, no economic domain can avoid acknowledging the ethical implications linked to all economic and social development." During the welcoming ceremony for World Youth Day on 17th July 2008, Pope Benedict XVI underlined that "*the wonder of God's Creation reminds us of the need to protect the environment and to exercise responsible stewardship of the goods of the Earth" and the need "to reflect upon the kind of world we are handing on to future generations*".

In this regard, reference should also be made to the *Compendium of the Social Doctrine of the Church* drawn up by the Pontifical Council for Justice and Peace and published in 2004. In this document the whole of Chapter 10 is devoted to environmental problems and, under paragraph 470 in relation to climate change, it is stated that: "*The climate is a good that must be protected and reminds consumers and those engaged in industrial activity to develop a greater sense of responsibility for their behaviour*."

Various Bishops' Conferences have in the recent past also looked at the issue of climate change. In addition, they have produced documents dealing generally with responsibility for Creation; in particular, the United States Bishops' Conference with a document in 2001 on '*Global Climate Change*' and the German Bishops' conference with an extensive expert document entitled '*Climate change: focus on global, inter-generational and ecological justice*' in 2006 (second updated edition 2007). Other Bishops' Conferences are also working on similar documents or have organised study seminars on the subject.

In ecumenical terms, in addition to stating that responsibility for Creation "s*hould be observed and promoted as a part of Church life at all its levels*" (Graz, recommendation for action no. 5), the World Council of Churches (WCC) has also announced a '*Climate Change Programme*' and, at European level, the three European Ecumenical Assemblies held so far, (starting with Basle (1989) and followed by Graz (1997) and Sibiu (2007)), have placed particular emphasis on Christians leading sustainable lifestyles "*that reverse our contribution to climate change*", as cited in recommendation no. 10 from Sibiu.

However, the issue goes beyond climate change: it is simply a visible symptom of the non-sustainability of our way of life. Meeting the challenge of climate change must therefore be seen in the context of sustainability in a just world offering an equal sense of well-being to peoples all over the world and over all the generations of mankind.

1. SCIENTIFIC FACTS ON CLIMATE CHANGE AND PROJECTIONS FOR THE FUTURE

A picture of unequivocal evidence of accelerating climate change is emerging from many parts of the world, including Europe. The latest report of the Intergovernmental Panel on Climate Change (IPCC), a UN-coordinated effort involving more than 2000 scientists from all over the world, has now been endorsed by almost every government in the world and raises important moral and ethical issues, not just for Christians but for all concerned with the harmony of God's Creation (see the key messages from the last IPCC report in Appendix).

Observed climate change

Climate does change naturally over time in response to external and internal factors. However of most significance for climate today are the changes occurring in the composition of the atmosphere. Greenhouse gases, such as carbon dioxide, methane and nitrous oxide, exert a disproportionate influence on the temperature of the Earth. Measurements taken from a variety of sources, such as bubbles of air in deep ice cores, show that the concentration of greenhouse gases has increased as a result of human activities to a level higher than at any time in the last 650,000 years.

As knowledge and understanding about the workings of the atmosphere have increased, the tone of the IPCC reports has become increasingly assured and IPCC's conviction that climate change today is driven by human action has become increasingly unequivocal. By the time of the publication of the 4th Assessment Report in 2007, this conviction had turned into a near certainty: "Most of the observed increase in globally-averaged temperatures since the mid-20th century is *very likely* due to the observed increase in anthropogenic greenhouse gas concentrations". In this context *very likely* equates to a greater than 90% probability.[1]

The debate as to whether the Earth is warming or not is now over. Warming has been unequivocally demonstrated from a variety of sources including surface and satellite observations, large-scale melting of snow and ice and rising global sea levels. Among the more significant findings, the following indicate the quickening pace of global climate change[2].

[1] See note 6 in the Appendix.

[2] For a more detailed description of the changes see the Appendix.

- The last 50 years have been the warmest in at least the past 1300 years in the Northern hemisphere with 11 of the warmest 12 years on record globally occurring since 1995.
- The average temperature of the oceans has increased to depths of 3 km. Such warming has caused seawater to expand, contributing to sea-level rise. The rate of sea-level rise has accelerated to 3.1mm/year over the past decade.
- Temperatures in the Arctic increased at almost double the global average rate in the past century. This has led to reductions of about 7% in seasonally frozen ground in the Northern Hemisphere and an ongoing reduction of Arctic summer sea ice of 7.4% per decade.
- Significant changes in precipitation are occurring. Increased precipitation is evident in northern Europe and northern and central Asia, and in eastern regions of North and South America. Reductions in rainfall are occurring in the Sahel, Mediterranean, southern Africa and parts of southern Asia.
- Marked changes in the frequency of extreme events such as storms, floods, droughts and heat waves are occurring. An increase in intense hurricane activity in the Atlantic has been occurring since the 1970s. Parts of Europe have experienced deadly heat waves and fatal flood events. Some portent of this is suggested by the abnormally hot summer of 2003 in western and central Europe when it is estimated that at least 35,000 excess deaths occurred.

These changes have come about remarkably quickly. While a small community of sceptics remains convinced that human activities are not the main causes, overwhelming scientific opinion is agreed that natural processes are *not* the cause of recent warming. But even if some doubts should remain, the precautionary principle dictates that we should reduce greenhouse gas emissions and adjust our lifestyles in order not to jeopardise the options open to future generations for coping with the problems that the present generation has largely created.

Time pressure on climate policy is growing

The IPCC confirmed that global anthropogenic greenhouse gas emissions increased by 70% for the period 1970 to 2004. In addition to the continuously growing emissions of greenhouse gases from the industrialised countries, emissions from countries in transition, especially China and India, are becoming increasingly important. Growth rates there currently exceed by far those in the USA and Europe. Nevertheless, Europe and the USA alone account for more than half of global CO_2 emissions since the beginning of industrialisation, and thus bear most of the responsibility for anthropogenic climate change.

Although the energy consumption per unit national product and the carbon intensity of energy production have decreased, these emission-reducing factors have been more than offset by the increases in world population and in global production. Further growth in world population and labour productivity will lead to a noticeable increase in greenhouse gas emissions if energy and climate policies are carried on as 'business as usual'. Special attention must also be given to the CO_2 emissions stemming from the deforestation of rain forests. These already amount to 20 % of worldwide CO_2 emissions. The essential diagnosis of the Fourth Assessment Report is therefore: "*We are not on the right track!*". It follows that considerable efforts are needed to decarbonise the economy. Worldwide emissions can only fall if energy and carbon intensity decrease faster than the growth in world population and labour productivity.

No industrialised nation has so far succeeded in permanently decoupling its economic growth from the emission of greenhouse gases. The economically most prospering countries like China and India – but also countries with direct access to coal such as the USA and Russia – are likely to increasingly generate electricity from brown and black coal, fossil fuels that are even more greenhouse gas intensive than the oil and gas that so far have fuelled much of the economic growth in Europe and the USA. At the present growth rate, with 'business as usual' thinking, even if energy efficiency is further increased and the use of renewable energy sources and nuclear energy is expanded as planned, this will most likely be insufficient to bring about a permanent decoupling of economic growth and emissions.

Climate projections: towards the warmest human climate ever?

Now that there is more confidence that global warming is a fact and that it is mostly due to the influence of greenhouse gases originating from human activities, it is important to quantify the changes that can be expected if emissions continue unabated. The IPCC has based its projections of unmitigated future climate on model simulations driven by a range of plausible emission scenarios over the next hundred years. In its last report in 2007, the IPCC estimates that without serious emission reduction policies, global temperature would likely rise by 1.6 to 6.9°C above the pre-industrial level[3] by 2100, depending on the emissions scenario and the model that is used. To put it into perspective, the last deglaciation, which lasted several thousand years, was associated with a global temperature increase of the order of 4°C (leading to the pre-industrial temperature). And the last time the Earth was warmer by more than 2 to 3°C above the pre-industrial level was about 3 million years ago. Many

[3] The pre-industrial temperature was about 0.5°C lower than the temperature of the late 20th century which is also used as a reference to express global temperature increases (see note d, Table 1 of the Appendix).

other climate parameters will be affected too: according to the IPCC: average sea levels will likely rise by between 18 and 59 cm (at least) over this century on the same scenarios and will continue rising for centuries once the temperature has stabilised. The water cycle will be intensified, generating more droughts in some regions and floods in others. The frequency of extreme hot temperatures, heat waves and heavy precipitation will very likely increase. Tropical cyclone intensity will likely increase. Precipitation increases are very likely in high latitudes and decreases likely in most subtropical land regions, continuing recently observed trends. There is high confidence in the projection that by mid-century, annual river runoff and water availability will decrease in some dry regions in the mid-latitudes and tropics. There is also high confidence that many semi-arid areas (e.g. Mediterranean Basin, western United States, southern Africa and north-eastern Brazil) will suffer a decrease in water resources due to climate change.

One should realise that there is a dual explanation for the considerable degree of uncertainty indicated by the range of temperature increases (1.6 to 6.9°C) contained in these projections. The first source of uncertainty is human: no one can predict which emission scenario will in the event be realised over the coming 100 years. The second is inherent in the science: climate models have different sensitivities to emission changes because of computer limitations and the choices made by modellers to approximate the physics of some elements of the climate system, such as clouds. For example, the lowest non-mitigated scenario which was considered leads to a range of likely temperatures ranging from 1.6 to 3.4°C above the pre-industrial level.

2. IMPACT OF CLIMATE CHANGE ON ECOSYSTEMS AND CITIZENS

The temperature changes described above have significant consequences for the climate system and these changes impact on natural and managed ecosystems as well as on economic sectors such as agriculture and forestry, water management, energy, and many aspects of tourism.

Though average conditions may change relatively slowly, other more extreme events will alter in frequency and intensity much more radically. Some of the important implications listed by the IPCC in their 4th Assessment Report for Europe are as follows[4]:

- Climate change is expected to magnify regional differences in Europe's natural resources and assets.
- Increased risk of inland flash floods, and more frequent coastal flooding and increased erosion.
- Mountainous areas will face glacier retreat, reduced snow cover and winter tourism, and extensive species losses. In southern Europe, climate change is projected to worsen conditions (high temperatures and drought) in a region already vulnerable to climate variability, and to reduce water availability, hydropower potential, summer tourism and, in general, crop productivity.
- Climate change is also projected to increase the health risks due to heat waves, and the frequency of wildfires.

Although climate change will have serious impacts on Europe, its overall impacts will be even more severe in other parts of the world. The world's poorest communities with low adaptive capacities and high vulnerability will suffer a range of serious impacts:

- Hundreds of millions of people will be exposed to water shortages and increasing drought, forcing several millions of people to migrate by the middle of this century.
- Up to 30% of the world's plant and animal species will be at increased risk of extinction, if global average temperature exceeds 2 to 3°C above the pre-industrial level. Nature's ability to adapt to climate change is slow and the main problem for many species may be the rapidity of the changes involved.
- Reductions in cereal crop yields will occur throughout the tropics. Even a small local temperature rise of less than 2°C will lead to a reduction in crop yields in

[4] For a more detailed description of impacts see the Appendix.

many parts of the tropics, while 3°C may have a similar effect in middle and high latitude regions.

- Increased damage from floods and storms will affect millions of people.
- Increasingly severe health problems from disease and malnutrition are likely to emerge. The range of vector-borne diseases such as malaria, dengue fever, yellow fever and some forms of meningitis will be affected.
- Deaths from heat stress will increase generally, especially in urban areas. Climate change is projected to bring some benefits in temperate areas, such as fewer deaths from cold exposure. Overall it is expected that benefits will be outweighed by the negative health effects of rising temperatures, especially in developing countries.
- Some low lying tropical nations may suffer major inundation from rising sea levels, especially in the densely populated delta regions of Asia and Africa. The viability of some small island nations will be severely threatened by rises in sea level and by saline intrusions into their groundwater resources.
- The melting of glaciers and snow cover is projected to significantly affect water availability for human consumption, agriculture and energy generation in regions supplied by meltwater from major mountain ranges, where more than one sixth of the population currently live.
- Conflicts over dwindling resources, such as water and food, are likely to become more common and deadly. Two thirds of humanity could be suffering from water shortages as early as 2050.

Figure 3 of the Appendix shows an overview of the effects (IPCC, 2007) related to different temperature increases. It demonstrates the necessity of limiting the temperature rise to the lowest feasible level.

In addition to these ongoing changes, that are in themselves daunting in their effects on our global society (and economy), climate 'tipping points' loom ahead: Crossing these tipping points could either initiate positive feedback loops in the climate system that mankind will not be able to stop or they could cause climate changes of a dimension that cannot be handled by our societies. There is some hope that stabilising the climate at or below 2°C above the pre-industrial level could prevent this. In view of these developments, there is no doubt that mitigation actions must be taken to reduce greenhouse gas emissions. The IPCC and the Stern Report arrive at the conclusion that, on the one hand, the costs of mitigating global warming are comparably small if immediate action is taken; on the other hand, that adaptation is more efficient but limited in scope. It is not a question of choice: both measures must be implemented the world over and this must be done rapidly and energetically.

3. ADDRESSING THE POLICY CHALLENGES OF CLIMATE CHANGE

The consequences of non-action

There are those who claim that taking remedial measures on a case by case basis as impacts of climate change - such as floods and droughts - occur is economically more efficient than taking mitigating actions to stabilize the climate. In the very short term, and from a purely financial point of view, this may well be true as, due to the inertia of the climate system, the main climate benefits from mitigating actions will not take effect within the next two decades. However, this approach is neither compatible with sustainable development, nor is it ethical in the Christian sense. Lives lost in climate-induced disasters, or plant and animals species once extinct, cannot be restored whatever the amount of money. Even more importantly, inaction for the next years will almost certainly make it impossible to avoid crossing climate tipping points leading to, for example, changes in the monsoon dynamics in China or India; or melting of Himalayan glaciers that supply about one sixth of the global population with water; or sea level rises well above one metre. The consequent need to relocate millions of people (in both Bangladesh and Egypt, for example, more than ten million people live below one metre of the average sea level) makes monetary scales absolutely meaningless.

Inaction is unpardonable because the actions required do not demand unacceptable sacrifices by the industrialised world – on the contrary, they primarily require structural changes that are affordable, and changes in social practices and habits; and these can be seen as the opportunity to return to the true values in life. Their costs in terms of money are well below the global annual expenditures on armaments. The choice therefore is not between fighting climate or poverty and illness, as is sometimes argued; on the contrary, climate protection is an essential contribution to fighting malnutrition, illness, and poverty.

Ways of reducing greenhouse gas emissions

Essentially, there are four ways of reducing greenhouse gas emissions, especially CO_2:

- Reducing demand for emissions-intensive goods and services: This option has by far the highest potential for emission reductions in the industrialised world and it can be implemented immediately, although some aspects, such as adapting land-use planning to reduce travel distances may take some time.
- Increased efficiency, which can save both money and emissions: The potential for resource efficiency far exceeds the potential for switching to low carbon

technologies and immediate implementation could boost local economies. The economic potential for emission reductions through efficiency improvements in, for example the building sector, is estimated by the IPCC to be up to three times that for other sectors including energy supply, industry, agriculture and transport at low carbon prices (see Figure 4 of the Appendix). Efficiency increases are a typical win-win situation. Yet, apparently, more incentives are needed to induce investments in efficiency. Rising energy costs are likely to advance this trend.

- Action on non-energy emissions: On a global scale, actions such as avoiding deforestation can make a considerable contribution to combating climate change. In the industrialised world appropriate measures could be, for example, switching to farming methods accumulating humus in the soil or reducing meat consumption.
- Switching to lower-carbon technologies for power, heat and transport: These are certainly needed to supply the energy that will still be required after the measures of demand-reduction and efficiency-increase; but their practical potential in the short term should not be overestimated, given the time that has been wasted by not implementing them widely.

The double challenge of Energy policy: Decarbonisation and scarcity

Over the last century economic growth and the resource-intensive lifestyles of the industrialised world were only made possible by drawing on non-renewable energy: stocks of coal, oil, gas and uranium. This has to change.

The IEA's *World Energy Outlook 2008*, to be published in November 2008, is expected to predict that energy supply will fall short of projected energy demand within this decade. This puts humanity at a crossroads: will a serious attempt be made to reduce energy demand and supply the remaining needs from renewable sources or will habit and greed prevail, leading to increased reliance on established coal technology with disastrous effects on the climate?

Renewable energies, solar (thermal and photo-voltaic), wind, water and biomass, when used in a sustainable manner are low in carbon emissions and essentially unlimited. In fact, energy from solar radiation falls on the Earth every day in quantities that are about eight thousand times larger than the total commercial uses of energy over the entire world. However, as efforts to develop renewable energy technologies and to penetrate the market have so far been half hearted at best, renewables will not become available quickly enough to close the energy gap.

In the transport sector, 95% of the energy comes from fossil fuels. Apart from solar powered electric vehicles, the only alternative to replacing fossil fuels without major technological changes will, for the time being, be biofuels.

Unfortunately, the use of biofuels was politically driven without at the same time defining sustainability principles. To continue with this unsustainable policy would lead to ecologically and/or socially unsustainable developments that would result in increased food prices and hunger among the world's poor. The EU is preparing to make sustainability a prerequisite when Member States include biofuels in their targets for the reduction of greenhouse gases; but additional measures are necessary to ban unsustainable biofuels as a means of reducing transport costs.

With sustainability in mind, it is important that biomass production must not compete with food production. There cannot be the slightest doubt that only land, crops and residues that are *not* needed for food production should be used to produce energy or to save energy. Therefore additional research and development efforts are urgently needed to develop a new generation of biofuels on the basis of e.g. straw or natural waste.

Nuclear energy, increasingly promoted as a low carbon solution to the climate problem as well as a means of closing the energy gap, can do neither in the short run: at best, global construction capacities may prove sufficient for maintaining the present nuclear share in the energy mix over the next decade, as an increasing number of nuclear power plants reach the end of their service life. Without entering into the details of the ongoing nuclear debate, it must be pointed out that the use of nuclear energy is in the best case only a niche but not a sustainable solution because of the resource, the safety, the waste and the proliferation problems it creates.

In view of the expected increased use of coal, different technologies are being developed to capture carbon and sequester it (CCS) in depleted oil and gas reservoirs, in aquifers, or in deep-lying geological formations. Although additional energy is needed for sequestration, the overall greenhouse gases and energy balance is considered to be positive. Additional research is needed regarding the long-term stability of CO_2 storage and other possible unexpected consequences of this technology.

All in all, a transition to renewable energies is economically and technically feasible; it is necessary in view of climate change and the end of the cheap oil era; and it is urgent. The roles of nuclear and CCS are subject to debate. In any case, increased resource efficiency and demand reductions have a significantly higher potential for solving the problem.

Cost considerations

The costs of mitigation which are based on efficiency increases and technological change to stabilise greenhouse gas concentrations at a level corresponding to the 2°C limit will amount to less than three percent of the world-wide national product by 2030, if the concentration of greenhouse gases in the atmosphere is stabilised at a level corresponding to the 2°C limit. These costs rise significantly with every year in which action is delayed: According to Nicholas Stern they have almost doubled since the publication of his first estimate in 2006 due to the two year delay.

Economic tools that encourage a market response to greenhouse gas emission reduction are urgently needed. There is an on-going debate on the tools best suited, for example, a global trading system for emission rights or taxes on greenhouse gas emissions; but the essential point is that emissions must be priced and that this price must be predictable in the medium term.

It is essential to keep in mind that climate change is but one symptom of the unsustainable way of life, modes of production and patterns of consumption that have evolved in the industrialised world. Reducing greenhouse gas emissions will not, by itself, solve the problem of sustainability. Neither will geo-engineering solutions such as the suggestion for introducing sulphate aerosols into the stratosphere in order to reflect some of the solar radiation. Without addressing the root problem we will sooner or later find ourselves face to face with other limits of the global ecosystem.

Time for effective climate policy is running out and the potential bill for non-action is running up. Taking the different routes towards the reduction of greenhouse gas emissions will need considerable resolve. In short, an enormous challenge to policy has arisen as a result of climate change. Some ethical considerations are therefore included in this report before we address – in subsequent chapters – the role of the European Union and the desirable contribution of the Church and Christians in Europe in combating climate change.

4. ETHICAL CONSIDERATIONS WITH REGARD TO CLIMATE CHANGE

More and more political leaders and representatives of business recognise the need to address the political challenge of climate change. Furthermore, mitigating measures and adaptation to climate change are achievable at manageable cost.

However, it is also evident that from a European point of view it will be only in the distant future that the benefits of climate change policies will be gained. Why should Europeans therefore accept new laws that pave the way towards a so-called low carbon economy and adopt a different lifestyle in order to address the challenges of climate change? Why should the European Union take a lead role? Why act here and now since the required changes will alter our current methods of production and patterns of consumption, not just at the margins, but at their very core? Changes on this scale will not be achieved in a democratic society simply by requiring citizens to obey the laws. Strong political leadership and, more profoundly, ethical reflection and debate are needed to win over not only the minds but also the hearts of citizens and to make change effective. In this latter respect the Christian ethical tradition has some interesting ideas to offer concerning:

- the meta-ethical question: why humanity's relationship with nature is of moral and ethical concern at all,
- guiding values and principles for setting up ethical norms with respect to climate change.
- ethical discourse and practical examples to encourage changes in the European way of life.

The responsibility for safeguarding the Earth

It must be recognised that the ecological problem is first of all a problem of public ethos, hard to solve without challenging certain ways of organising society, without questioning the ways we live together and the value system of civil society. We should realise at once that the prevalent culture is still quite inadequate to deal with the environmental question. At the heart of this inadequacy lies the still dominant conviction according to which the environment is a mere stock of resources for humanity and, as such, not for inclusion in the realm of ethics. This situation cannot be tolerated any longer. The reason is the simple fact that today humanity's capacity for destruction has become a 'biocide' phenomenon in the sense that for the first time humanity is in

a position to bend nature to its own ends, not just to take advantage of nature, but to manipulate it.

The time has arrived for recognising that the ever-increasing production of material goods is incompatible – given the known production techniques, the present organisation of the economy and the rate of increase of the global population – with safeguarding the natural environment. Above all, the moment has arrived for recognising that when our societies modify the environment too rapidly, they create a situation in which the speed of those changes surpasses the speed of their own adaptation to them. We should be asking ourselves whether the challenge of ecology is not only the pressing urgency of restructuring the present methods of production but, above all, the adoption of new lifestyles, less dependent on material goods and based much more on cultural and relational goods.

It is time to recognise that humanity is part of nature, and is internal to it. The relationship is one of being born into nature; and also a relationship of orderly change, because humanity, as part of nature, changes it: something both inevitable and positive. But this should not mean destruction or irreversible degradation. The anthropological foundation of environmental responsibility as favoured by us is based on the concept that the human being is the only moral subject who has responsibility for mankind, nature and future generations. It follows that mankind's responsibility extends beyond human beings, incorporating non-human living entities as well as the Earth's ecosystems.

Stewardship for God's Creation

In recent decades Christian theology has prepared the ground for a renewed vision of God's Creation and a sharpened perception of the place and role of humankind. Theologians have frequently stressed that human beings are part of God's Creation and not its master. Human beings created in the image of God should try to understand nature in order to participate in its life and to become stewards of God's Creation. Such a renewed vision may contribute towards a resolution of the difficulty that various environmental ethics have encountered: namely, to show that humanity's relationship with the environment may reasonably be considered as also a moral problem because it implies an extension of the concepts of duty and responsibility. Further theological works at all levels in the Church on the relationship between the threefold conception of God, nature and the human being are therefore essential and need to be encouraged. They will help us to see more clearly the moral dimension of our relationship with nature.

On 6th August 2008 on the occasion of a meeting with priests and deacons, the Holy Father once again clarified the position: "*To the extent that the Earth was considered God's Creation, the duty of "subjecting" was never understood as an*

order to make it a slave, but rather as a duty of being a custodian *of Creation and developing its gifts; of collaborating ourselves in an active way in God's work, in the evolution that God placed in the world, so that the gifts of Creation are prized and not trampled upon or destroyed*."

Values and principles for making ethical judgements on climate change policies

The Catholic Church is constantly rereading the gospel and its spiritual tradition in the light of the mores and conventions of the age. Its social teaching has evolved over centuries on the basis of a set of guiding values and principles. They are, among others: respect for human dignity; aspiration for global justice and a disposition towards the weakest and for future generations; application of the principles of subsidiarity and solidarity, sustainability and responsibility for the common good. These values and principles can also be applied to the evaluation of climate change policies.

Respect for human dignity

Respect for human dignity is a central value in the Christian tradition. It encompasses the whole person in all his or her dimensions. Therefore, respect for human dignity includes also respect for the spiritual dimension of each human being and its integration into God's Creation. Our current model of consumption puts too much emphasis on the consumption of material goods and therefore on the material dimension of human dignity. It tends to ignore the need to develop other dimensions. In this respect it can be said that policies that support this model do not fully respect human dignity. Current discussions on policies for combating climate change may imply changes in our overly materialistic lifestyle and therefore constitute an opportunity for rediscovering other dimensions of human dignity.

Aspiration for global justice – a bias in favour of the weakest

The aspiration for global justice and special attention for the poor and for those generations who are not yet born are core values of Catholic social teaching. The *contraction and convergence*[5] *approach* to the reduction of greenhouse gas emissions is one option for achieving more global justice through an emission allotment and trading scheme, and a minimum requirement in the light of these values. *Contraction* relates to the need to reduce the total amount of anthropogenic emissions in order to protect the climate. *Convergence* relates to the distribution of these outputs. In order to achieve an equitable allocation of emission rights, it is often suggested that each human being in the world should gradually receive the same emission rights: based on their current per capita

[5] See Global Commons Institute (GCI), http://www.gci.org.uk/

emissions, fewer emission rights will gradually be allocated to the industrial countries, while the developing countries will increasingly be granted more emission rights until each country achieves the same per capita rights by 2050.

However, the industrial countries do not necessarily have to achieve all of the emission reductions which have been imposed on them within their own economies: they may also buy emission rights from developing countries, since many emissions in developing countries can be reduced at lower costs than in developed countries. At a first glance, the principles of *contraction and convergence* would therefore be consistent with the idea of global justice and with special attention to the poorest. However, it ignores the fact that the atmosphere has been freely used since the beginning of industrialisation, especially in Europe and the USA. The already accumulated carbon debt is therefore not taken into account as only future emissions will be equally distributed among all the nations. The c*ontraction and convergence* approach would therefore represent only the absolute minimum in equity terms.

Subsidiarity: a principle of organisation

Where 'global common goods' such as the Earth's climate system are concerned, it is becoming increasingly evident that unilateral policies are ineffective. The lack of political institutions (not bureaucracies) at the global level makes it hard to solve so many of the questions of our age, but especially the environmental problem. The principles of subsidiarity and solidarity together with the responsibility for safeguarding the Earth point to the need for effective global governance to protect the environment, including the fight against climate change by means of the reduction of global greenhouse gas emissions. However, this does not preclude other actors such as enterprises, NGOs and consumers from taking their own initiatives. A *global agreement to combat climate change* should include an ambitious and equitable programme to reduce global greenhouse gas emissions, mechanisms to finance adaptation measures especially in deeply affected and poor regions, as well as the prevention of deforestation and the need for global research discussed below.

Solidarity: the principle of charity

Christians believe that all human beings are children of God which leads them to a conviction of their profound interdependence. The principle of solidarity draws on this conviction and transposes it to the ethical dimension. It covers not only individual but also collective aspects. "*The duty of promoting solidarity also falls on the shoulders of nations*", as Pope Paul VI stated (Populorum Progressio 48).

In the debate about the appropriate instruments and methods for combating climate change at the global level, the principle of solidarity should guide the financing of adjustment measures. Therefore, mechanisms need to be identified for guaranteeing that global transfer payments will be given to those who have

the most urgent need. Furthermore, solidarity is needed for the agreement to fund research at the global level and for measures to prevent deforestation.

Sustainability

The principle of sustainability combines ecological responsibility, the struggle against poverty at the global scale and economic efficiency. It is intrinsically linked to the problem of poverty, both absolute and relative, and to development. Efforts to improve or conserve the quality of the environment in the North will be of very little use without an urgent and comprehensive programme of action against world poverty. The growing gap between the rich and the poor has to be addressed. The concept of sustainable development calls upon all actors to protect the climate system for the benefit of present and future generations. In preserving the basis of life for future generations we are at the same time safeguarding the future of existing societies. Today's decision-makers also have a special responsibility to sufficiently take into account the interests of future generations.

The precautionary principle

The principle of caution and precaution requires taking action to avoid possible damage in spite of the fact that there is no absolute certainty due to insufficient understanding or knowledge. The degree of action must be in an acceptable relationship to the possible damage and the uncertainties involved. Measures required to combat climate change are a prime example of this dilemma. It is very easy to either exploit people's anxieties in a populist way to trigger action or to stop anything from actually being done by putting alleged counter-expertise forward. The application of the precautionary principle therefore requires participation and transparency in political decisions, as well as basic trust and confidence by the citizens in their administrators.

Moderation – a rejoicing not a boring virtue

However, 'making the ethical case' for climate change policies will probably not be sufficient to bring about the changes in lifestyles that will inevitably result from a progressive transition towards a low carbon economy. Just passing on ethical knowledge in addition to scientific facts on climate change leads nowhere. A significant change in lifestyles will, however, become possible, if 'moderation' is accepted as a central virtue and as a rejoicing and satisfying concept. The ascetic tradition of Christianity may provide here a credible input to an urgent and necessary debate.

First of all, it must be acknowledged that our model of consumption, our lifestyles, are very inflexible and difficult to modify. Nevertheless, it is also evident that the ever-increasing production of material goods is incompatible with safeguarding the natural and urban environments. The pressure to

permanently increase material living standards has therefore become a serious ethical problem in a society that bases itself on the principles of individual freedom and self-realisation. The first imperative in order to make change possible is therefore to admit a plurality of lifestyles and to ensure that this plurality becomes effective and that lifestyle becomes a subject of real choice. A second step would be a general commitment to the *concept of moderation* in order to fight against the over-consumption of the well-to-do on the one hand and the imposed austerity on the poorest on the other. The concept of moderation can be more precisely specified: It should be proportional and should permit everybody to assess what is essential for her or for him and therefore eliminate the superfluous. Finally, the virtue of moderation should be creative, intelligent and productive and as such become a condition for greater solidarity and development.

Thus, the beautiful biblical notion of affluence should be given a more precise definition of its meaning and content, since richness is not only material, it is also relational and spiritual. A good balance of these three dimensions would provide us with a more global vision of richness but it assumes moderation, as it is difficult to experience all dimensions of richness at the same time. Promoting the concept of moderation, therefore, has the aim not of diminishing but rather of supporting a higher quality of life and a greater reason to rejoice. It is not about renouncing the desire for material goods but of discerning and better distinguishing what is essential and what is superfluous and setting them in comparison with relational and spiritual richness.

The search for a more relational and spiritual lifestyle fits well with today's interest in different lifestyles as a result of climate change. The Catholic Church and all the other Christian traditions are best placed to propagate such changes in lifestyles and can therefore do the most to support climate change policies. They can do it best through concrete proposals and by their modest examples. The words of Pope Benedict XVI on 6 August 2008 may help in following this route: "*In fact, it's not just a question of finding techniques that can prevent environmental harms, even if it's important to find alternative sources of energy and so on. But all this won't be enough if we ourselves don't find a new style of life, a discipline which is made up in part of renunciations: a discipline of recognition of others, to whom Creation belongs just as much as those of us who can make use of it more easily; a discipline of responsibility to the future for others and for ourselves. It's a question of responsibility before Our Lord who is our Judge, and as Judge our Redeemer, but nonetheless our Judge*."

5. THE ROLE OF EUROPE IN COMBATING CLIMATE CHANGE

In a world of many different states and countries with no single global economy we have to find solutions to protect our 'global commons'. However, no single country will be able to take the necessary protection measures on its own: To deal with global environmental problems effectively, global solutions that include all the countries of the world are needed. To stabilise the concentration of greenhouse gas emissions at a non-dangerous level, worldwide cooperation is indispensable.

The principle of common, but differentiated responsibilities

The international agreements to combat climate change are based upon the principle of common, but differentiated responsibilities. This principle has been accepted by all states that are parties to the Framework Convention on Climate Change. It recognises the global responsibility for the protection of the Earth's climate system and aims towards worldwide cooperation. It leads to different commitments with regard to prerequisites and content. The industrialised states including the Member States of the European Union have here a special responsibility.

The Earth's climate system can only be protected effectively if the 'owners' of the remedial measures are called upon to meet their obligations. Furthermore, this principle is justified because of the differing contributions towards having caused climate change in the past (responsibility for the damage).

The principle of common, but differentiated responsibilities is a dynamic principle that does not necessarily differentiate between the countries of the North and the South. Rather, it creates different obligations depending on the existing state of affairs in each country. As a result, it has to be developed continuously and adapted to the changing conditions that have to be brought into line with the promotion of corporate social responsibility. The universal and transnational character of the Catholic Church places it in an ideal position to stress the link between ecological and development concerns at the global level.

The special responsibility of the European Union for combating climate change

Within the framework of the agreed principle of common but differentiated responsibilities, the European Union bears a special responsibility for combating climate change, not only in view of the history of global climate change but also in view of its technological and financial means and its experience with

cooperative action. Of course, this special responsibility for the protection of the Earth's climate system has to be taken up not only by the European Union but by all industrialised countries that possess the necessary technological and financial means to combat climate change. But even if certain countries do not live up to their responsibilities for the poor and for future generations, this can not be taken as an excuse for the European Union not to introduce its own necessary measures; but the EU should also make every effort to convince all actors concerned of the necessity to protect the Earth's climate system.

What is lacking today is leadership and a clear voice speaking out in the interest of those who already bear or will bear the highest burden of climate change: the poorest and future generations. The European Union is asked to raise its voice for them.

Agreed and proposed EU targets for reducing greenhouse gas emissions

Very energetic action will be needed if we want to keep the global temperature increase below 2°C above the pre-industrial level. According to the last IPCC report (2007), global reductions of CO_2 emissions (from 2000 to 2050) of between 50 and 85% are needed to keep the temperature increase below 2 to 2.4°C. This means emission reductions of 80 to 95% (from 1990 to 2050) for the industrialised countries.

As a first step, the European Union and its Member States committed themselves, in the Kyoto Protocol, to a reduction in their emissions of six greenhouse gases by at least 8% by 2008-2012 compared to 1990 levels. In March 2007, the European Council declared a 20% greenhouse gas reduction target by 2020 for the European Union, which will be increased to 30% if other developed countries commit themselves to comparable emission reductions. To achieve this goal, the European Commission in January 2008 put forward an integrated package of ambitious proposals to combat climate change including: targets for increasing the share of renewables in the energy mix; an improved emissions trading system; an emission reduction target for sectors not covered by the European Emissions Trading System (ETS); new rules on carbon capture and storage; and new rules on environmental subsidies.

However, measures to combat climate change and to reduce greenhouse gas emissions have to be taken mainly at national, regional and local levels. Thus, the Member States of the EU play a decisive role in the effective implementation of the EU climate change strategies. But, climate change is not only – by far – a question to be solved by governments and officials. By contrast, enterprises, non-governmental organisations, consumers and all individuals have to take up their own responsibilities.

The role of civil society in the fight against climate change

We are deeply convinced that the only plausible way out of the present crisis is the elaboration of a cultural perspective in which civil society with its intermediate bodies (associations, NGOs, foundations, grass-root movements, Churches) effectively interact with governments and market forces. The environmental problem can be delegated neither to governments nor to market forces alone. Indeed, *eco-efficiency* ("to do more and better with less") is important but represents only a partial answer to environmental problems. Even *eco-justice* using instruments such as eco-incentives, eco-taxes, in addition to traditional direct regulation, although necessary, is not by itself sufficient. A new conceptual framework is required with a holistic approach to environmental problems and a clearly defined role for the different actors involved.

We would like to emphasise the ability of civil society to enlist political assistance from the grass-roots up, in relation to both quality of life improvements and the direct participation of local, national and international communities in the choice of development strategies. In particular, NGO's are demonstrating increasingly effective planning and operating capabilities, together with research centres and intergovernmental organisations. Their activities demonstrate the importance of sustainability to a large audience and present innovative proposals for participation in managing the difficult questions at stake.

Furthermore, NGOs and other organised parts of civil society play a decisive role in encouraging individuals to adopt more sustainable lifestyles. What characterises such lifestyles is the notion of an *eco-sufficiency* strategy: 'to live better with less'. In turn, such a notion comes from a concept of well-being that does not depend on the excessive consumption of material goods. In this regard, a movement of socially responsible consumers, based upon the idea of ethical consumption, should be acknowledged as a major force for the dissemination of environmentally friendly ideals.

CONCLUSIONS

Consequences for the ecclesiastical communities and for individual Christians

It is true that some people in the Church claim that the share of human responsibility for global warming has been exaggerated, and are of the opinion that natural variations in climate have always existed. They emphasise above all that many environmentalists regard the number of people on Earth as the greatest threat to the environment and therefore recommend the use of population control methods to reduce the Earth's population, thereby subordinating the development of humanity to a partially deified nature. In contrast to this, it must be acknowledged that the relevant international studies on climate change and its causes are widely accepted as serious works of science. We are indeed facing one of the great ethical challenges of humanity as well as of Christian witness.

In his meeting with the clergy on 6 August 2008 in Brixen, the Holy Father said in no uncertain terms:

"Thus, I believe we must attempt with all the means we have to present the faith in public, especially where there's already a sensibility for it. I think the sensation many people have today that the world may be slipping away – because we ourselves are driving it away – and the sense of being oppressed by the problems of Creation gives us a fitting occasion in which our faith can speak publicly and can present itself as a positive proposition."

The ecological crisis forms a new context for the major questions of justice and peace on the global scale. New forms of poverty and of social and political conflicts have developed. The Church must respond to these and enter into a new global dialogue with society. In this respect, the contribution of religions and churches to peace is also being solicited ever more strongly from the purely secular side. Christians have a great potential for introducing the liberating power of faith into this dialogue, since it is not a question merely of finding technological solutions, but rather of attaining a fundamental understanding of what gives human life meaning and what values should orient our lives.

Such an understanding also generates lifestyles which are sustainable, for which responsibility can be taken vis-à-vis global humanity today and vis-à-vis future generations. The concept of 'lifestyles' relates not merely to the private life of individuals, but also to church communities and to the socio-economic structures within which the life of Christians takes place. Thus it is no longer enough just to issue theoretical declarations on the environmental question;

rather, an ecological conversion is required: we need Christian life testimonies which are credible.

Sustainable lifestyles and Christian values

Christians are going to have to distance themselves from the lifestyle predominant in our countries which is too single-mindedly focused on consumption, and especially a disproportional consumption of energy. Through its advertising, the business world of course conveys the message that possessing and consuming as many goods as possible is *the* path to individual happiness. By contrast, extolling renunciation and the simple life appears to have little resonance. It is therefore necessary to demonstrate the essence of a genuine quality of life, that the Christian preaching is thus linked to the desire for joy and happiness. We attain happiness primarily through good relationships: with our fellow human beings, with Creation itself and with our God, the Creator and Redeemer, the author of everything which is good.

We need a more comprehensive vision of human life, so that we are not seduced into pursuing selfish interests. We need a new way of dealing with our time; for example, we need to begin once again cultivating Sunday as the weekly day of rest, we need to rediscover the tranquillity which allows our soul to 'catch up', celebration in the form of an encounter with the beautiful, with things that exceed our day-to-day horizons, ultimately with God Himself in various forms. We also need a responsible relationship with the spaces in which we live: for example, we must reconsider our mobility which, without doubt, entails high levels of energy consumption.

The Holy See has published very important documents on responsibility for Creation and on various social challenges of our time, for which we are thankful. We also note that the Vatican is serious about supporting this by means of appropriate good practice. For example, it was recently announced that the large roof of the Audience Hall of Paul VI will be equipped with solar energy installations. It would also be an important signal to all Christians and the world if the *United Nations Framework Convention on Climate Change* and the *Kyoto Protocol* were to be ratified by the Holy See, or even if a major encyclical on environmental issues could set out the good practices of the churches as an example to others. The Church should also be to the forefront in investing its funds in ethical and sustainable projects and in developing corporate social responsibility concepts for their economic activities.

There are relevant documents from individual Bishops' Conferences – and from individual dioceses and orders – with respect to requirements for the management of church buildings and properties, for an appropriately ecological organisation of large church events, and for performing an eco-balance of the parishes. Monasteries and church communities in particular have, both

historically and in our own time, developed models of a sustainable relationship with the environment. Likewise, the 'day of responsibility for Creation' introduced in several Bishops' Conferences and ecclesiastical communities (or a period of responsibility for Creation spanning from 1st September until the Feast of Saint Francis of Assisi or the Harvest Thanksgiving) can offer an occasion for expressing responsibility with respect to climate change in educational institutions and for concrete projects. Thus, the essential thing is to adapt the Christian tradition of the humble life, of fasting as well as a value-conscious shaping of life to current circumstances. In our age, the longing for a life nourished by spiritual forces is growing in many people.

As Christians, we should be aware that we are called upon to testify to the hope which fills us, a hope based on Christ, because everything is created for Him and experiences its perfection in Him. Ecological responsibility fits within this hope; it thus constitutes an essential element of Christian faith relating to Creation and redemption. In the ecumenical context too, environmental responsibility is an issue shared by all Christians – indeed, it constitutes an area where a common commitment with other religions and with the whole of society becomes possible.

APPENDIX: CLIMATE CHANGE 2007
KEY MESSAGES FROM THE IPCC AR4 SYNTHESIS REPORT[6]

1. Observed changes in climate and their effects

- Warming of the climate system is unequivocal, as is now evident from observations of increases in global average air and ocean temperatures, widespread melting of snow and ice and rising global average sea level.
- Observational evidence from all continents and most oceans shows that many natural systems are being affected by regional climate changes, particularly temperature increases.
- There is medium confidence that other effects of regional climate change on natural and human environments are emerging, although many are difficult to discern due to adaptation and non-climatic drivers.

2. Causes of change

- Global greenhouse gases (GHG) emissions due to human activities have grown since pre-industrial times, with an increase of 70% between 1970 and 2004.
- Global atmospheric concentrations of CO_2, methane (CH_4) and nitrous oxide (N_2O) have increased markedly as a result of human activities since 1750 and now far exceed pre-industrial values determined from ice cores spanning many thousands of years.
- Most of the observed increase in global average temperatures since the mid-20th century is very likely[7] due to the observed increase in anthropogenic GHG concentrations. It is likely that there has been significant anthropogenic warming over the past 50 years averaged over each continent (except Antarctica) (Figure 1)

Global and Continental temperature change

[6] This text, prepared under the responsibility of Jean-Pascal van Ypersele, contains exclusively material extracted from the Summary for Policymakers of the Synthesis Report of the IPCC (Intergovernmental Panel on Climate Change) Fourth Assessment Report (AR4, published in 2007). "IPCC AR4 Synthesis Report" refers to: "Climate Change 2007: Synthesis Report. Contribution of Working Groups I, II and III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change", IPCC, Geneva, Switzerland. With very few exceptions, the text is composed from the headlines and from key messages bolded in the original text. The latter can be found (with additional figures) at www.ipcc.ch.

[7] Where uncertainty in specific outcomes is assessed using expert judgment and statistical analysis of a body of evidence (e.g. observations or model results), then the following likelihood ranges are used by IPCC to express the assessed probability of occurrence: virtually certain >99%; extremely likely >95%; very likely >90%; likely >66%; more likely than not > 50%; about as likely as not 33% to 66%; unlikely <33%; very unlikely <10%; extremely unlikely <5%; exceptionally unlikely <1%.

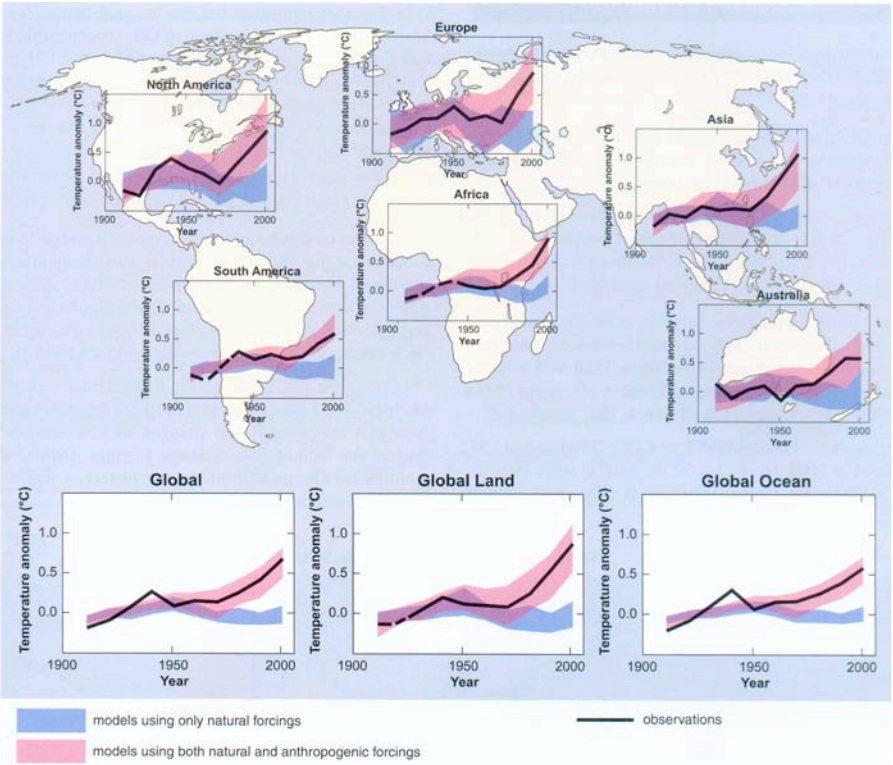

Figure 1 *(Figure SPM.4 from the IPCC AR4 Synthesis Report). Comparison of observed continental- and global-scale changes in surface temperature with results simulated by climate models using either natural or both natural and anthropogenic forcings. Decadal averages of observations are shown for the period 1906-2005 (black line) plotted against the centre of the decade and relative to the corresponding average for the period 1901-1950. Lines are dashed where spatial coverage is less than 50%. Blue shaded bands show the 5 to 95% range for 19 simulations from five climate models using only the natural forcings due to solar activity and volcanoes. Red shaded bands show the 5 to 95% range for 58 simulations from 14 climate models using both natural and anthropogenic forcings.*

- Advances since the IPCC Third Assessment Report (TAR, published in 2001) show that discernible human influences extend beyond average temperature to other aspects of climate.
- Anthropogenic warming over the last three decades has likely had a discernible influence at the global scale on observed changes in many physical and biological systems.

3. Projected climate change and its impacts

- There is high agreement and much evidence that with current climate change mitigation policies and related sustainable development practices, global GHG emissions will continue to grow over the next few decades.
- Continued GHG emissions at or above current rates would cause further warming and induce many changes in the global climate system during the 21st century that would very likely be larger than those observed during the 20th century (Table 1, Figure 2).

Table 1 *(Table SPM.1 from the IPCC AR4 Synthesis Report).* Projected global average surface warming and sea level rise at the end of the 21st century.

Case	Temperature change (°C at 2090-2099 relative to 1980-1999) [a, d]		Sea level rise (m at 2090-2099 relative to 1980-1999)
	Best estimate	*Likely* range	Model-based range excluding future rapid dynamical changes in ice flow
Constant year 2000 concentrations[b]	0.6	0.3 – 0.9	Not available
B1 scenario	1.8	1.1 – 2.9	0.18 – 0.38
A1T scenario	2.4	1.4 – 3.8	0.20 – 0.45
B2 scenario	2.4	1.4 – 3.8	0.20 – 0.43
A1B scenario	2.8	1.7 – 4.4	0.21 – 0.48
A2 scenario	3.4	2.0 – 5.4	0.23 – 0.51
A1FI scenario	4.0	2.4 – 6.4	0.26 – 0.59

Notes:

a) Temperatures are assessed best estimates and likely uncertainty ranges from a hierarchy of models of varying complexity as well as observational constraints.

b) Year 2000 constant composition is derived from Atmosphere-Ocean General Circulation Models (AOGCMs) only.

c) All scenarios above are six SRES marker scenarios. Approximate CO_2-eq concentrations corresponding to the computed radiative forcing due to anthropogenic GHGs and aerosols in 2100 for the SRES B1, AIT, B2, A1B, A2 and A1FI illustrative marker scenarios are about 600, 700, 800, 850, 1250 and 1550 ppm, respectively.

d) Temperature changes are expressed as the difference from the period 1980-1999. To express the change relative to the period 1850-1899 add 0.5°C.

Scenarios for GHG emissions from 2000 to 2100 (in the absence of additional climate policies) and projections of surface temperatures

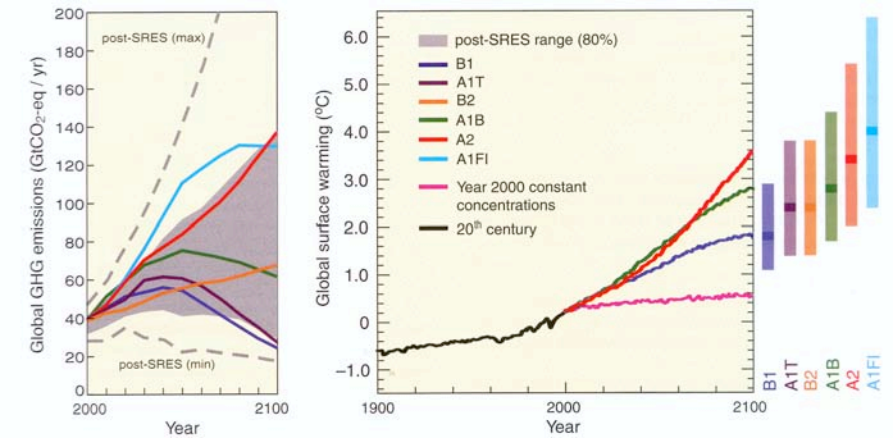

Figure 2 *(Figure SPM.5 from the IPCC AR4 Synthesis Report).* ***Left Panel:*** *Global GHG emissions (in $GtCO_2$-eq) in the absence of climate policies: six illustrative SRES[8] marker scenarios (coloured lines) and the 80th percentile range of recent scenarios published since SRES (post-SRES) (gray shaded area). Dashed lines show the full range of post-SRES scenarios. The emissions include CO_2, CH_4, N_2O and F-gases.* ***Right Panel:*** *Solid lines are multi-model global averages of surface warming for scenarios A2, A1B and B1, shown as continuations of the 20th -century simulations. These projections also take into account emissions of short-lived GHGs and aerosols. The pink line is not a scenario, but is for Atmosphere-Ocean General Circulation Model (AOGCM) simulations where atmospheric concentrations are held constant at year 2000 values. The bars at the right of the figure indicate the best estimate (solid line within each bar) and the likely range assessed for the six SRES marker scenarios at 2090-2099. All temperatures are relative to the period 1980-1999. To express the change relative to the period 1850-1899 add 0.5°C.*

[8] SRES refers to the scenarios described in the IPCC Special Report on Emissions Scenarios (SRES, 2000). The SRES scenarios are grouped into four scenario families (A1, A2, B1 and B2) that explore alternative development pathways, covering a wide range of demographic, economic and technological driving forces and resulting greenhouse gas emissions. The SRES scenarios do not include additional climate policies above those in place in 2000. In particular, they do not assume implementation of the Kyoto Protocol.

- There is now higher confidence than in the TAR in projected patterns of warming and other regional-scale features, including changes in wind patterns, precipitation and some aspects of extremes and sea ice.
- Studies since the TAR have enabled more systematic understanding of the timing and magnitude of impacts related to differing amounts and rates of climate change (Figure 3).
- The uptake of anthropogenic carbon since 1750 has led to the ocean becoming more acidic. While the effects of observed ocean acidification on the marine biosphere are as yet undocumented, the progressive acidification of oceans is expected to have negative impacts on marine shell-forming organisms (e.g. corals) and their dependent species.
- Altered frequencies and intensities of extreme weather, together with sea level rise, are expected to have mostly adverse effects on natural and human systems.
- Anthropogenic warming and sea level rise would continue for centuries due to the time scales associated with climate processes and feedbacks, even if GHG concentrations were to be stabilised.
- Anthropogenic warming could lead to some impacts that are abrupt or irreversible, depending upon the rate and magnitude of the climate change.

4. Adaptation and mitigation options

- A wide array of adaptation options is available, but more extensive adaptation than is currently occurring is required to reduce vulnerability to climate change. There are barriers, limits and costs, which are not fully understood.
- Adaptive capacity is intimately connected to social and economic development but is unevenly distributed across and within societies.

Examples of impacts associated with global average temperature change (Impacts will vary by extent of adaptation, rate of temperature change and socio-economic pathway)

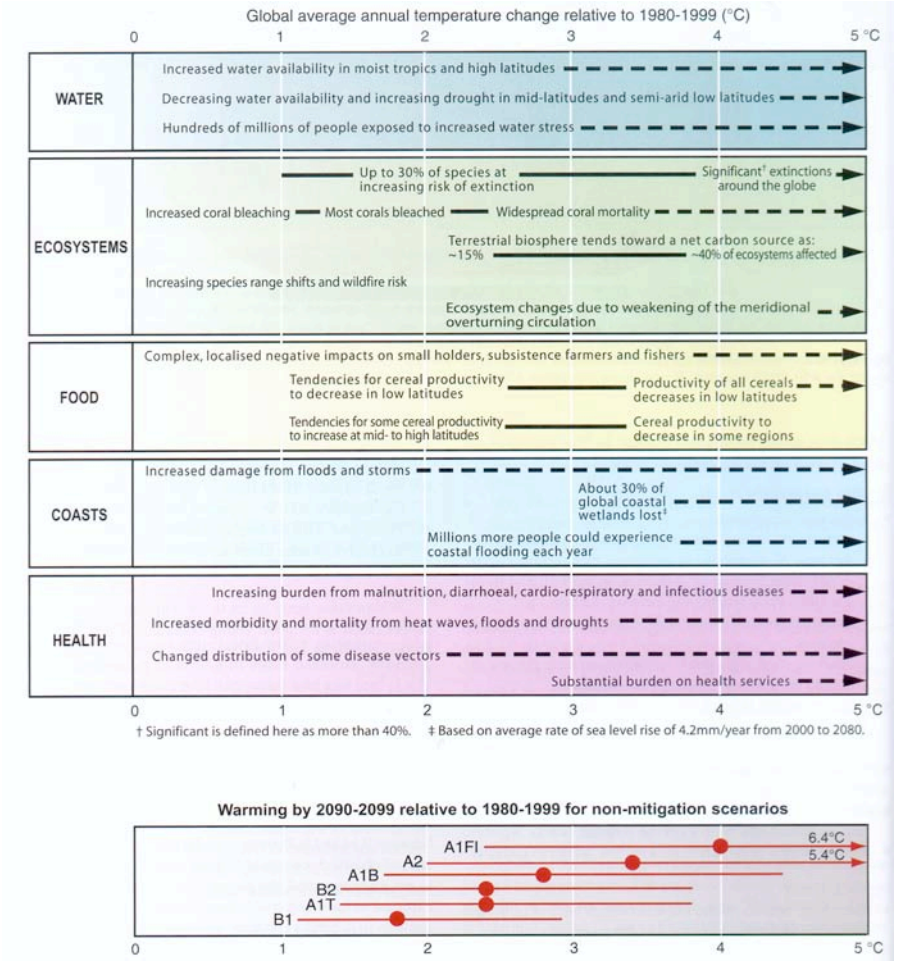

Figure 3 *(Figure SPM.7 from the IPCC AR4 Synthesis Report). Examples of impacts associated with projected global average surface warming. Upper panel: Illustrative examples of global impacts projected for climate changes (and sea level and atmospheric CO_2 where relevant) associated with different amounts of increase in global average surface temperature in the 21st century. The black lines link impacts; broken-line arrows indicate impacts continuing with increasing temperature. Entries are placed so that the left-hand side of text indicates the approximate level of warming that is associated with the onset of a given impact. Quantitative entries for water scarcity and flooding represent the additional impacts of climate change relative to the conditions projected across the range of SRES scenarios A1FI, A2, B1 and B2. Adaptation to climate change is not included in these estimation. Confidence levels for all statements are high. Lower panel: Dots and bars indicate the best estimate and likely ranges of warming assessed for the six SRES marker scenarios for 2090-2099 relative to 1980-1999. To express the change relative to the period 1850-1899 add 0.5°C.*

- Both bottom-up and top-down studies indicate that there is high agreement and much evidence of substantial economic potential for the mitigation of global GHG emissions over the coming decades that could offset the projected growth of global emissions or reduce emissions below current levels (Figure 4). While top-down and bottom-up studies are in line at the global level there are considerable differences at the sectoral level.

Economic mitigation potentials by sector in 2030 estimated from bottom-up studies

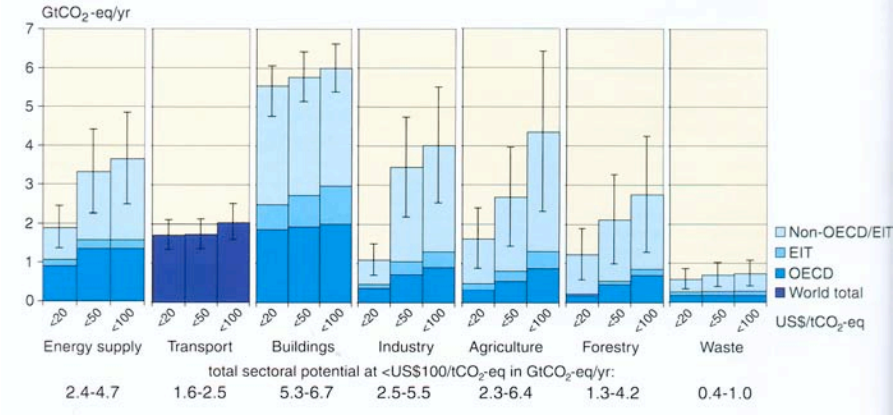

Figure 4 *(Figure SPM.10 from the IPCC AR4 Synthesis Report). Estimated economic mitigation potential by sector in 2030 from bottom-up studies, compared to the respective baselines assumed in the sector assessments. The potentials do not include non-technical options such as lifestyle changes.*
Notes:

a) The ranges for global economic potentials as assessed in each sector are shown by vertical lines. The ranges are based on end-use allocations of emissions, meaning that emissions of electricity use are counted towards the end-use sectors and not to the energy supply sector.

b) The estimated potentials have been constrained by the availability of studies particularly at high carbon price levels.

c) Sectors used different baselines. For industry, the SRES B2 baseline was taken, for energy supply and transport, the World Energy Outlook (WEO) 2004 baseline was used; the building sector is based on a baseline in between SRES B2 and A1B; for waste, SRES A1B driving forces were used to construct a waste-specific baseline; agriculture and forestry used baselines that mostly used B2 driving forces.

d) Only global totals for transport are shown because international aviation is included.

e) Categories excluded are: non-CO_2 emissions in buildings and transport, part of material efficiency options, heat production and co-generation in energy supply, heavy duty vehicles, shipping and high-occupancy passenger transport, most high-cost options for buildings, wastewater treatment, emission reduction from coal mines and gas pipelines, and fluorinated gases from energy supply and transport. The underestimation of the total economic potential from these emissions is of the order of 10 to 15%

- A wide variety of policies and instruments are available to governments to create the incentives for mitigation action. Their applicability depends on national circumstances and sectoral context.

- Many options for reducing global GHG emissions through international cooperation exist. There is high agreement and much evidence that notable achievements of the UNFCCC and its Kyoto Protocol are the establishment of a global response to climate change, stimulation of an array of national policies, and the creation of an international carbon market and new institutional mechanisms that may provide the foundation for future mitigation efforts. Progress has also been made in addressing adaptation within the UNFCCC and additional international initiatives have been suggested.
- In several sectors, climate response options can be implemented to realise synergies and avoid conflicts with other dimensions of sustainable development. Decisions about macroeconomic and other non-climate policies can significantly affect emissions, adaptive capacity and vulnerability.

5. The long-term perspective

- Determining what constitutes "dangerous anthropogenic interference with the climate system" in relation to Article 2 of the UNFCCC involves value judgements. Science can support informed decisions on this issue, including by providing criteria for judging which vulnerabilities might be labelled 'key'.
- The five 'reasons for concern' identified in the TAR remain a viable framework to consider key vulnerabilities. These 'reasons' are assessed here to be stronger than in the TAR. Many risks are identified with higher confidence. Some risks are projected to be larger or to occur at lower increases in temperature. Understanding about the relationship between impacts (the basis for 'reasons for concern' in the TAR) and vulnerability (that includes the ability to adapt to impacts) has improved.
- There is high confidence that neither adaptation nor mitigation alone can avoid all climate change impacts; however, they can complement each other and together can significantly reduce the risks of climate change.

- Many impacts can be reduced, delayed or avoided by mitigation. Mitigation efforts and investments over the next two to three decades will have a large impact on opportunities to achieve lower stabilisation levels. Delayed emission reductions significantly constrain the opportunities to achieve lower stabilisation levels and increase the risk of more severe climate change impacts (Table 2).

Table 2 *(Table SPM.6 from the IPCC AR4 Synthesis Report). Characteristics of post-TAR stabilisation scenarios and resulting long-term equilibrium global average temperature and the sea level rise component from thermal expansion only.*

Category	CO_2 concentration at stabilisation (2005 = 379 ppm)[b]	CO_2-equivalent concentration at stabilisation including GHGs and aerosols (2005 = 375 ppm)[b]	Peaking year for CO_2 emissions[a,c]	Change in global CO_2 emissions in 2050 (percent of 2000 emissions)[a,c]	Global average temperature increase above pre-industrial at equilibrium, using 'best estimate' climate sensitivity[d,e]	Global average sea level rise above pre-industrial at equilibrium from thermal expansion only[f]	Number of assessed scenarios
	ppm	ppm	year	percent	°C	metres	
I	350 – 400	445 – 490	2000 – 2015	-85 to -50	2.0 – 2.4	0.4 – 1.4	6
II	400 – 440	490 – 535	2000 – 2020	-60 to -30	2.4 – 2.8	0.5 – 1.7	18
III	440 – 485	535 – 590	2010 – 2030	-30 to +5	2.8 – 3.2	0.6 – 1.9	21
IV	485 – 570	590 – 710	2020 – 2060	+10 to +60	3.2 – 4.0	0.6 – 2.4	118
V	570 – 660	710 – 855	2050 – 2080	+25 to +85	4.0 – 4.9	0.8 – 2.9	9
VI	660 – 790	855 – 1130	2060 – 2090	+90 to +140	4.9 – 6.1	1.0 – 3.7	5

Notes:

a) The emission reductions to meet a particular stabilisation level reported in the mitigation studies assessed here might be underestimated due to missing carbon cycle feedbacks (see also Topic 2.3).

b) Atmospheric CO_2 concentrations were 379ppm in 2005. The best estimate of total CO_2-eq concentration in 2005 for all long-lived GHGs is about 455ppm, while the corresponding value including the net effect of all anthropogenic forcing agents is 375ppm CO_2 -eq.

c) Ranges correspond to the 15th to 85th percentile of the post-TAR scenario distribution. CO_2 emissions are shown so multi-gas scenarios can be compared with CO_2-only scenarios (see Figure SPM.3).

d) The best estimate of climate sensitivity is 3°C.

e) Note that global average temperature at equilibrium is different from expected global average temperature at the time of stabilisation of GHG concentrations due to the inertia of the climate system. For the majority of scenarios assessed, stabilisation of GHG concentrations occurs between 2100 and 2150.

f) Equilibrium sea level rise is for the contribution from ocean thermal expansion only and does not reach equilibrium for at least many centuries. These values have been estimated using relatively simple climate models (one low-resolution AOGCM and several EMICs based on the best estimate of 3°C climate sensitivity) and do not include contributions from melting ice sheets, glaciers and ice caps. Long-term thermal expansion is projected to result in 0.2 to 0.6 m per degree Celsius of global average warming above pre-industrial. (AOGCM refers to Atmosphere-Ocean General Circulation Model and EMICs to Earth System Models of Intermediate Complexity.)

CO_2 emissions and equilibrium temperature increases for a range of stabilisation levels

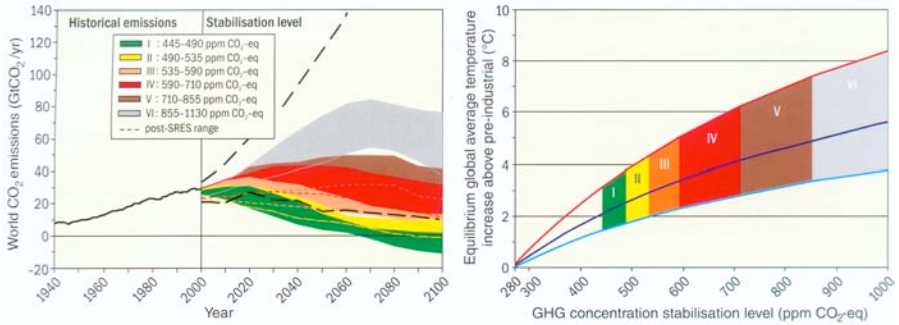

Figure 5 *(Figure SPM.11 from the IPCC AR4 Synthesis Report). Global CO_2 emissions for 1940 to 2000 and emissions ranges for categories of stabilisation scenarios from 2000 to 2100 (left-hand panel); and the corresponding relationship between the stabilisation target and the likely equilibrium global average temperature increase above pre-industrial (right-hand panel). Approaching equilibrium can take several centuries, especially for scenarios with higher levels of stabilisation. Coloured shadings show stabilisation scenarios grouped according to different targets (stabilisation category I to VI). The right-hand panel shows ranges of global average temperature change above pre-industrial, using (i) 'best estimate' climate sensitivity of 3°C (black line in middle of shaded area), (ii) upper bound of likely range of climate sensitivity of 4.5°C (red line at top of shaded area) (iii) lower bound of likely range of climate sensitivity of 2°C (blue line at bottom of shaded area). Black dashed lines in the left panel give the emissions range of recent baseline scenarios published since the SRES (2000). Emissions ranges of the stabilisation scenarios comprise CO_2 -only and multigas scenarios and correspond to the 10th to 90th percentile of the full scenario distribution. Note: CO_2 emissions in most models do not include emissions from decay of above ground biomass that remains after logging and deforestation, and from peat fires and drained peat soils.*

- There is high agreement and much evidence that all stabilisation levels assessed can be achieved by deployment of a portfolio of technologies that are either currently available or expected to be commercialised in coming decades, assuming appropriate and effective incentives are in place for their development, acquisition, deployment and diffusion and addressing related barriers.
- The macro-economic costs of mitigation generally rise with the stringency of the stabilisation target. For specific countries and sectors, costs vary considerably from the global average.
- Responding to climate change involves an iterative risk management process that includes both adaptation and mitigation and takes into account climate change damages, co-benefits, sustainability, equity and attitudes to risk.

MEMBERS OF THE COMECE AD-HOC WORKING GROUP ON CLIMATE CHANGE*

Prof. Dr. Franz FISCHLER
Chairman

Former Member of the European Commission
President of "Ökosoziales Forum" (Austria)

Prof. Dr. Ottmar EDENHOFER
Co-Chair of Working Group III of the IPCC
Deputy-Director of the Potsdam Institute for Climate Impact Research (Germany)

Jean-Baptiste de FOUCAULD
Inspecteur général des Finances
Ministère de l'Economie, des Finances et de l'Industrie (France)

Rev. Prof. Dr. Karl GOLSER
Professor of moral theology at the Philosophisch-Theologische Hochschule Brixen, professore di teologia morale allo Studio Teologico Accademico Bressanone (Italy)

Prof. Dr. Leszek KARSKI
Professor at the Chair of Environmental Protection and Management, Institute of Ecology and Bioethics,
Deputy Dean at the Faculty of Christian Philosophy, Cardinal Stefan Wyszynski University, Warsaw (Poland)

Prof. Dr. Helga KROMP-KOLB
Head of Institute of Meteorology
University of Natural Resources and Applied Life Sciences, Vienna (Austria)

Dr. Charlotte KREUTER-KIRCHHOF
Secretary
Assistant Professor
Institute for international law, University of Bonn (Germany)

**** The views expressed in the text are personal and should not be attributed to institutions or organisations to which members of the group are related.***

Prof. Dr. John SWEENEY
Professor of Geography
Director: Irish Climate Analysis and Research Units
National University of Ireland, Maynooth (Ireland)

Prof. Dr. Jean-Pascal van YPERSELE
IPCC Vice-Chair
Institut d'astronomie et de géophysique G. Lemaître
Université catholique de Louvain (Belgium)

Prof. Dr. Stefano ZAMAGNI
Professore ordinario di Economia Politica, Università di Bologna
Adjunct Professor of International Political Economy, Johns Hopkins University, Bologna Center (Italy)

**** The views expressed in the text are personal and should not be attributed to institutions or organisations to which members of the group are related.***