Informe sobre

el canvi climàtic a Catalunya

Resum executiu

Generalitat de Catalunya
Consell Assesor per al Desenvolupament Sostenible

BIBLIOTECA DE CATALUNYA. DADES CIP:

Informe sobre el canvi climàtic a Catalunya : resum executiu
Text en català, castellà i anglès
ISBN 84-393-6708-2
I. Llebot, Josep Enric, dir. II. Jorge Sánchez, Joan, dir. III. Queralt, Arnau, ed. IV. Rodó, Jordi, ed. V. Consell Assessor per al Desenvolupament Sostenible (Catalunya)
1. Canvis climàtics Catalunya 2. Gestió ambiental Catalunya
551.58(467.1)

Departament de la Presidència
Consell Assessor per al Desenvolupament Sostenible de Catalunya (CADS)
http://www.cat-sostenible.org

Direcció de l'estudi: Josep Enric Llebot Rabagliati i Joan Jorge Sánchez.

Edició a cura de: Josep Enric Llebot Rabagliati, Arnau Queralt Bassa i Jordi Rodó Rodà.

Traducció: Tau Traduccions, SL (versió castellana) i David Belayla (versió anglesa).

Aquest estudi ha estat elaborat per encàrrec del Consell Assessor per al Desenvolupament Sostenible de Catalunya (CADS), òrgan adscrit al Departament de la Presidència, i del Servei Meteorològic de Catalunya, empresa pública del Departament de Medi Ambient i Habitatge de la Generalitat de Catalunya i ha comptat amb la coordinació de l'Institut d'Estudis Catalans (IEC).

Tiratge: 1.500 exemplars

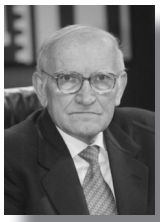
Disseny i producció gràfica: MTMGRUP

Impressió: Gràfiques Oller

Dipòsit Legal: B-8912-2005

Aquesta publicació ha estat feta amb paper ecològic estucat semimat de 135g. i les cobertes en cartolina ecològica de 400g.

Preface



There is growing evidence that anthropic activity is the culprit for changes in systems determining Earth's climate. Climate change on the global scale is a reality and is therefore linked to human activity, overlapping natural patterns of Earth's climatic variability. Essentially, climate change is caused by certain gases with a "greenhouse effect" (such as, for instance, methane or carbon dioxide) emitted to the atmosphere as a result of the behavioural and consumption patterns of human societies.

In the face of the complexity of this phenomenon, the United Nations Environmental Programme and the World Meteorological Organization created, sixteen years ago, the Intergovernmental Panel on Climate Change (IPCC), who periodically draw up a summary of the state of the art on climate change. Their studies are based on predictions on the evolution of emissions and possible impacts of future climate change on the natural environment and human activity on the global scale.

Despite climate change being a planetary phenomenon, the potential impacts, and subsequent human adaptative action, differ across countries and climatic zones. Today, intensive research is conducted leading to works focusing on particular geographical areas (the work done in. In this line, work done in California, Greater London and the Alps stands out).

Along these lines, the Advisory Council for the Sustainable Development of Catonia (CADS), advisory commission for the Catalan Government in sustainable development matters, has promoted and coordinated the undertaking of a study on the possible effects of climate change in our country, with the support of the Meteorological Service of Catalonia and the Institute of Catalan Studies.

This study, initiated in October 2002, brings together work by fifty Catalan experts on various fields of knowledge related to this phenomenon. Their pluridisciplinary analyses have especially focused on Catalonia, on climate change indicators, their causes and potential impacts, on mitigation and adaptation possible action, and on the existing legislatively-established powers framework for facing anthropogenic climate change from Catalonia.

Here, we have gathered together and analysed climatic change researches produced in Catalonia, inserting them within the frame of IPCC work, and evaluating existing internationally available information sources potentially applicable to our country. The final aim was to deliver an up-to-date prospective analysis of possible climate change effects on the various sectors which are strategic to Catalonia.

Thus, we have collected in a single document the state of the art about the issue of climate change of anthropic origin in Catalonia, with an aim to making it available to the public at large and, especially, to public planners and managers. This document also contains a few proposals by the participating experts and thus aims to contribute to preparing our country for potential climate changes. With appropriate information, potentially harmful effects may be minimized and facing changes may be more efficient. We cannot only hope.

Gabriel Ferraté i Pascual
President
Advisory Council for the Sustainable Development of Catalonia

Index

Resum de les conclusions de l'informe sobre **El canvi climàtic a Catalunya**

Executive summary of the report on Climate change in Catalonia

Introduction

The Intergovernmental Panel on Climate Change (IPCC), created by the United Nations and the World Meteorological Organization in 1988, is an independent institution delivering regular up-to-date reports from scientific and technical perspective with state-of-the-art knowledge on climate change. In these reports, the IPCC also gives advice on possible courses of action to political and social representatives when facing climate change.

Until now, the IPCC has published three global reports on the state of climate change science, the latest published in July 2001[1]. In this report, the need is stated for conducting detailed, specific studies on impacts, and adaptation and mitigation measures against the harmful effects of climate change, as this phenomenon will impact different geographical areas on the planet in different ways and with different intensities.

Indeed the problem of climate change is global, but, in contrast, impacts and subsequent adaptative action may differ across countries and regions. In Catalonia, the Advisory Council for the Sustainable Development of Catalunya and the Meteorological Service of Catalonia has promoted the present report, with the ultimate aim of gathering together state-of-the-art information on potential climate effects on our country.

During this study, locally-generated information about climate change impinging on Catalonia has been gleaned, and information collected elsewhere has been assessed which is applicable to Catalonia, detecting existing gaps of knowledge, and extracting conclusions about the present situation and future perspectives. Finally, proposals are made about the various possible courses of action. Hence, the project has not strictly pursued the production of new material, but aimed to deliver a scientific and technical state-of-the-art digest of information presently available in Catalonia, providing an overview of the potential local consequences of climate change.

The report is structured around the three following broad sections:

1) **The Science of Climate Change:** present-day state and predicted climate evolution, climate change indicators and Catalonia, emissions inventories and future local climate change projections.

[1] Catalan edition: Grup Intergovernamental d'Experts sobre el Canvi Climàtic (2003): *Canvi Climàtic 2001. III Informe del Grup Intergovernamental d'Experts sobre el Canvi Climàtic*. Barcelona: Consell Assessor per al Desenvolupament de Catalunya.

2) **Impacts, vulnerability, mitigation and adaptation** to climate change effects in sectors, i.e. transport, industry, agriculture, tourism, public health and natural systems.

3) **Climate change management tools:** framework for a scheme of reserved powers for Catalonia developing policies for fighting against climate change and its potential harmful effects, implementing economic tools. Social perception of climate change, etc.

The present report extracts main conclusions reached by each participating author. Clearly overall consensus on the various issues could not be attained and, therefore, authors only express their own views in respective chapters. Also, due to the different sort of approaches followed in the elaboration of the report, in the scientific and technical chapters conclusions are the result of measurements and quantitative analysis whereas other chapters include a prospective analysis. Similarly, the inter-disciplinary nature of the climate change issue has lead to conclusions appearing more than once in different sections. Although this has been avoided where possible, some of these repetitions have been maintained because these points are raised in the context of different sector or activity analyses. Inevitably, the single perspective from any one report will lead to biases and, therefore, the interested reader should read the complete published work. There, one will be able to grasp the multiple facets and rich complexity of climate change analysis in Catalonia.

Next, a summary index for the report is included, with the names of participating authors,

A. THE SCIENCE OF CLIMATE CHANGE

A1. A generic view on climate change global.
Josep Enric Llebot. *Professor of Condensed Matter Physics at the Universitat Autònoma de Barcelona (UAB).*

A2. An historic perspective on climate change.
Antoni Rosell*. Research Professor of the Institució Catalana d'Estudis Avançats (ICREA) in the Institut de Ciència i Tecnologia Ambientals of the UAB. "Honorary Research Fellow" in the Department of Geography at the University of Durham.*

A3. Geographical factors, climatic regionalization and trends in climate series of Catalonia.

Javier Martín Vide. *Professor of Physical Geography at the Universitat de Barcelona (UB).*

A4. Anthropogenic forcing and climate changes.

Xavier Rodó. *ICREA. Director of the Laboratori de Recerca del Clima. Parc Científic de Barcelona (UB).*

Miquel-Àngel Rodríguez Arias. *Researcher at the Laboratori de Recerca del Clima. Parc Científic de Barcelona (UB).*

A5. Future projections on climate in Catalonia.

Josep Calbó. *Director of the Institut de Medi Ambient. Universitat de Girona (UdG).*

A6. Estimation of greenhouse effect gases production in Catalonia during 1990-2001.

José María Baldasano Recio. *Professor of Environmental Engineering at the Universitat Politècnica de Catalunya (UPC).*

René Parra. *Ph.D. in Environmental Engineering.*

Eugeni López. *Research assistant at the Laboratori de Modelització Ambiental, belonging to the Department of Engineering Projects (UPC).*

B. IMPACTS, VULNERABILITY, MITIGATION AND ADAPTATION

B1. Energy.

Joaquim Corominas. *Director of Ecoserveis and Ecofys. Associated Professor at the Department of Geography. Universitat Autònoma de Barcelona (UAB).*

B2. Infrastructure and urban environment.

Ricard Pié. *Professor at the Department of Urban and Regional Planning in the Escola Tècnica Superior d'Arquitectura de Barcelona. Universitat Politècnica de Catalunya (UPC).*

Josep Maria Vilanova. *Associated Professor at the Department of Urban and Regional Planning in the Escola Tècnica Superior d'Arquitectura de Barcelona. Universitat Politècnica de Catalunya (UPC).*

Robert Vergés. *Professor at the Deparment of Transport and Highway Engineering. Universitat Politècnica de Catalunya (UPC).*

Joan Lluís Zamora. *Professor at the Department of Architectural Technology (I) in the Escola Tècnica Superior d'Arquitectura de Barcelona. Universitat Politècnica de Catalunya (UPC).*

B3. Transport.

Francesc Robusté. *Professor at the Deparment of Transport and Highway Engineering. Universitat Politècnica de Catalunya (UPC).*

B4. Industry.

Joan Jorge. *Professor at the Department of Applied Physics. Universitat Politècnica de Catalunya (UPC).*

B5. Agriculture and forestry.

Maria Teresa Sebastià. *Professor of Botanics at the Escola Tècnica Superior d'Enginyeria Agrària. Universitat de Lleida (UdL). In charge of the Section of Plant Ecology and Forest Botanics at the Centre Tecnològic Forestal de Catalunya (CTFC).*

Pere Casals. *Researcher at the Centre Tecnològic Forestal de Catalunya.*

Glòria Domínguez. *Responsible for the Area of Forestry Policy and Rural Development at the Centre Tecnològic Forestal de Catalunya (CTFC).*

Joan Costa. *Professor of Fruticulture at the Escola Tècnica Superior d'Enginyeria Agrària. Universitat de Lleida (UdL).*

Lluís Martín. *Professor of Horticulture and Coordinator of the Horticulture Unit at the Escola Tècnica Superior d'Enginyeria Agrària. Universitat de Lleida (UdL).*

B6. Waste.

Teresa Vicent. *Professor of the Department of Chemical Engineering. Universitat Autònoma de Barcelona (UAB). Researcher at the Institut de Ciència i Tecnologia Ambientals (ICTA).*

Xavier Gabarrell. *Professor of the Department of Chemical Engineering. Universitat Autònoma de Barcelona (UAB). Director of the Institut de Ciència i Tecnologia Ambientals (ICTA).*

B7. Tourism.

David Saurí. *Professor at the Department of Geography (UAB). Researcher at the Institut de Ciència i Tecnologia Ambientals (ICTA).*

Joan Carles Llurdés. *Professor at the Department of Geography (UAB) and at the Escola Universitària de Turisme i Direcció Hotelera (UAB).*

B8. Hydric resources and water supply.

Josep Mas-Pla. *Professor of Hydrogeology at the Area of External Geodynamics. Universitat Autònoma de Barcelona (UAB).*

B9. Natural systems: terrestrial ecosystems.

Josep Peñuelas. *Research Professor at the Consell Superior d'Investigacions Científiques (CSIC). Director of the Ecophysiology Unit CSIC-CEAB-CREAF (Centre d'Estudis Avançats de Blanes).*

Iolanda Filella. *Scientist of the Consell Superior d'Investigacions Científiques (CSIC). Ecophysiology Unit CSIC-CEAB-CREAF (Centre d'Estudis Avançats de Blanes).*

Santi Sabaté. *Professor of Ecology at the Department of Ecology. Universitat de Barcelona (UB). Researcher at the Centre de Recerques i Aplicacions Forestals (CREAF).*

Carlos Gracia. *Professor of Ecology at the Department of Ecology. Universitat de Barcelona (UB). Researcher at the Centre de Recerques i Aplicacions Forestals (CREAF).*

B10. Soil.

Josep Maria Alcañiz. *Professor of Edaphology and Agricultural Chemistry at the Universitat Autònoma de Barcelona (UAB). Researcher at the Centre de Recerca Ecològica i Aplicacions Forestals (CREAF).*

Jaume Boixadera. *Associated Professor of Edaphology and Agricultural Chemistry at the Escola Tècnica Superior d'Enginyeria Agrària of the Universitat de Lleida (UdL).*

Maria Teresa Felipó. *Professor of Edaphology and Agricultrual Chemistry at the Department of Naturals Products, Plant Biology and Edaphology of the Universitat de Barcelona (UB).*

Oriol Ortiz. *Professor of Edaphology and Agricultural Chemistry at the Universitat Autònoma de Barcelona (UAB). Researcher at the Centre de Recerca Ecològica i Aplicacions Forestals (CREAF).*

R.M. Poch. *Professor and researcher at the Escola Tècnica Superior d'Enginyeria Agrària, belonging to the Universitat de Lleida (UdL) and at the Centre Tecnològic Forestal de Catalunya (CTFC).*

B11. Coastal areas and sedimentary dynamics.

Agustin Sánchez-Arcilla. *Professor of Harbours and the Coastal Zone at the Hydraulic, Maritime and Environmental Engineering Department at the Universitat Politècnica de Catalunya (UPC). Director of the Laboratori d'Enginyeria Marítima (LIM / UPC).*

José A. Jiménez. *Professor at the Hydraulic, Maritime and Environmental Engineering Department. Universitat Politècnica de Catalunya (UPC).*

Joan Pau Sierra. *Director of the Hydraulic, Maritime and Environmental Engineering Department. Universitat Politècnica de Catalunya (UPC).*

B12. Health.

Marc Sáez. *Professor of Statistics and Econometry at the Universitat de Girona (UdG). Chair of the Research Group on Statistics, Applied Economy and Health (GRECS). Universitat de Girona (UdG).*
Aitana Lertxundi-Manterola. *Associated Professor of Computer Science and Statistics at the Universitat de Girona (UdG).*

C. MANAGEMENT TOOLS

C1. Institutional framework.

Isabel Pont. *Professor of Administrative Law at the Universitat Autònoma de Barcelona (UAB).*
Mar Campins. *Professor of International Public Law at the Universitat of Barcelona (UB).*

C2. Economic Tools.

Flàvia Rosembuj. *Professor of Mercantile Law at the Universitat de Barcelona (UB). Visiting Scholar at the Columbia University.*
Lluís Esquerra. *Partner of the Mercantile Law Department of the Barcelona-based Office of the firm Garrigues Advocats i Assessors Tributaris.*

C3. Perception and communication of climate change.

Joan David Tàbara. *Associated Professor at the Universitat Pompeu Fabra (UPF). Researcher at the Institut de Ciència i Tecnologia Ambiental (ICTA), belonging to the UAB.*

A. The science of climate change

A1

A GENERIC VIEW ON CLIMATE CHANGE GLOBAL

1. **The climatic system has changed, both at global scale and at regional scales, since the end of the pre-industrial era, and some of the changes can be attributed to human activity.** The atmospheric concentration of gases responsible for the greenhouse effect (GEG) has risen since the mid-nineteenth century, as a consequence of the use of fossil fuels, waste management and changes in agricultural practices and land use.

   Increasingly evidence suggests warming up of the globe and, in consequence, also indicates other environmental changes. Globally, the last decade in the 20th century has been the warmest since 1861[2], the year 1998 has been the hottest (+ 0.55°C as compared to the average of the period 1961-1990), and the year 2002, the second hottest (+ 0.48°C), since 1861. There is increasing evidence, from paleoclimatic data and from the use of climatic models, that the warming experienced over the past 50 years is caused by human activity. Changes in sea-level, marine ice and snow cover, and precipitation, are consistent with the hypothesis of warming up of the lower atmosphere.

   However, there are relevant climate indicators which have not changed: from available records of ice cover in Antarctica, starting in 1978, no significant trend is observed for a reduction. Also, no changes have been observed in the intensity and frequency of tropical and extra-tropical storms, nor in that of tornadoes.

2. **All future scenarios forecast by the IPCC predict that CO_2 concentration during the 21st century will continue to increase and, hence, global temperature and sea-level will continue increasing, too.** The six main scenarios predict that the CO_2 concentration will rise to 540-970 ppm. Also, they predict that the rise in global average temperature during the period 1990-2100 will be in the range of 1.4°C to 5.8°C. Annual rainfall

[2] Year 1861 is the beginning of the last International Period.

will change globally, although at regional scales, behaviour may differ. Glaciers will continue to retreat, and sea-level will continue to rise. The sea-level is projected to rise by 0.09 to 0.88 m.

These changes in physical properties of the climatic system will lead to both positive and negative changes on biological and social systems, although it is thought that effects will be negative rather than positive on the global scale. Possible impacts of climate change will affect more severely more vulnerable systems. Impacts are predicted on agriculture, public health, ecological productivity of systems, soils, water supply, and so on.

3. **An increase is predicted in climatic short-term variability.** Climatic models project that increases in the atmospheric concentration of GHG will induce changes in the frequency, intensity and duration of extreme events, such as heat waves, torrential rains, tropical storms, etc. However, up until now no clear signal has been detected in this respect in an experimental way. Similarly, the risk of sudden changes increases (rapid climatic changes) because of the non-linear nature of the climatic system. Paleoclimatic and modelling studies have shown that in the North Atlantic, and particularly in Europe, sudden changes may occur in one or two decades caused by global warming.

4. **Inertia in all systems advises establishing strategies to adapt to climate changes.** The short-term stabilization of CO_2 emissions will not manage to stabilize the atmosphere content before 100 years, neither will it manage to stop the rise in sea levels nor the decrease in ice-covered sea surface. For other GHG, shorter stabilization periods are predicted.

5. **The rate and magnitude of global warming and other derived consequences can be reduced by lowering GHG emissions.** The larger these reductions in emissions, the slower the rate of warming. Reductions in emissions are essential for stabilizing the radiative forcing. Nowadays, technologies are available which could achieve this reduction in emissions. Forests, soils and terrestrial ecosystems, and the marine planktonic ecosystems, offer a good potential for absorbing the excess carbon dioxide in the atmosphere, as long as appropriate use is made, and although this potential is not perennial. The calculation of the emission mitigation costs is fraught with difficulty. Technology transfer mechanisms should be enhanced in order to achieve the most rapid stabilization at the minimum cost.

6. **Anthropogenic climate change naturally is related to other environmental and socio-economic problems. Hence, the ways of facing these problems often will be common and act in synergy.**

A2 AN HISTORICAL PERSPECTIVE ON CLIMATE CHANGE

7. **The climate in Catalonia, generically responds to natural changes in the global climate system, such as glaciations or the shorter-term variability (milennia or centuries) of glacial and interglacial periods.** However, paleoclimatic studies are scarce in Catalonia which help to understand the variability and trends of natural change of Catalan climates, their causes, and the adaptation response of natural and social systems to these changes. In fact, no historic/paleoclimatic records exist of the evolution of sea temperature near the Catalan coastal zone, and there are very few land-based continuous climatic sequences ranging back to more than a few hundred years. In fact, there is only one which ranges back the past 30,000 years and is published in indexed international journals.

8. **Temperatures in Southern Europe have increased progressively over the past 8,000 years.** The extant Mediterranean climate, predominant in large areas of Catalonia, spread from the south during the holocene (the past 10,000 years). Thus, while these conditions occurred in the South-East of the Iberian peninsula more than 10,000 years ago, in Catalonia, conditions as found today, began in the south about 7,600 years ago, and only reached the centre and North of Catalonia about 4,000 to 5,000 years ago.

   In those times, deciduous vegetation in coastal zones was progressively replaced by sclerophilous, and from about 2,900 years ago, persistent droughts were usual during summer. Apparently, there is a natural tendency towards aridification of the country, with less and less rainfall and higher temperatures. This tendency is in contrast with the drop in temperatures occurring during the Holocene in Northern Europe.

9. **Abrupt climatic changes and extreme weather have occurred in Catalonia in the past,** following similar trends and frequencies to those

in other parts of the planet. Studies are needed which permit us to establish which are the natural trends of climatic variability in Catalonia, determining, for instance, the natural frequency of extreme climatic situations, or the variability of rainfall regimes in different areas of the country. Until now, it is not known where adverse climatic situations may occur which are much more extreme than those possibly registered since instrumental records of climatic variables are available.

Also, we still have to determine the responses to changes of the most vulnerable natural systems of Catalonia, such as coastal areas and, especially, deltaic zones, or alpine ecosystems, or how does climate in Catalonia respond in a generic way to global phenomena such as *El Niño*, or to potencial sudden changes related to vulcanism, solar variability or oceanic circulation.

GEOGRAPHICAL FACTORS, CLIMATIC REGIONALIZATION AND TRENDS IN CLIMATE SERIES OF CATALONIA

A3

10. **Generalizations are difficult and, consequently, a great number of weather stations are needed to understand the past, present and future climatic diversity of Catalonia.** The climatic situation of Catalonia shapes a unique setting with multiple influences, subtropical and temperate, Atlantic and Mediterranean, under varied aerologic effects. The great contrasts in altitude and exposition of Catalonia generate, without having to descend to the microclimate scale, to a complex mosaic of climes. (Remarkable contrasts in temperature, pluviometry, etc. can be found across such a small country, hardly a few tens of thousands square kilometers, both at the climatic and meteorological scale.)

    The need for long and homogeneous quality climate series, calls for care for weather observatories and their observers, and for large emphasis on paleoclimatic studies, essential base for future climate studies. More studies and researches are still needed for a deeper, spatially resolute understanding of atmospheric behaviour and of the rest of components of the climatic system in Catalonia.

11. **Climatic complexity in Catalonia, past and present, hinders the determination and assessment of present changes and, especially,**

the establishment of predictions for the future. While the present climatic regionalization of Catalonia is certainly complex, i.e. difficult to capture on a map, the future limits and divisions apparently will also be of complicated forecast. Nevertheless, it is convenient to rely, today and in future scenarios, on physiographic units when establishing climatic boundaries, due to the relevance of geographical units in Catalonia.

12. **Research is needed on the typically Mediterranean low-frequency patterns of variability.** The NAO, i.e. the main low-frequency pattern of variability in Western Europe, has a relatively modest influence on Catalonia, because of the leeward orientation of the Iberian Peninsula (in the Catalan coast, winter rainfall is negatively correlated, albeit very weakly, to the NAO index). Research into the typically Mediterranean low-frequency patterns of variability, which help understand the autonomous behaviour of the Mediterranean basin and, through the analysis of trends, project future results for the Western Mediterranean and for the Iberian Peninsula, are seen as a necessary and promising line of research.

13. **The variation in rainfall count in Catalonia is still uncertain.** No significant changes in amount of rainfall are evident from looking at series of yearly rainfall going back a century or more. The putative rainfall reduction finds no evidence in secular series of rainfall. In contrast, there is a significant trend for a drop in the annual rainfall of the whole of Catalonia during the period 1961-1990. Increasing uncertainty in water supplies generated by the larger pluviometric variability in Catalonia will likely be more relevant than a moderate reduction in total rainfall.

14. **In Catalonia, the future evolution of pluviometry is one of the main themes, which should be taken into account.** Because of the moderate amount of rainfall, and the sharp variability in rainfall in Catalonia, this climatic element will be decisive when projecting previsions about future climate and its socio-economic effects on the country, beyond temperature. The uncertainty in hydric supplies deriving from the greater pluviometric variability would probably be, in Catalonia, as serious or more than a moderate reduction of total amounts of rainfall.

15. **Temperature across Catalonia shows similar variations and trends to those global from the last third of the nineteenth century until present, and warming is conspicuous from the 1980s and 1990s.** The decade of the 90s has been the warmest since instrumental records are available. It is possible that an increase has occurred in atmospheric

pressure through the twentieth century, both annual and during winter months, with a similar behaviour to that of the Mediterranean basin as a whole.

16. **A change in the number, frequency, intensity and/or persistence of extreme weather episodes has not been ascertained.** Until present, the presumed increase in volume of rainfall, has not been demonstrated, although the effects of this meterological phenomen risk have lead to larger economic losses in the past years. This emphasizes the need for new studies and analyses of climatic risks in order to identify the real present tendencies, and their future projection, considering their natural origin, and characterizing their frequency, intensity and persistence.

ANTHROPOGENIC FORCING AND CLIMATE CHANGES

A4

17. **The response to ENSO (El Niño Southern Oscillation) in remote regions such as Europe or the Mediterranean, can vary from episode to episode,** due in large part to the great differences between the different episodes (different "*El Niño*" events, for example). This feature may hinder its use as a climate predictor for the Iberian Peninsula. However, the large delay in its effects may compensate for this. On the other hand, this response may also be masked by the high internal atmospheric variability at our latitudes.

18. **In a context of climatic change, it is thought with high certainty that the NAO will become deeper and more variable in the future,** although it is still not clear to what extent will its winter influence impinge on the climate of Catalonia.

19. **Interannual variability of ENSO can rise due to global warming and to tropical Pacific warming.** As still there is no clear relation between ENSO and Mediterranean climate, more efforts should be devoted to research to get near instrumental data and to develop better regional simulations for the Mediterranean area.

A5

FUTURE PROJECTIONS ON CLIMATE IN CATALONIA

20. **Uncertainties still exist in the modelling of global climate.** The best global predictions for future climate are obtained from the use of numeric models for climate simulation, in particular from the use of coupled 3-D models, called AOGCM (Atmospheric Oceanic General Circulation Models (AOGCM). These models usually work with resolutions of the order of 2,5º latitude and longitude (Catalonia is represented by one single cell).

    The climatic models used by the IPCC usually reproduce present climate and changes during the nineteenth and twentieth centuries quite well, and there is a widespread consensus on general past climatic conditions being dramatically different those at present. Therefore, future predictions are increasingly reliable. Uncertainties are revealed by the different climate predictions provided by different models with equal inputs of CO_2 and aerosol concentration increase.

21. **There are various global predictions which are much more uncertain about changes in variability and the occurrence of extreme events.** In particular, various studies suggest a reduction in rainfall days, which, combined with an increase in total precipitation, implies an increase in the intensity of precipitation. Predictions are also believed pointing towards higher maximum temperatures and more hot days over continental areas, increases in the sultriness index, and increases in evaporation during summer in the continents, with the ensuing risk of droughts and forest fires.

22. **A regionalization of climate change predictions specifically for Catalonia is needed.** The issue is not sufficiently developed, such that regional predictions lack the reliability and solidity of global projections. In fact, the definition itself of climate involves intrinsically an increase in the difficulty of its prediction as we reduce the spatial scale. In particular, the prediction of future climate for a small area such as Catalonia will be highly complicated and uncertain. No modelling study has been found, nor statistical downscaling study, which is exclusively focused on Catalonia. Indeed, all future projections in Catalonia have been gleaned from studies applying to much larger areas.

23. **Near-surface air temperature in Catalonia may increase across the country during the twenty-first century,** as a consequence of global warming. The exact magnitude of the increase is difficult to predict, given the large number of uncertainties associated and the very complexity of the climatic system. A largely general consensus exists, however, about the increase being higher than the average for the planet (~3,5ºC by the end of the twenty-first century). This increase would not be uniform in time nor space, and increases would be more noticeable during summer than winter, and larger inland than on the coast.

24. **Precipitation in Catalonia during the next years may not vary substantially.** The various regionalized results give slightly different predictions, between moderate reductions and very slight increases. In slightly more detail, there is a nearly general agreement in predictions of small to moderate (up to 20%) decreases in precipitation during summer; and small increases (up to 10%) during winter. No predictions of significant changes during spring have been found, while for autumn, the reduction in rainfall could be even smaller than that during winter. The only study which allows to separate spatial variations in these changes predicts less rainfall in the Pyrynees and Western Pre-Pyrynees by the end of the twenty-first century, possibly due to summer decreases, and increases throughout the rest of the country.

ESTIMATION OF GREENHOUSE EFFECT GASES PRODUCTION IN CATALONIA DURING 1990-2001

A6

25. **It is essential to have transparent, documented and comparable inventories.** The IPCC has developed technical guides including a methodology for calculations and results reporting which must be followed by parties during the official presentation of their emission data. The present methods scheme of the IPCC is good, although some gaps and unresolved technical aspects remain. The inventory of calculated emissions includes arguable assumptions, such as not accounting for emissions from forest fires, or assuming that CH_4 emissions from controlled waste dumps are produced completely and the same year when waste is dumped. It would be convenient to apply this methodology in Catalonia.

26. **During the period 1990-2001, emissions have increased in line with the trend for the rest of Spain.** In year 1990, a total emission of 39.282 Gg *(1 Gg = 10^9 g)* of CO_2 equivalents was produced. The year 2001, this emission was of 52.270 Gg, a 33% larger. On average, emissions are 72% from consumption of fossil fuels, 9% from agricultural practices, 13% from industrial production activity, and 5,5% from waste management.

27. **The per capita CO_2 emissions in Catalonia during the year 2001 have been of 8,4 tons of CO_2 per inhabitant and year.** These emissions are whithin the average of values indicated by the UN for the rich countries and for States with average income.

28. **Given the dynamism of consumption, the fulfilment of the emission reduction commitments under the Kyoto protocol is becoming complicated,** despite the forecasts on the energy programme.

B. Impacts, vulnerability, mitigation and adaptation

B1

ENERGY [3]

29. Many proposals in the *Llibre Blanc de l'Energia a Catalunya* ("Energy White Paper for Catalunya") are still valid today. The implementation of those still pending should be promoted. On the other hand, a few need revising to adapt to internationally-established CO_2 emission reduction requirements.

30. It is likely that the transposition to Spain of the European Directive providing emission caps for certain atmospheric contaminants[4] will involve important difficulties for fulfilment in Catalonia. The member States have the powers for distributing internally to regions and sectors, the national emission quotas agreed upon at the Community level. The *Pla de l'Energia a Catalunya en l'Horitzó de l'any 2010* suggests using the emission indicator GHG per unit of Gross Value Added (GVA). (The distribution of GHG emission quotas among the Autonomous regions in Spain will be an important issue in the future. It is important to prepare thoroughly the bases for negotiation.)

31. There are various possible actions in the two main energy fronts for curtailing CO_2 emissions:

I) The adoption of strategies for energy savings and energy efficiency in processes and equipment, in buildings and vehicles, and/or to lead to changes in consumer habits.

II) The change to forms of energy lower intensities of CO_2 emissions. However, we must realize that there is little room for this type of action, given the widespread conversion to natural gas. On the other, atomic energy is not a valid option for achieving Kyoto commitments within the EU, given the problems its use may involve. The most advisable option is to use renewable energy

[3] Energy policies by the Government of Catalonia are based on two documents, i.e., the Llibre Blanc de l'Energia a Catalunya (White Energy Paper in Catalonia), covering the period 1981 i 2000, and the Pla de l'Energia a Catalunya en l'Horitzó de l'Any 2010 (Energy Plan for Catalonia in the Horizon of the year 2010), approved in 2002 and with the horizon of year 2010.

[4] Directive 2001/81/CE of the European Parliament and of the Council of 23 d'octubre 2001 on national emission ceilings for certain atmospheric pollutants. OJ L 309, 27/11/2001.*atmosfèrics.* DO núm. L 309, de 27/11/2001.

sources (RE). In Catalonia, there are enough renewable resources, and sufficient knowledge and technology to significantly increase the contribution of RE sources if the appropriate conditions are established for their active promotion, similarly to those given to other energy sources in the past. Many of these conditions are clearly set out in the *Llibre Blanc de l'Energia a Catalunya.*

32. **Hydrogen must be considered in energy balances resulting from fuel change scenarios.** The energy supplied by fuels is primarily due to the oxidation of the carbon and hydrogen they contain, producing carbon dioxide and water, respectively, the latter generally in the form of vapour. The emissions and energy yield from the production of hydrogen fuel must be considered. Because water vapour is a greenhouse effect gas and is linked to important feedback mechanisms, we ought to study its introduction into fuel change balances and use the technology of vapour condensation.

33. **There are technical actions for reducing emissions** of GHG which have not been proposed in official documents, such as:

    I) not authorizing thermoelectrical plants without co-generation, or

    II) adding turbine and generator to existing reservoirs without them.

    It is necessary to promote the assignment of costs to the different types of electricity (renewable, including hydraulic; and non-renewable, fossil fuel and atomic), avoiding the funding of non-renewable electricity by the hydraulic, which cheapens the selling price instead of achieving price competitivity for renewable sources. Also, it is essential to reach agreements for the importing of green energy, in the form of fuels and electricity, and to adapt the systems of cost assignment and taxation to real costs. We must take into account that the costs of reducing CO_2 emissions are in the order of magnitude of bonuses assigned to renewable-source electricity.

34. **During the next five years we should take into account increases in energy costs, energy demand and environmental demands, the growth of competence for access to petroleum, generalized integration of energy criteria in decision-making processes and, finally, the generalization of renewable energy sources.** These key elements are described next:

34.1. Costs increases

This increase could be due generally to fuel costs increases (especially those of fossil origin), and to the progressive internalization of externalities and the predicted increase in costs of equipment and energy installation for improving energy efficiency.

34.2. Demand increases

It is likely that the demand of transport, leisure, comfort and modern household appliances continues to increase. Clearly, this will lead to increases in GHG emissions. Information about emissions derived from these activities should be given in a clear, reader-friendly and succinct way, together with advice on investment in more efficient equipment and on the reduction of activities which may contribute to energy consumption.

34.3. Environmental demands increases

Increasing awareness of the potential consequences of climate change will increase public demands for reducing GHG emissions, increasing the pressure for reducing energy consumption and increasing measures promoting energy savings and efficiency and the need for increasing the participation of sources and technologies with a smaller contribution to climate change. It is best to inform about the need to initiate corrective actions, than to impose the measures when they become necessary.

34.4. Increased competition for access to petroleum

A larger increase rate of petroleum consumption than availability of new reserves leads to stronger competition. The consequences of world-wide competition for a basic resource such as petroleum are difficult to predict. Education and information should open up new energy sources with a smaller change cost.

34.5. Integration of energy criteria into decision-making

In the same way, introduction of safety, environmental and quality criteria into decision-making, energy criteria will also follow in this process. To achieve this, it is necessary to greatly improve both the “energy culture” of the public. Also, policy-makers and technical staff must be adequately informed and committed.

34.6. Generalization of the use of renewable energy sources

Renewable sources of energy will become widespread, driven

by institutional promotion, and caused by their need. The use of renewable source energies frequently transfers some of its impacts, such as visual impact, to the end-users, driving a reaction against their introduction. It is important to educate the public about the impacts of the energy system in order to correctly assess impacts of different sources and technologies. The visibility of impacts should contribute to limit energy infrastructures and energy consumption.

35. Classical analysis of the energy system in Catalonia with respect to greenhouse effect gases emissions.

Strong points and opportunities	Weak points and challenges
• Large consumption of Natural Gas • Weight of atomic energy in energy production • Coal is of small importance • Unexploited potential of wind energy • Unexploited potential of solar energy • Social support for solar energy • Potential use of heat produced during electricity generation in thermal power plants • Associations and society at large are in favour of using renewable energy sources • Technology is available for reducing emissions • Existence of “cutting-edge” firms in the renewable and energy efficiency sector • Potential for promoting green or sustainable tourism activities • Existence of EU projects for reducing GHG emissions • Reduction of the energy expenditure • Renewal of obsolete equipment • Knowledge export • Technology export • Professional updating • Updating of education programmes • Introduction of generation equipment in existing reservoirs not being presently used for electricity generation • Use of biogas from urban waste dumps not presently used for electricity generation	• Considerable importation of electricity • Dependence on the energy jurisdiction of organisms outside Catalonia • Near-saturation of the hydroelectric potential • Certain opposition to wind energy • Importance for fuel consumption of through-transit • Lack of energy local firms • Little university education • Little public awareness of the need to reduce GHG emissions • Introduction of new plants lacking co-generation • Important increases in electric consumption due to the building of new infrastructures with great energy demands • Decision of the central government about the distribution of emissions among autonomous regions • Fossil fuel price rises • Increasing environmental demands from the EU • Inconsistent initiatives by different administrations • Increase in the electrical climatization of homes

INFRASTRUCTURE AND URBAN ENVIRONMENT

B2

36. **The present urbanising process in Catalonia** has involved the expansion of the low-density residential model, with intense land consumption and an increase in the demand for new urban infrastructure. This generates obliged mobility and leads to an inefficient network of public transport.

    To face these problems, we need to develop land and urban planning which stops this type of growth, avoiding an unjustified use of land and reduced mobility -having repercussions on GHG emissions to the atmosphere- through a rational distribution of land uses and networks of public transport. Urbanization also limits land which is available to act as a carbon sink.

37. **The predicted effects of climate change advise the revision of infrastructure design and construction criteria.** In the case of communication infrastructures, this revision must be done taking into account the possible increased occurrence of torrential rains; both from the point of view of maintenance and use of appropriate construction techniques, and from the point of view of potential risks associated to the "barrier effect" for the free circulation of surface waters. Sewarage systems are presently designed for small return periods, of the order of ten years. We must either accept a potentially large increase in flooding risks compared to those today, or enlarge the capacity of our systems and plan flooding areas that act as flood lamination systems during the heaviest rains.

38. **Adaptable infrastructures are needed in the face of future scarcity in water resources** and to be able to deal with extreme events. Under present conditions, simulations for the urban area of Barcelona show that deficits in excess of 10% can already occur once in every ten years. Evidently, if dry periods become more intense and frequent, and population increases continue as lately, the situation will tend to worsen notably. To overcome these difficulties, we must inter-connect networks and search for new supply sources; moreover, we may have to search for these alternative supply sources in different climatic zones lacking these same problems.

39. **Buildings are one of the main causes for the generation of the ultimate conditions making up the urban microclimate:** temperature, humidity, radiation and ventilation can be skilfully modelled by buildings, creating streets and squares with better environmental conditions than those expected for the area's climate. This is so not only because of urban planning itself (sun-shade, windward-leeward, covered-uncovered), but also because of the envelope and cladding materials used for roofs and façades.

    New buildings are apparently lighter, have larger glassed surfaces and incorporate, increasingly, materials with higher thermal conductivity. An artificial heating system can readily provide a comfortable winter. In this way, however, thermal inertia is also reduced and summer heat is notably increased inside buildings. While artificial heating systems have been predominant in our area, now climatization systems are starting to be widespread, too. All this implies an increase in energy consumption in detriment of passive systems of thermal comfort.

B3 TRANSPORT

40. **The huge increase in daily mobility of population and the increase in goods transport** are occurring worldwide. Besides the positive evolution of the energetic efficiency of vehicles, the distances covered grow, the mean occupancies of the vehicles diminish and global mobility increases around 50% over the GDP. To reduce the emissions caused by this increased mobility, it is essential to promote and extend the railway system as an alternative to other, more polluting means of transport. An alternative option is the generalized promotion of hydrogen cells as the best technological option for terrestrial vehicles in medium term.

41. **The transport sector is the fastest growing sector as energy consumer and producer of GHG in the European Union.** Forecasts from the European Union for the period 1998-2010 in Western Europe are 38% increase in goods, and 24% increase in passenger transport. Technological improvements and better fuels have lead to significant reductions in the emissions of certain pollutants. However, air quality is still poor in most European cities. New practises for goods, as just on time and zero stock have priority over transport costs and however over

the emissions impact. In that case, the scenarios in the mean time are not very optimistic even the recent actions carried out about goods transport in interurban areas (taxes for using roads) and in urban areas (control over charge and discharge and parking time).

INDUSTRY B4

42. **Catalan industries are sensitive to climate change in different degrees according to the type of industry, and therefore must adapt according to their specialization and expertise.**

43. **Changes in climate will become more evident before firms decide to invest to adapt and mitigate change.** With the operating life of industrial machinery being between 10 and 40 years, industrialists are in a position to change machines only when renewal becomes necessary, and not before.

44. **The possibility must be studied of establishing funding mechanisms either from the public sector, or from industry federations, to help coping with adaptation costs.** In the next years, it is essential that tools for continuous adaptation are given support, forcing firms to innovate, to rethink processes, and situating industry at the level of environmental awareness society is beginning to demand. It has been demonstrated that eco-labelling and energy savings associated to a marketed product, among other aspects, may increase product demand.

AGRICULTURE AND FORESTRY B5

45. **The effects of climate change on agriculture are uncertain, diverse and complex,** and interact with each other and with cultural, political and socio-economic factors. The main factors are the abandonment of agriculture and changes in land use. These factors may have repercussions as serious or more as climate change itself. The reduction of crop land and forests because of urbanization is very strong in some areas, mainly near the largest urban areas. The abandonment of land in other areas may

lead to the loss of biodiversity, to a reduction in landscape quality, and to an increase in the risk of forest fires. In contrast, the conversion of crops to forests could increase the carbon sink.

46. **The response to climate change varies according to agricultural and forest species.** This differential effect has been observed for high-temperature stress, for the degree of sustained response and acclimatisation to CO_2 increases in the atmosphere and for vulnerability to O_3 concentration increases.

47. **Temperature increases can lead to the rapid mineralization of organic matter in agricultural and forest soils in the short term,** and in the long term, to a reduction in soil nutrient availability. The latter may worsen if an increase occurs in the C/N ratio of matter returning to soils, due to an increase in atmospheric CO_2.

48. **The greatest threat to Catalan agriculture and forestry is reduced water availability** due to the increase, with temperature, of evapotranspiration and the possible reduction in rainfall. If water supply to irrigated areas is secured, these areas could increase their productivity. This issue, however, is complex and is under the influence of multiple factors impinging on crop productivity, such as soil type, and so on.

49. **Changes in the climatic variables will affect productivity and crop risks.** The reduction in cold-hours could lead to a drop in the production of woody crops, such as apples, pears, cherries and peaches in traditionally fruit-producing areas such as the Plana de Lleida. A change in the variety which is cultivated could solve the problem for species like the peach, but for apples and pears the risc es higher. If the increase in temperatures advances the flowering period, or the risk of frost damage is maintained, the degree of uncertainty in production will increase. If the risk of frost damage is reduced, earlier-blooming peach or apricot varities could be introduced, of lower quality and less productive, but of higher sales price. Also, the growing of medlar could be introduced, and citrus crops extended, possibly introducing, if the increase in temperatures and reduced frost-damage risk was substantial enough, tangarines and lemons. The reduction in the number of frosty winter days would also favour other unirrigated woody crops, such as olives, with a reduction in the risk of crop loss and a lower need for replacement.

50. **The reduced water availability will be criticial for unirrigated areas,** reducing the productivity of crops, such as olives, almonds, hazelnuts or grape. The effect of climate change over vinyeards would probably depend on particular microclimatic effects. Also, the increase in hydric stress will have an important effect on other unirrigated crops, such as cereals, in areas which are already relatively dry. In contrast, they may be cultivated more extensively in unirrigated areas which nowadays are more humid, such as the Berguedà.

51. **Consequences to small producers can be important.** The difficulty in adapting to alternative crops and their limited capacity to survive temporary market rejection, where a small flaw may render the product unsaleable.

52. **Increases are predicted in invasibility, pest occurrence, and crop and cattle diseases.** Nowadays, restrictions to distribution are primarily due to low temperatures and frost risk. The impact on weeds will depend on the particular species and, specifically, on the cultivation mode and specific ecophysiology and competitiveness. The atmospheric CO_2 increase could increase the resistance of vegetables due to the increase in production of secondary compounds, although a C/N ratio increase in resulting plant matter could stimulate consumption and worsen the quality of soil organic matter, subsequently having negative impacts on nutrient availability.

53. **Alpine meadows, similarly to mountain forests, are highly threatened ecosystems under conditions of climate change.** Our meadows and forests are a biodiversity reservoir and a source for diverse products and externalities. The traditional extensive management of pastures has modelled their ecological, landscape and cultural values. Warming may have a positive effect over productivity, but there is a real threat of species extinction and biodiversity loss. Forests and pastures have an added value in that they may help to mitigate climate change thanks to the function of forest soils as carbon sink. More knowledge is needed, though, on the relationship between the management of these ecosystems and their sink function.

    The main value of forests in Catalonia is in products without direct market value and in externalities, such as biodiversity, and hydric protection and regulation. Also, our forests are extraordinarily multifunctional in their market products. Today, non-wood forest products are not very

competitive in international markets, and climate change will worsen that. Non-wood products amount to a substantial economic volume, but their use is heterogeneous and scarcely regulated. Climate change may lead to a reduction in mushroom production, but to an improvement in the quality of medicinal and aromatic plants, and to an increase in honey production and other bee-hive products.

54. **On the long term a change could occur in the distribution of forest vegetation in Catalonia.** Lowland and southern areas would become richer in bushy plants and the typically Mediterranean forest would be found higher up in mountaineous areas. Montane forests would become more rare. Forest communities are more resilient in the face of change than other, more ephemeral plant communities, but this capacity of buffering changes could disappear if the forest is destroyed by large-scale perturbations, such as the large forest fires which have occurred over the past years. In this case, differences in the ability to regenerate of different species and their respective vulnerability to hydric stress and other could determine important changes in the composition and function of our forests.

55. **Climate change will involve an increase in forest fire risk in the Mediterranean zone and an extension of high-risk areas to areas where present risk is lower.** The primary natural risk in forests of our country is fire. This risk is often increased by anthropic pressure. Vulnerability would increase due to drought, abandonment of rural areas, potentially increasing in unirrigated crop areas with decreases in the productivity and competitivity of agricultural products, succession towards young and over-dense forests, and less intensive forest management because of the reduced cost-effectiveness of wood products and uses.

B6 WASTE

56. **Waste with largest contributions to GHG emissions (CO_2 and CH_4) is that of urban origin.** This waste is disposed of in dumps (75% of total waste production), incinerated (23%), or is treated in sewage treatment plants (2%). A large part of this waste is generated from non-fossil organic matter. Waste production has increased in Catalonia by 50% during the

past decade. Nowadays, controlled disposal of urban waste is the most used option for this type of waste. Controlled disposal made up for 65,3% of generated urban waste by year 2000. There are over 32 dump sites in operation in Catalonia at present.

57. **Biogas use is key in reducing emissions produced during anaerobious digestion of organic matter,** both in waste dumps, or as a recycling treatment of organic matter for energy production. By this process, a large part of waste can be treated: agricultural, cattle, industrial organic, urban and industrial waste water, sewage treatment plant (STP) sludge and the organic fraction of urban waste. Biogas is a fuel which generates neutral energy from the point of view of CO_2 emissions. Biogas has a high energy content and can be used in various ways with high performance, especially for electricity production, to cook, heat, dry, etc.

58. **European and Catalan legislation and the PROGREMIC planning *(Local plan for the management of urban waste in Catalonia 2001-2006)* will help to reduce emissions.** The proposed mitigation measures (reduction of organic matter supplied to dumps, implementation of collection at source, collection of biogas in waste dumps, use of biogas, etc.) will be readily implemented in new waste dumps, but an added effort will be needed to implement these measures in dumps at the end of their service life or in old dumps. A close monitoring of recently closed waste dumps will be needed. The most significant change of measures proposed as regards mitigation is the energetic use of biogas. Its not sufficient with simply collecting it. Energy must be obtained from it, as this is how it may substitute other emissions. Another problem may be the effectiveness of the collection or capture networks of biogas in waste dumps; all too often one is too optimistic and low efficiencies must be expected.

    In the next years, carbon dioxide equivalent emissions generated by waste treatment processes could be reduced as compared to those in year 2000. The initial situation was among the worst possible scenarios, i.e., 65% or urban waste in year 2000 was dumped. A substantial part of the rest was incinerated. With views to 2006 (if the PROGREMIC plan is followed), 55% of organic matter will be recycled by methanization and composting. Emissions during methanization are good because they replace other, harmful, emissions in order to obtain energy. Composting may reduce emissions by a factor of 10 as compared to waste dumps, because CH_4 is not generated. Both processes will mean considerable global reductions.

59. **It will be necessary to look for adequate design and operation of the dumps** because an important part of the organic matter (OM) remaining, though, will be dumped. For methanization and, particularly, for composting processes to function correctly it is very important to separate sufficiently the organic fraction during collection at source. For this, adequate planning and participation by the public at large are crucial. Also, to reduce emissions from waste dumps, a correct design and functioning is needed, and very especially the recovery and collection (capture and energetic use) of biogas.

60. **Main reductions will occur starting from year 2006,** because of the time needed to build the new installations and improve present installations. PROGREMIC planning is adequate to reduce emissions, although it could have been more ambitious as regards biogas recovery installations for the future.

61. **Waste water treated in sewage treatment plants presently contributes little to global waste production (2%).** During the next years in Catalonia, an increase is expected in these emissions compared to year 2000, because of actions planned. These are absolutely necessary for appropriate waste water management. For example, the beginning of operations of the STP of Baix Llobregat. This plant will mean a 10-15% emissions increase, made up by the substantial represent increase in the volume of waters which are now treated. Also, the upgrading of numerous STPs for nutrient removal, will also increase slightly nitrogen oxide (NO_x) emissions.

62. **Pig slurry management would need to incorporate emissions from this waste as a planning criterion.** From data on production of potential waste for obtaining biogas, the "maximum potential biogas production" from these substrates in Catalonia could be estimated. Predictions for 2010 show biogas production may represent less than 10% of the total obtainable. The ICAEN energy scenario for 2010 shows CO_2 and methane emission increases, generated by the excedent pig slurries which cannot be landfilled. Hence, these excedents will need to be treated either in thermal drying plants, generating CO_2 and COV gases, in lagoons, or in sewage treatment plants for nutrient removal, etc.

TOURISM B7

63. **Tourism is one of the main economic activities in Catalonia.** It is a very diversified sector, comprising mass-tourism (sun&beach), winter tourism (skyiing) and emerging forms of alternative tourism such as those related to nature and adventure, cultural and urban heritage, to the practice of certain sports such as golf or nautics, theme parks, etc. The so-called "sun and beach tourism" is still dominant, followed by sky tourism (largely dominated by the domestic market). Also, a large part of the various forms of alternative tourism, maybe less dependent on climate but dependent on the potential effects of climate change over certain ecosystems, show remarkable dynamism, which will probably increase in the future.

64. **Climate is essential for a great part of the Catalan touristical offer.** Therefore, any change in the offer could lead to very significant impacts on tourism; however, whether these changes are positive or not will depend on each subsector and on the adaptation/mitigation strategies which are taken. There is a lack of awareness among the Catalan tourism sector on the potential impacts of climate change.

65. **There is a plausible hypothesis stating an increase could occur in people influx due to the lengthening of the touristical season and the reduction in seasonality of sun&beach tourism in Catalonia.** In addition, higher temperatures in competing destinations could also positively influence this subsector. Some of the impacts deriving from climate change, such as increased frequency of extreme phenomena, and sea-level rises, could have negative consequences for sun&beach tourism, because of threats to the basic resource, beaches themselves. If these changes are confirmed, then decisions should be taken as regards construction of defense works or replanning of the whole length of the main coastline. Both alternatives have potentially very high costs. On the other hand, climate change may impact this type of tourism through impacts on future water availability.

66. **The main impacts of climate change would probably affect first the winter tourism in Catalonia,** although impacts would vary considerably depending on the location of sky resorts. In any case, the response to climatic variability in the form of snow cannons could intensify in the future, especially in the easternmost resorts of the Catalan Pyrynees.

Artificial snow is a common adaptation to climatic variability, although it also has clear environmental limitations. Sky sport will probably be able to maintain itself above 2,000 m altitude thanks to snow cannons. This would imply, however, the abandonment of part of present installations below this altitude.

67. **Impacts over alternative tourism in Catalonia will vary depending on the specific type of activity.** Cultural and urban tourism would not seem, a priori, to be impacted by climate change. In contrast, so-called eco-tourism and rural tourism could suffer impacts in the measure that natural heritage sustaining them evolves in response to climate change.

68. **The orientation of the tourism sector towards diversification and integration of products and packages would tend to increase its capacity to face possible impacts of climate change.** Catalan tourism has already initiated a process of adaptation to new tendencies in the sector, especially those orientated towards diversification and integration of "products" and "packages", as well as quality improvement, including significant changes in the environmental performance of firms and touristical destinations. As the risk of depending on a single sphere of activity is reduced, the sector would be better prepared to face possible impacts of climate change. It remains to be seen, however, whether this tendency is realized in the next few years.

B8 HYDRIC RESOURCES AND WATER SUPPLY

69. **In Catalonia, effects of climate change over hydrological resources should be estimated taking into account the widespread tendency in the Mediterranean area: temperature increases, maintenance or slight reduction in precipitation and increased occurrence of extreme episodes (e.g. torrential rains).** Repercussions on the hydrological dynamics are complex, but, broadly speaking, a substantial increase in evapotranspiration, a slower aquifer recharge and, except during extreme episodes, smaller fluvial discharges would all occur. The variability within and between years observed since 1960 in the river Fluvià could be an indicator of changes occurring in hydrological dynamics. In the coastal

strip, the possible rise in sea-level, together with the abovementioned repercussions, could favour the intrusion of a saline wedge and, hence, reduce exploitation.

70. **Variations in demand and land-use changes in Catalonia will probably lead to the major short and medium-term modifications to hydrological resources, rather than global influences.** Specifically, land-use changes (abandonment of pastures and crops) in the Ebre basin could have influenced significantly the recent discharges of the river itself. During the next years, it is crucial that hydrological policies are defined which specifically contemplate potential reductions in resource availability while simultaneously guaranteing water supplies. Management proposals are needed in which limitations due to the influence of environmental change, including climatic and anthropic causes, over human supply, and the equally-important water availability for ecosystems, are explicitly included. At present, the demand from internal basins makes up for about 80% of resources. This requires a finer management, in which savings initiatives, uses control, and, possibly, limits to land development will become essential.

71. **Presently, knowledge is acceptable about surface water resources, and approximate about underground resources.** We must improve our knowledge about the different components of the hydrological cycle, through the monitoring of discharges and levels, and water quality, through studies and maps about change vulnerability, through studies of socio-economic repercussions, and through the prevention of uncertainty in water supplies in a context of variability. To adapt to climate change, the main challenge is to adapt to changes in uses and, especially, to changes in land organization influencing hydrological dynamics; i.e., to promote a combined use of surface and underground resources according to local availability.

72. **No proposals for fighting climate change are given from the field of hydrology,** although there is scope for action bearing on the potential effects of climate change on water availability and hydrological dynamics. These actions, through adequate planning and solid environmental education, should promote the effective utilization and savings of local hydric resources.

73. **Climatic tendencies will not favour the recovery of present deficiencies in resource availability.** Specifically, the recovery of

groundwater levels in intensely exploited aquifers, quality improvements in areas with polluted surface or underground waters, or the salinization of coastal aquifers, and greater water availability for wetlands and riparian areas would become less likely, given the changes in hydrological dynamics implied. The risk of flash-floods in Catalonia is real.

74. **In balance with the concern for securing human supplies, environmental concerns should be included, too.** Ecosystem dynamics depend, from many points of view, on adequate water availability. Nature is not just another consumer, but the main consumer. We must "negotiate" what percentage of resources belong to Nature, and which are we prepared, in the role of water managers, to hand over. Clearly, from the anthropic perspective, it is a deal favouring human needs; but we should realize that good hydrological functioning guarantees environmental protection and resource availability.

75. **Environmental education is a basic tool for the good management of hydric resources in Catalonia.** Actions involve the whole of Society. We cannot simply call it a government problem, and think it can be solved by simply passing laws. It is quite clear that a large part of citizenship is aware of the need for involvement in the protection of water resources, etc. What remains unclear is whether citizens will know how to involve in an efficient manner, although the will to do so exists; here is where education, promoted from the government, and with the invaluable aid of numerous associations, must widen awareness and knowledge about the apropriate forms of action.

76. **Options of adaptation to climate change as regards resources and hydric demand.** It is known that the effects of anthropogenic climate change can only be absorbed through finalist planning which is in advance of its effects. This planning must be considered from both the points of view of supply and demand. The following table summarizes and assesses some of these options.

Resources	
Option	**Remarks**
1. Domestic supply	
1.1. Increase regulation and reservoir infrastructures	There are few options of building reservoirs in Catalonia. Strong social opposition. Substantial environmental impact.
1.2. Increase derivation from rivers and abstraction from aquifers.	Most rivers have discharges below the desirable minimum, and long dry reaches during summer (or longer periods). The possibility of exploiting groundwaters is still feasible in a few localities, especially in mountain and urban areas.
1.3. Diversions, or increase of diverted water discharges.	Costly, high social opposition, strong environmental impact (to the point of being unfeasible) in any river in Catalonia.
1.4. Desalinization. Promotion of new technologies for potabilization treatments.	The use of saline water is a viable option, and socially accepted. Costly, though price is sensibly inferior to that of diversion. It can mean a considerable reduction in resources of coastal areas. Improvements in treatments allows the use of resources previously rejected for reasons of bad quality (e.g., water from the the river Besós).
1.5. Re-utilization.	Limitations to use because of quality. Suitable for irrigation (golf) and public use.
2. Agricultural uses	
2.1. Increase regulation and reservoir infrastructures.	Costly, large environmental and social impacts. Scarce possibilities of creating new works because of land scarcity.
3. Industrial uses (refrigeration)	
3.1. Use of poorer quality water and/or water re-utilization.	Viable.
4. Hydroelectrical plants	
4.1. Increase capacity of reservoirs.	Costly, high environmental impact.
4.2. Simulation prediction of inputs.	Little reliability in the face of uncertainty about the magnitude of climate change.
5. Pollution control	
5.1. Increase treatment capacity.	Costly.
6. Flash-flood management.	
6.1. Construction of contention dams.	Costly, environmental impact on the riparian area. Limited use of the affected area.
6.2. Headwater elements to reduce flash-flood peaks.	It is only effective in small catchments. Regular management is required.

Demanda	
Option	**Remarks**
1. Domestic suply	
1.1. Incentives for savings (price policy).	Limits to applicability. The iniciative of institutions and a social contract are needed.
1.2. Increase of wastewater recycling.	Viable, locally costly due to the duplication of distribution networks. Improve the quality of sewage discharged to channels with little dilution because of the scarcity of natural discharges.
1.3. Reduction of water losses in the distribution network.	Costly in the oldest installations.
2. Agricultural uses	
2.1. Increases in efficiency.	Through technology use or a price policy.
2.2. Change to crops with less irrigation demands.	Difficult to apply due to the specialization of certain areas to a few products and due to market and EU legislation limitations enacted through its agricultural policies.
3. Industrial uses (refrigeration)	
3.1. Promote water reutilization.	Depends on the particular industrial process.
3.2. Efficency process.	Investment in technological improvement is needed.
4. Hydroelectrical plants.	
4.1. Increase in turbine efficiency.	Investment in technological improvement is needed.
5. Pollution control.	
5.1. Reduction of effluent volumes to be treated.	Investments or technology, or imposition of taxes to discharge flows.
5.2. Management of discharges at the watershed scale. Land-use planning with respect to waste production/ disposal.	Especially diffuse discharges (pig slurries).
6. Flash-flood management.	
6.1. To improve prevention and protection systems.	Of limited use in small basins, i.e. with a short response time, typical of Catalan rivers, with the exception of the Ebre river.
6.2. To regulate land development by limiting use of floodable areas.	Political and economic connotations. Improvements would be required of urban and old industrial works in these areas.

NATURAL SYSTEMS: TERRESTRIAL ECOSYSTEMS

77. **Climate change adds to multiple pressures presently acting on terrestrial ecosystems in general, and obviously over ecosystems** in Catalonia, too: land-use change, high resource demands and over-exploitation in some cases, abandonment in others, nutrient and pollution deposition, etc. All these factors may impinge on terrestrial ecosystems or endanger them, and similarly on the goods and services they provide. The impact of climate change will be modified by the type of management adopted and by interactions with those other pressures.

78. **In Catalonia, similarly to the rest of the planet, at present there is substantial evidence, both observational and experimental, about the links between climate change and ecosystem biological and physical processes.** The beginning of spring has moved forward, and the onset of winter is delayed, such that the vegetative period has been protracted by about 5 days per decade on average during the past fifty years.

79. **Competitive abilities between species have varied,** though changes have been different for each species, and derived changes can be expected in community composition and in species distributions. In fact, in the Montseny, *Quercus* and beech trees are apparently growing at higher altitudes, driven by land-use changes and progressive climate warming.

80. **It is more likely that species are displaced than whole ecosystems,** given the different response of each species and the possible introduction of invasive species. In the most extreme cases, the populations of some species are endangered by the synergy between climate change-induced stress, changing their habitats to inadequate for their survival, and land fragmentation, hindering their migration to habitats more adequate for survival.

81. **Water availability plays a key role in determining the composition of vegetation and species distributions in Catalan terrestrial ecosystems, primarily those Mediterranean.** The progressive aridification experienced in the past years (i.e. climate warming and increased potential evapotranspiration with no corresponding increases

in precipitation), and that predicted for the next decades (warming and, in addition, a reduction in water availability) will have large consequences on physiology, phenology, growth, reproduction, species establishment and, finally, on the distribution of biota, and therefore, on the structure and functioning of ecosystems.

82. **Experimental studies about climate warming and drought have shown how some species are more affected than others.** Thus, competitive abilities of species are altered, effects eventually leading to changes in the composition of biological communities. For instance, a reduction has been observed in the diversity of our scrublands. In addition to these structural changes, functional changes have also been observed, such as the reduction in CO_2 absorption caused by drought and by the greater nutrient loss in leachates following rains, caused by climate warming.

    Many other changes have also been observed during the past decades in response to climate change, i.e. more frequent forest droughts, higher forest fire risks, larger emissions of biogenic volatile organic compounds from our ecosystems. The expected aridity increase will lead to an increase in the risk of soil degradation through processes which are already in operation in our country, such as soil erosion, salinization and organic matter loss.

83. **Changes affect, and will continue to affect, the multiple resources and services** provided by terrestrial ecosystems (supply of natural renewable resources, such as foods, drugs, wood products, game, mushrooms, pastures, etc.), such as environmental resources (biodiversity maintenance, regulation of air composition and climate, land and water conservation, carbon reservoir, etc.) and social (recreational and educational uses, traditional values such as culture, tourism and trekking, etc.).

84. **Responses to climate change and other factors involved in global change will alter the carbon reservoir capacity of forests, but the magnitude and direction of changes remain unclear.** The increase in atmospheric CO_2 concentration could lead to an increase in tree and bush growth, as well as the amount of fallen leaves and root growth and, hence, net primary production. However, the last open-air fumigation experiments with CO_2, and those conducted near natural CO_2 sources, i.e. under natural conditions and/or in the long term, suggest that these effects of CO_2 may saturate because forests are reaching their maximum absorptive capacity and plants may climatize to this CO_2 increase.

85. **The temperature increase may have both positive and negative effects on the carbon balance,** largely as a function of the evolution of water availability. In Mediterranean ecosystems, where climate change can readily reduce soil humidity, productivity may decrease rapidly and, subsequently, also carbon absorption. In addition, ecosystem productivity, including organism mortality and soil carbon dynamics, as well as biome productivity, including perturbations such as forest fires, are less likely to be positive.

86. **Models predict an average net production of about 60 g C m^2 $year^{-1}$ for forest ecosystems in Catalonia, currently and by mid-21st century,** although, by then, this net production will result from a circa 60% higher than today gross primary production and total respiration, as a result of the annual 1% increment in atmospheric CO_2, annual increment of 0.04ºC in temperature, and 0.03% annual reduction in precipitation; all average predicted values from the IPCC (2001). Also, these changes will decrease further the soil water reserve, thus seriously compromising the role of many of our terrestrial ecosystems as carbon sinks in the next decades.

87. **We should take into account that the carbon balance is seriously influenced by land-use change, often more than by climate change, or by the CO_2 concentration increase.**

88. **We must continue conducting studies for improving our knowledge about the present and future extent of changes to the functioning and structure of Mediterranean ecosystems.** Experimental conditions of these studies must approximate as much as possible natural conditions. We must use technological advances and apply them to the different time and spatial scales providing a picture of the scale of alteration of processes. These studies must comprise from the most remote periods to those in the near-future, passing through the past decades, to present, and from descriptive to experimental studies, as well as modelling studies across space and time scales.

89. **The foresting policies of abandoned agricultural areas and of perturbed areas, in the next years will have to take into account those conditions predicted for the immediate future,** in order to alleviate effects of both climate change and atmospheric CO_2 increases. Among these, reduced water availability, consequence of both rainfall decreases and/or increases in potential evapotranspiration, and of the higher demand of the more active ecosystems.

90. **The management of forests and generally all areas of natural interest, should incorporate the landscape scale,** including large-scale planning which considers the combination of areas of various types, as well as the multiple use and effect of perturbations, such as forest fires.

B10 SOIL

91. **The soil maps and databases for Catalonia must be completed,** to aid in the calculation of better estimates of GHG emission rates and the carbon sequestering potential. Equally, mitigation measures should be based on the potential of each soil type, therefore it is essential to increase our knowledge about this natural resource. We must promote baseline studies about soils in Catalonia to improve our understanding and to allow quantification of below ground soil processes which are affected, or are agents, of climatic change. The use of data generated from soil studies in Central Europe and across the planet have limited use. This has lead to large associated uncertainty in predictions obtained from simulation models of belowground soil processes which make use of this information.

92. **Soils in Catalonia have, overall, high carbon sequestering potential, although water scarcity limits inputs and stabilization in the form of soil humus.** Irrigation is one of the most effective practices for increasing carbon reserves in soils; thus, new irrigated areas may become good carbon sinks. Limited water reserves may set restrictions to these forecasts.

93. **The management of nitrogen fertilizers can be much more effective and feasible than other measures in mitigating effects of climatic change,** because nitrogen oxides specifically contribute 89% to soil GHG emissions (European data). This issue merits further study, agroenvironmental measures must be enforced and agricultural good practices codes, established. It is necessary to develop and apply agricultural practices in those aspects related to the efficient use of nitrogen fertilizers, recycling of agricultural and urban organic waste, in combination with the appropriate growing techniques which help to integrate and maintain organic carbon in soils. Thus, techniques of minimum cultivation, ecological growing and no cultivation are apparently the most adequate for those types of crops where they are applicable.

In order to implement these technologies rather than conventional agriculture, necessary incentives will need to be established. The generalized application of residual sludge should be better controlled. Stabilized STP sludge should be used, allowing to permanently fix the organic matter and nitrogen into the soil.

94. **It is important to establish and maintain a monitoring network with experimental plots, adapted to the characteristics of the main agricultural systems in Catalonia,** in which changes are quantified, processes are measured, and technologies are tested. Equally, continuity must be given to microbasins and forest plots monitoring relevant properties related to climatic change. These pilot areas should integrate into State and European monitoring networks. It is also important to use agricultural and environmental policy tools to secure carbon sequestering and to implement appropriate soil management, favouring practices with the strongest effects on climatic change.

95. **Environmental education focused on agricultural workers to implement the Code of Good Practice. This code, which should be completed, developed and applied, will be a very useful measure.** Equally, awareness must be raised among the public in general about the need for consolidating the collection at source of urban waste for them to be utilized, prior to treatment, as fertilizers for increasing the organic content of soils and thus reducing the need for other nitrogen sources.

COASTAL AREAS AND SEDIMENTARY DYNAMICS

B11

96. **On the medium term, climate change may contribute to the modelling of Catalan coastal areas. The main transformation agents could be the following:**

    I) **relative increase in average sea level,**

    II) **increase in storm persistence and slight increase in storm intensity.** The increase in storm persistence would lead to increases in erosion processes and flooding, as natural recovery of the sedimentary body would be hindered,

III) **increase in flood probability** (i.e. a decrease in its return period), with ensuing decreases in the ability to recover naturally of affected areas, and

IV) **reduction in the sedimentary volume available in the sandy coastal strip** due to the reduction in sedimentary input from rivers. This reduction, independently from other factors, is associated, from the climatic-change point of view, to the increase in intensity of rainfall regimes and to the larger sediment losses to the continental platform.

97. **The response of the coast to these modelling factors depends on the shape of the coast. Therefore, the low-lying sedimentary coasts will be the most vulnerable.** Changes in climatic conditions may accelerate erosion processes and increase the frequency and magnitude of floods, directly threatening deltas and coastal wetlands in Catalonia (e.g. delta of rivers Ebre, Tordera, Llobregat, Aiguamolls de l'Empordà, etc.).

98. **The Catalan coastal zone is in a fragile equilibrium and has a high natural value. Thus, action should be taken in sufficient advance of potential climate change. It will not be feasible to defend all low-lying coastal areas in Catalonia simultaneously and within a period of few years.** Planning of response strategies should begin now, so we have a margin of possibly one or two decades for implementation, in a similar way to how other, more directly threatened, countries have done.

99. **The possible response strategies must consider geomorphology, ecology and economy of each coastal stretch, together with existing infrastructure and social perception and cultural values of those communities "utilizing" these stretches.** The assessment of natural and economic functions will justify or limit investment in order to face local climate changes. Any coastal works will have to form part of the integrated planning of the coastal stretch, defined as the corresponding physiographic, ecological and socioeconomic unit. The response strategies will be essentially of two types:

1) **Retreactive.** Actions must accurately assess the implications of land loss and land availability in the coastal strip.

2) **Protective and/or defensive.** This action must also assess accurately the costs of initial construction and maintenance together with impacts on the coast of these works.

In both cases, assessments must be done within a single time-frame which is consistent with the predicted speed of climatic change. This analysis must be performed within the framework of integrated coastal management, taking into account the coast's dynamism and the impossibility to maintain (sustain) a coastline "fixed" in its present position.

HEALTH B12

100. Climate change could have, globally, important effects over health. Although health may be affected both by climate variations and weather changes, it is, in fact, the relationships between climatic variability (deviations from the average regional climate within a period between a few weeks and a few years) and health which will allow us to infer the possible effects of climate change over public health, if there are any effects.

Climatic variability (anthropogenic) can affect health through numerous pathways. The magnitude of effects, also, will partly depend on the ability to anticipate them and on the education and planning of emergency responses potentially reducing the impacts. Therefore, the ultimate impact on public health, in general, will depend on whether health tensions caused by climatic variability or, on the other hand, adaptation measures designed to protect the populations against these tensions, have the larger weight.

101. Weather and climatic variability may affect health through direct and indirect mechanisms. Direct effects include primarily physical impacts which cause physiological stress (for example, temperature), or physical damage to people (for example, storms or flash-floods). The most important and evident effects of climatic variability over the health of Catalan people are direct effects. We believe that the main effects will be linked to temperature increases. Some studies have found for Spain a considerably wide range for comfort temperature. Also, comfort temperature decreases when other variables are taken into account, such as air pollution.

Although it is difficult to generalize, these results suggest that temperature increases, not necessarily in the range of extreme situations such as heat waves, can cause an effect on public health. On the other hand, we think

that effects of flash-floods on health and welfare cannot be ignored, even in developed countries such as Catalonia.

102. With respect to indirect effects, firstly, climate change may affect public health by modifying primarily levels of air pollution (anthropogenic), but also pollen levels (biogenic). The main effect, given the anticipated increase in concentrations due to climate change, wil be cause by ozone. Increasingly, the population will be at risk, especially persons with respiratory diseases, for instance asthma, as well as people living in areas with potentially greatest ozone levels.

On the other hand, the impact on health of some of the contaminants is more evident during summer or with high temperatures. The problem is that most studies have investigated the possible independent effect of temperature and/or air pollution over public health, but not the interactions between these variables, although recently a few iniciatives have been taken towards approaching this aspect.

103. The complexity and multiple factors determining the spread of diseases makes it very difficult to generalize about the mechanisms, and even less so, about the direction of changes in Catalonia. According to the report *Climate Change* and *Human Health* produced by the working group bringing together the World Health Organisation, the World Meterological Organisation and the Environmental Programme of the United Nations, the incidence of infectious diseases will increase as a consequence of global warming. Although the increase in water temperatures and other climatic factors may increase the number of viable bacteria in water and in fish, the maintenance of water treatment infrastructures, both for potable and waste water, will prevent the occurrence of large cholera outbreaks in Catalonia. A few climatic factors (air temperature and rain) affect the survival and reproductive rates of bacteria and viruses in the environment. In Catalonia, hygiene conditions and water treatment, both of potable and waste water, will prevent sporadic outbreaks from becoming epidemic, such as now occurs in South America or in South-East Asia.

C. Management tools

C1

INSTITUTIONAL FRAMEWORK

104. The adoption of the United Nations Framework Convention on Climate Change (1992) and the Kyoto Protocol (1997) are the main steps taken by the international community towards fighting against the phenomenon of climatic change. In these legal tools, commitments of States are explicitly stated regarding both the prevention and reduction of greenhouse-effect gases, and the co-operation in scientific, technical and technology matters. At the same time, legislation has been passed for implementing its legal dispositions, and the various control mechanisms of their application have been established.

To delimit these commitments, both the Convention and the Protocol make a basic and preliminary distinction between developed countries, or with transition economies, and developing countries, on the principle of common but differentiated responsibilities. In addition, to help achieve these objectives, both texts contemplate, as compensation for developing countries which have committed to reducing emission of greenhouse-effect gases, three tools designed to relax the fulfilment of the established targets: two mechanisms are considered "in project", i.e. the Joint Implementation and the Clean Development Mechanism, while the third is the articulation of a system of negotiable emission permits (emission trading).

105. The European Community and its member States have ratified the Framework Convention and the Protocol. They have committed to fulfill the obligation to reduce and limit emissions of greenhouse-effect gases. This is done through the establishment of joint quantitative targets. These are subsequently distributed internally, between member States, according to their economic capacity and degree of economic development. This has become known as the *European bubble*.

The Community institutions have taken two main legislative measures, i.e. the establishment of the European Inventary on Pollutant Emissions (2000) by virtue of the *Directive 96/61/EC, 24 June 1996*[5], Directive 2003/87/EC establishing a regime for emission right trading of greenhouse-

[5] *Council Directiva 96/61/EC, of 24 September 1996, concerning integrated pollution prevention and control (OJ L 257, 10.10.96).*

effect gases within the Community[6] which entered in force on 1rs' Januari 2005; Decisión 280/2004/EC of the European Parliament and of the Council of 11 February 2004[7], concerning a mechanism for monitoring Community greenhouse gas emissions and for unplementing the Kyoto Protocol; and Directive 2004/101/EC of the European Parliament and of the council of the 27 October 2004, establishing a scheme for greenhouse gas emissions allowance trading within the EC[8]. The regulation on certain fluorinated greenhouse gases, which should be considered in future, is only a proposal[9].

106. The peculiar distribution of public powers across the various administrative levels in Spain makes it necessary to determine which powers are available to the central government for fighting against climate change and its effects, and which are reserved to the Autonomous regions. The Spanish Government has powers in multiple sectors, such as, *inter alia,* agriculture, environment, research, forestry and forest services, cattle paths, and in the mining and energy sectors. However, in certain sectors, powers are reserved only for passing basic legislation, i.e. for laying the legal foundations, or for giving special authorisations. There are other aspects which are not exclusive competence of the State and therefore could be in the powers of Autonomous regions.

107. Respect to the legitimate exercise of powers by all levels of administration obliges to integrate Autonomous regions into the decision-making process concerning matters under their jurisdiction, and concerning matters over which they may have to exert legislative or executive functions. This general approach should be followed when taking the important internal decisions still to be taken about climate change.

[6] *Directive 2003/87/EC of the European Parliament and of the Council of 13 October 2003 establishing a scheme for greenhouse gas emission allowance trading within the Community and amending Council Directive 96/61/EC. (OJ L 275/32, 25.10.2003).*

[7] *Decision 280/2004/EC,* (OJ L 49/8, 19.2.2004).

[8] *Directive 2004/101/EC of the European Parliament and of the Council of 27 October 2004 amending Directive 2003/87/EC establishing a scheme for greenhouse gas emission allowance trading within the Community un respect of the Kyoto Protocol's project (OJ L 338/18, 13.11.2004).*

[9] *COM (2003) 492, adopted by the European Comission on 11th August 2003.*

108. There are a number of specific actions still to be taken by the Spanish Government:

1) The development, promotion and dissemination GHG emission technologies for control, reduction and prevention.

2) The adoption of measures to adapt to possible impacts of climatic change in the context of the State's public policy.

3) The achievement of quantified targets established in Annex B of the KP and within the framework of the European bubble, by the first commitment period (2008/2012).

109. Catalonia has its own framework for a scheme of reserved powers, allowing to develop own policy in climatic change matters. The Government of Catalonia has legislative and executive powers in multiple sectors, such as, *inter alia*, agriculture, environment, research, forestry and forest services, and the mining and energy regime.

110. Although regional representatives have been incorporated to the *Consejo Nacional del Clima*, we must also advocate for a representation in the real decision-making organisms. It would be convenient to promote tools which guarantee regional powers, such as sector conferences, cooperation agreements or joint plans and programmes. In addition, internal decisions, i.e. those left to the discretion of Member States by International treaties, must involve regions in Spain. Regions need to participate when defending State positions in climate change matters in Europe and overseas, given the particular relevance to regions that decisions will have later.

111. In the context of climatic change, the Catalan Government could be interested in the following actions:

1) Implementation of the Catalan Fighting Strategy against Climatic Change and design and application of specific plans developing it.

2) Identification of organisms which will be held accountable for those policies enacted by the Government of Catalonia and allocation of functions among them.

3) Definition of the task of intervention or enforcement to be implemented by the Generalitat Goverment of Catalonia in climatic change matters with the aim to guarantee commitments fulfillment.

4) Adaptation in the context of climatic change of the task of promotion carried out by the Generalitat in the various sectors involved.

5) Analysis of potential lines of concert action with other Autonomous regions.

C2 ECONOMIC TOOLS

112. The Kyoto Protocol allows flexibility in the use of mechanisms for fulfilling greenhouse gas emissions reduction targets, a reflection of the tendency at the international scale towards integrating economic analysis in environmental policy. The KP gives alternatives to industrialized countries for reducing their GEG emissions in the most effective and rational way, that is, at the lowest economic cost for emissors and similar environmental results.

The kyoto Protocol is the first international law instrument which advances in the debate about the use of economic tools in environmental protection, aside from arguments as to the convenience of their use, and stressing the importance of finding best ways for their implementation.

113. Emissions trading is an economic instrument that allows free transfer of previously assigned rights to GEG emissors. The emissions trading system is based on an imperative to limit global maximum emissions, which is lower than the present emissions level, the tights are distributed among the different emissors participants in the trading system as fractions. Participants which achieve reductions in their emissions below the units assigned, can sell their surplus to other participants in need of them. Need can arise from having received less units than initially required, or because of subsequent increases in their production system and ensuing emissions.

The efficiency of the emissions trading system is based on two premises, i.e.:

I) Participants with lower costs of reductions will tend to reduce their emissions, and

II) The price paid by buyers of rights is cheaper than the cost of directly reducing emissions. The price of an emission unit is therefore an expression of the standard reduction cost.

114. In accordance with the provisions of Directive 2003/87/EC, on 1 January 2005 the CO_2 emissions trading market will come into operation in the European Union, with the participation of 15,000 industrial facilities in over 25 states. The European market includes only the direct reductions in CO_2 of electricity generating facilities and industries that are high energy consumers, such as iron and steel manufacture, hydrocarbon refining, cement and lime, ceramic products, glass, paper and paper pulp. The first perior of fulfilment is 2005-2007 and the subsequent periods will have a duration of five years.

115. In order to set up the market of the Europena Union, the rights have been freely allocated to each facility by the competent national authority[10]. The National Allocation Plan establishes the maximum limits for the national market corresponding to the period 2005-2007 and the allocations to each of the sectors included in the Directive, in addition to the emissions corresponding to the sectors not included in this legal text. The rights will be allocated to each facility individually in accordance with the applications made by the latter.

116. The legal obligation of the facilities specified in the National Allocation Plan for emission rights of the Spanish State consist in handing over annually a number of rights equivalent to their emissions as verified by the competent authorities.

117. The following options are available for fulfilling the obligations: (a) a reduction in the emissions; (b) bilateral purchase of emission rights outside the market; (c) joining an alternative platform of negotiation and purchase of rights on the market; or (d) conversion of the units resulting from flexible mechanisms into emission rights. Bilateral purchase may be cheaper, but it requires the coverage of the counterparty risk and bilateral negotiation of the sales contracts. Using the existing markets is simpler to manage, but the prices of the rights can be higher. The facilities may also convert the rights resulting from the flexible mechanisms of the Kyoto Protocol into European emission rights.

118. The aim of the project mechanisms (the Clean Development Mechanism, or CDM, and the Join Implementation Mechanism, or JI) is to direct involved countries towards the path of reducing their potential emissions, through clean-technology transferral and financial resources for specific projects from industrialized countries,

[10] *Royal Decree 1866/2004 of 6th September approving the National Allocation Plan for 2005-2007. (BOE 7-9-2004).*

who are those obliged to reduce GEG emissions. Within our powers, the subject obliged by international law will be the Spanish State, which has been allocated total anthorophogenic GEG emission amounts for a given fulfilment period (the first period is from 2008 to 2012).

Without prejudice to the binding to the public international legislation, the private sector will necessarily involve, especially in the use of flexibility mechanisms, both in project mechanisms and those concerning the emission rights market. When referring to the private sector economic actors, both direct and indirect GEG emitters (electrical companies, large electricity consumers, waste management firms, etc.), entities which are susceptible to reducing GEG emissions (renewable energy promoters, research and development of clean technologies, energy savings, improvements in land use, and so on) and all the financial market subjects (financial institutions funding projects, investment funds societies, intermediary institutions, organized-market management societies, etc.) are included.

119. Local economic actors should be informed about available alternatives so they can evaluate costs and benefits and can modify their choices and behaviours in favour of the environment. Catalonia has those competitivity elements and factors needed for consolidating these market mechanisms, and concentrates great potential for action in the framework of KP project mechanisms, based on its research excellence and development of clean technologies, in its promotion of the sector of renewable energy, energy savings and efficiency, and a wealth of financial institutions. Technical assistance should be provided from the Administration to the different sectors to reduce transaction costs to informed actors.

120. Direct investment in developing countries from local firms should be promoted, under the auspices of the CDM, or in transition economies, with the aid of the joint implementation mechanism as a bilateral tool. Promotion should contribute to real technology transfer, including, among others, promotion of renewable energy, of energy efficiency, or even of the carbon sequestering by sinks. It is essential that Catalan firms draw up strategies for contributing to the development of poor countries, taking advantage of the new rules of the game designed by the KP. These strategies must be directed towards working together with potential market parties in order to increase market capacity and for the transfer of in-depth knowledge about CDM and JIM modes and a clear understanding of the concepts of *additionality* and *baseline*.

The different possibilities for action in Catalonia could include material publication about project mechanisms, the initiation of inverse missions in regions for promoting knowledge exchange and coordination with EU or UN programmes, to help potential actors to interpret complex rules and to navigate through the process prior to approval.

121. The creation of intangibles should be given support to increase goodwill of Catalan firms. Catalonia could play a main role in facilitating that economic actors can define and develop practical methods for determining baselines -especially for small-scale projects, i.e. those Catalan actors are likely to develop in the creation of monitoring tools for relevant data and for calculating emissions reductions, and finally, in the definition of procedures for validating and verifying emissions reductions.

That is, it is a question of allowing local firms to create immaterial goods, intangibles, which are sources of knowledge and, hence, of wealth, and which can, or can not, be transformed into rights of property, i.e., into a verified quality carbon unit. Catalan firms can be, with the support from the Catalan government, owners of knowledge that can become in an intangible -an idea in the sense of product from a creative process, albeit elementary, which is embodied in things or elements: the verified reduction unit.

122. Catalonia could promote and bring together interests from firms active in the above stages of development of a project mechanism, i.e. local firms capable of defining standar baselines for small-scale projects, of creating instruments for evaluating data and calculating emission reductions, and of verifying and validating them. A multidisciplinary workgroup could be created giving support to different sector local firms having substantial impacts on global warming, during the design, implementation, verification and obtention of a carbon unit resulting from a CDM or JIM project. Once technical assistance is organized -through cooperation between the public and private sectors- existing initiatives could be used promoting technological offer and demand between Catalan firms and those abroad, to encourage international agreements and technology transfer projects.

123. Catalan firms should be able to obtain quality carbon units. The primary aim is that Catalan firms obtain, as a result of projects, a quality carbon unit -which should secure more important benefits deriving from

projects. The verified quality carbon unit could help fulfill KP commitments (if project mechanisms are considered bilateral instruments requiring both the agreement of the State-of-origin and of the State hosting the project), or as objects for buying and selling contracts or in other types of financial contract.

By making Catalan firms owners of a carbon unit, Catalonia makes it possible that local firms can obtain additional benefits from project investments which take into account aspects of global warming or may even give access to additional funds for emission reduction projects. Carbon unit is a subjective right, an asset, for its holder. Precisely, additional funding could be obtained -with the guarantee of a quality carbon unit- around a new Catalan multilateral institution which can diversify risk across diverse specific projects, and managing and processing the certification of carbon units, i.e. a Catalan carbon Fund. Thus, Catalonia has the opportunity for helping to define for the country, which are the quality carbon units, having competitive prices in international carbon markets, and to promote technology investments in developing countries.

PERCEPTION AND COMMUNICATION OF CLIMATE CHANGE

C3

124. Climatic change, both its causes and consequences, is not only a scientific or technical problem, but, especially, also has a set of political and social facets. These suggest that a much wider debate and wider participatory spaces are still needed, not limited to the exploration, however in-depth, rigorous or integrated, from work contributed by research emanating from single scientific disciplines or group of disciplines. Quantitative data shows climatic change has not been a main cause for environmental concern for Catalans, both in the mid-nineties and presently. However, it appears that concern is growing about global environmental problems and links to other global processes such as the ozone layer thinning.

125. A learning-focused debate about global warming on Planet Earth among the public at large could help in,

I) Increasing awareness about uncertainties over the ultimate existence or non-existence of global climatic change;

II) Increasing the feeling that action is necessary;

III) Producing greater acceptance for the need to apply economic and legislative measures (which were substantially rejected at the outset);

IV) Leading to greater awareness of the need for reducing consumption. Main sectors requiring action are: energy, transport, and waste, together with land planning. Nevertheless, the general perception is maintained that decisions relative to climatic change should not follow primarily economic criteria, and that prohibitions and legal and economic measures are less preferable than education or voluntarily-adopted measures; and that, within the possible alternatives identified for fighting against climatic change, it would also be preferable to find alternative energy sources, reducing waste and finding new transport means, than reducing own consumption.

126. **Press coverage of climatic change has been small in Catalan press during the period 1990-2002.** In any case, cover has been cyclic and has increased considerably during key international events and conferences, such as during the KP negotiation. Still, Catalan press releases have increased during the period, and have probably exerted a substantial effect over public opinion concerning climatic change, given the complexity of issues and hence the information dependence of public at large in these matters.

Glossary

Annex I Countries
Countries listed into the Annex I to the United Nations Framework Convention on Climate Change (UNFCCC). This list includes all the countries in the Organization of Economic Cooperation and Development (OECD) in 1990, plus countries with economies in transition, Central and Eastern Europe (excluding the former Yugoslavia and Albania). Under article 4.2 of the UNFCCC, these countries commit themselves to return individually or jointly to their 1990 levels of greenhouse gas emissions by the year 2000.

Annex II Countries
Countries listed into the Annex II to the United Nations Framework Convention on Climate Change (UNFCCC). This lists includes all countries in the OECD in 1990. Under Article 4.2 of the UNFCCC, these countries are expected to provide financial resources to developing countries in order that they comply with the obligations of the Convention (such as preparing national reports) These countries are also expected to promote the transfer of environmentally sound technologies to developing countries.

Annex B Countries
Countries listed into the Annex B to the Kyoto Protocol, which include the developed countries that have commited to control their greenhouse gas emissions in the period 2008–12, including those in the OECD, Central and Eastern Europe and the Russian Federation.

Baseline Emissions
Emissions that would occur without policy intervention (in a business-as-usual scenario).

Carbon Equivalent (CE)
Metric measure used to compare the emissions of the different greenhouse gases based upon their global warming potential (GWP).

Carbon Sequestration
The long-term storage of carbon or carbon dioxide in the forests, soils, ocean, or underground in depleted oil and gas reservoirs, coal seams and saline aquifers.

Carbon Sinks
Natural or man-made systems that absorb carbon dioxide from the atmosphere and store them (for instance, trees, plants and the oceans).

Certified Emission Reduction Unit (CER)
Specified amount of greenhouse gas emissions reduction achieved through a Clean Development Mechanism project.

Clean Development Mechanism (CDM)
Mechanism defined in Article 12 of the Kyoto Protocol, which sets the framework for the development of projects in developing countries with de following two objectives: (1) to address the sustainable development needs of

the host country; and (2) to generate emissions credits that can be used to satisfy commitments on Annex 1 Parties and thus increase flexibility in where government Parties meet their reduction commitments. Projects that limit or reduce greenhouse gas emissions can earn the investor (government or industry) credits if approved by the CDM Executive Board. A share of the proceeds from the project activities is to be used to cover administration costs, and to create an adaptation fund which will assist developing countries that are particularly vulnerable to the adverse effects from climate change to take action to adapt.

Emissions Reduction Unit (ERU)
Specified amount of greenhouse gas emissions reductions achieved through a Joint Implementation project or as the unit of trade in greenhouse gas emissions trading systems.

Emissions Trading
A market-based approach to achieving environmental objectives that allows those reducing GHG emissions below what is required to use or trade the excess reductions to offset emissions at another source inside or outside the country. In general, trading can occur at the domestic, international and intra-company levels.

General Circulation Model (GCM)
A global, three-dimensional computer model of the climate system which can be used to simulate human-induced climate change.

Global Warming Potential (GWP)
Index used to translate the level of emissions of various gases into a common measure in order to compare the relative radiative forcing of different gases without directly calculating the changes in atmospheric concentrations. GWPs are calculated as the ratio of the radiative forcing that would result from the emissions of one kilogram of a greenhouse gas to that from emission of one kilogram of carbon dioxide over a period of time (usually 100 years).

Inventory of greenhouse gases emissions
Inventory of the greenhouse gases emissions that countries must submit regularly. The IPCC has provided guidance on how to estimate and report on anthropogenic GHG emissions and removals, using a standardized tabular reporting format for six major sectors: energy, industrial processes, solvents and other product use, agriculture, land-use change and forestry, and waste.

Joint Implementation
Kyoto mechanism that allows developed countries (or companies from those countries) to cooperate on projects to reduce greenhouse gas emissions and share the emissions reduction units (ERUs).

Kyoto 'Basket'
Group of six greenhouse gases -carbon dioxide, methane, nitrous oxide, HFCs, PFCs and SF6– whose emissions have to be controled by the Parties to the Kyoto Protocol.

Kyoto Mechanisms[1]
Procedures that allow Annex 1 Parties to the Kyoto Protocol to meet their commitments under this protocol based

[1] Formerly known as *Flexibility Mechanisms*.

on actions outside their own borders. They include Joint Implementation (Article 6), the Clean Development Mechanisms (Article 12) and Emissions Trading (Article 17).

North Atlantic Oscillation index
The difference of sea level pressure between two meteorological stations situated over Iceland and Portugal. It is a large-scale mode of natural climate variability having large impacts on weather and climate in the North Atlantic region and surrounding countries.

Radiative Forcing
A change in the balance between incoming solar radiation and outgoing infra-red and short-wave radiation. Without any radiative forcing, solar radiation absorbed by the earth would continue to be approximately equal to the infra-red radiation emitted from the earth. The addition of greenhouse gases absorbs an increased fraction of the infra-red radiation in the atmosphere, reradiating it and creating a warming influence.

Reservoir
Component or components of the climate system where a greenhouse gas or a precursor of a greenhouse gas is stored (for instance, oceans, soils and forests).

Abreviations

AOGCM: Atmospheric Oceanic General Circulation Model

CDM: clean development mechanism

UNFCCC: Framework Convention on Climate Change

EC: European Community

EDAR: wastewater treatment plant

EU: European Union

GEG: greenhouse effect gases

ICAEN: Institut Català d'Energia (Catalan Institute for Energy)

IPCC: Intergovernmental Panel on Climate Change

JI: joint implementation

KP: Kyoto Protocol

PROGREMIC: Local plan for the management of urban waste in Catalonia

RSU: Urban Solid Wastes

VOCs: volatile organic compounds

UN: United Nations