THE ECONOMICS OF CLIMATE CHANGE IN MEXICO

SYNOPSIS

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SYNOPSIS

Dr. Luis Miguel Galindo
Coordinator
“The Economics of Climate Change in Mexico” is a study coordinated by Dr. Luis Miguel Galindo Paliza, of the Faculty of Economics of the National Autonomous University of Mexico, at the request of the Ministers of Finance and for the Environment and Natural Resources. The Mario Molina Center, the National Ecology Institute and the Center for Atmosphere Sciences of the National Autonomous University of Mexico have all participated. Financial resources were provided by the Ministry of the Environment and Natural Resources, from the area for international cooperation of the Government of the United Kingdom, and from the Inter-American Development Bank. Technical support was provided by the World Bank and the Economic Commission for Latin America and the Caribbean of the United Nations Organization. The focus, methodology and policy recommendations are the responsibility of the study coordinator. This document is a synopsis of the research undertaken.
# THE ECONOMICS OF CLIMATE CHANGE

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PROLOGUE

Climate variability has been a constant throughout history. From the first records left by human beings with regard to their relationship with the climate, the principal and most common observation has been that the climate is changeable and, to a large extent, unpredictable.

To this natural variability of the climate, recent decades have witnessed the addition of unsettling proof that human activities themselves are effecting changes in the climate with undesirable effects. This is what the term anthropogenic climate change refers to: alterations of the delicate equilibrium of the global climate caused by human beings.

Anthropogenic climate change has thus become a serious cause for concern for public policy, both from the global perspective and with regard to its local effects which, in turn, have serious risk implications for the viability of economic progress, wellbeing and public health.

To mention a few of the undesirable effects of anthropogenic climate change we can cite extreme weather events, such as droughts which reduce food production, or torrential rains which cause dangerous floods; falling agricultural productivity; greater frequency of forest fires; severe damage to coastal infrastructure such as ports and docklands, due to unusually high sea levels; effects -with varying degrees of seriousness- on commerce and tourism and, of course, at the top of the list, serious effects on public health, for example as a result of heat stroke or vector-borne diseases.

For the Government of President Felipe Calderón Hinojosa, the harmful effects of anthropogenic climate change are a serious cause for concern. This has translated into the implementation of a range of public policies specifically designed to ameliorate its effects and to encourage an intelligent and healthy adaptation to climate change which will allow for reducing the associated risks to the economy and public health, as well as the transformation of systems of production, distribution and consumption, thereby reducing social and economic vulnerability to those effects.

Economy and ecology are inextricably linked. The very etiology of both words, which derive from oikos, the Greek word for house, refers to the need to care for, conserve and make use of our common home that is the planet and, more specifically, our national environment, in which we develop as human beings, with our desire for material progress and spiritual wellbeing, and our profound calling to achieve happiness.

From the outset, we stand in the firm conviction that one of the ineludible tasks of government is to address those basic human needs which are as yet unmet for clearly avoidable reasons, as outlined by Manuel Gómez Morín several decades ago. It is in this context that combatting climate change and its harmful effects falls within the priorities of the governmental agenda.

Thus, our country has ratified without reticence the United Nations’ Framework Convention on Climate Change and the Kyoto Protocol. We have also led developing country proposals in diverse
international fora, such as that for a Green Fund to complement existing funding mechanisms and thereby guarantee the financial viability of measures to mitigate and combat climate change.

To date, Mexico has presented three National Communications including national inventories of greenhouse gases (GHG), with a fourth to be concluded later this year. Among developing countries, Mexico is unrivalled in its leadership in this regard.

In the field of research and dissemination of human knowledge about climate change, this book represents a clear sign of the level of Mexico’s Federal Government’s commitment. The Ministry of Finance and the Ministry for the Environment and Natural Resources commended the Faculty of Economics of the National Autonomous University of Mexico with undertaking this work.

“The economics of climate change in Mexico” has been coordinated by Dr. Luis Miguel Galindo, and attempts to make a serious and well-founded estimation of the possible economic costs that anthropogenic climate change will generate in our country, especially for those sectors of the population which, due to their poverty, are especially vulnerable.

This is an invaluable piece of work which contributes greatly to estimating with increasing rigour the economic implications of climate change for Mexico. One of its main findings is heartening and serves as a profound lesson for public policy: The costs of efficient and effective action to combat climate change and ameliorate its effects, are well below the harmful costs to the economy which can be avoided by such action, and are outweighed by the gains in potential growth and development which such actions are likely to achieve. This means that decisive action today on this issue is a sound public investment; indeed, we conclude that it is an essential investment.

The study which the reader now holds, and which we are most pleased to present, will be of immense usefulness in orienting strategy and guidelines for public policy. We also hope that it will be the first of a number of serious and thoroughly researched such studies undertaken in Mexico, with the backing and encouragement of a diversity of public and private, national and international organizations, to the benefit of all of us who share this common home, our planet.

Agustín Carstens
Minister of Finance

Juan Rafael Elvira Quesada
Minister of the Environment and Natural Resources
Preface

While the Stern Review looked at the impacts of climate change at a global level it is at a local level where the impacts will be realised and both adaptation and mitigation responses will take place. Although the problem of climate change is global in nature, it is only through detailed understanding of what climate change means at a national level that countries will come together and form an effective global response. Because of this I was delighted that colleagues from the Stern Review and I had the chance to discuss the issues with members of the study team and learn about the excellent work they have done on analysing the Economics of Climate Change in Mexico.

The main finding of the Stern Review was that the costs of taking action to reduce the impacts of climate change are less than the costs of inaction. This simple statement is built on detailed analysis of the wide-ranging potential impacts of climate change and an understanding of mitigation and adaptation responses. To do this properly requires reflecting on the nature of the problem which means incorporating risk and uncertainty (that means that some very severe outcomes are possible) and that it affects human health, biodiversity and the way that we can live in addition to traditional economic sectors. It means measuring what counts rather than counting what we can easily measure to avoid reporting only a subset of the risks. This study does a good job in doing that. By reflecting the risks that Mexico would face from unabated climate change it shows that Mexico has a strong interest in action to reduce climate change impacts.

The Mexican study shows that without action the Mexican economy will suffer significant economic costs as a consequence of climate change. Despite partial short term gains in some activities and regions there are net costs overall and that these costs will increase during this century, in particular in the agricultural and water sectors. Furthermore, there will be important losses outside the economic sectors and market prices, that people value such as biodiversity. Moreover the key conclusion is that it is a better for the Mexican economy to actively participate in an effective international agreement than just face the economic costs of adaptation.

That the Mexican Government has supported this study, indicates that the policymakers are increasingly clear that not only is climate change, if left unmanaged, a severe, or insuperable challenge to their growth and poverty reduction goals, but also that action will lead to a wide range of business opportunities for growth and development. In the transition to a low-carbon growth path the markets for low-carbon, high-efficiency goods and services will expand, creating opportunities for farsighted governments and businesses to benefit from. The study both makes a major contribution to the understanding of climate change in Mexico, and strengthens the global case for strong action.

I congratulate those who have commissioned and supported the study and those who carried it out. And I look forward to the leading role that I am convinced Mexico will play in action on climate change.

Nicholas Stern
IG Patel Professor of Economics & Government London School of Economics and Political Science
First of all, I would like to acknowledge the importance of celebrating “World Environmental Day”, especially in such a splendid place as this, in which natural beauty, environmental conservation and economic development prosper in harmony.

It is likely that many of you will be wondering why the Minister of Finance is present at this World Environment Day celebration, and that my participation has to do with climate change. But this should not come as a surprise. In the last few years, all over the world, the conclusion has been reached that human induced climate change is both a technical environmental problem and an economic problem of the greatest importance. This is due to the simple fact that everything done to improve the environment necessarily implies costs, but also because inaction on this issue will generate much greater costs in the medium to long term. Thus it has become increasingly desirable that finance ministers of all nations become more directly involved in environmental issues.

Fittingly, one of the pioneering works aligning ecology and public finances was the review of the economics of climate change undertaken by Sir Nicholas Stern. The publication of the Stern Review in October 2006 marked a watershed in this sense.

By clearly outlining the estimated global costs of anthropogenic climate change, together with the global costs of ameliorating the probable damage, the Stern Review paved the way for the analysis of the best options for tackling this serious threat. In this sense, it laid out a blueprint for action that other nations could follow.

So it is in the case of Mexico, where President Calderón has established sustainable development as one of the five priorities of the National Development Plan.

With the aim of contributing to a better understanding of climate change, its effects and implications from an economic perspective, and to set out the best public policy options for tackling it, the Ministry of Finance and the Ministry of the Environment and Natural Resources commended the National Autonomous University of Mexico the task of drawing up a study similar to the Stern Review, but limited in scope to cover the economic costs of climate change in Mexico.

The work undertaken for this study was coordinated by Dr. Luis Miguel Galindo and drew on the knowledge and expertise of distinguished Mexican environmentalists, and on the research carried out at national and international institutions.
This study contributes to a more precise and rigorously founded understanding of the economics of climate change in Mexico and for Mexico. Its main conclusion alerts us to the fact that the costs of effective, timely and global action to ameliorate its effects are less than the grave economic damage that will certainly derive from doing nothing. Therefore, decisive and opportune action on this issue is an excellent public investment.

We hope that this work will encourage greater public awareness in Mexico about the risks and consequences of human induced climate change; that it will catalyze new research; and that it will give rise to serious reflection on the range of options available to governments to confront this phenomenon and convert it into an opportunity for achieving sustainable development.

In this regard, the Governments of Mexico’s 32 States can and should act on this issue by:

Issuing regulations and standards:
- Making direct investments in environmental infrastructure and ecosystem rehabilitation
- Promoting public-private investments in ecology related initiatives
- Using markets, through the elimination of perverse subsidies, levying taxes and charges relating to environmental damage and costs; authorizing focalized subsidies; and
- Creating markets, guaranteeing property rights, promoting compensation programs with tradable permits and allowances, implementing green procurement policies, establishing environmental investment funds and paying for ecosystem services.

The study which we present today is testimony to the emphasis placed by the Government of President Felipe Calderón Hinojosa on making environmental conservation a top priority. It is proof positive of its commitment to Mexicans and to the world on the issue of climate change.

This study strengthens Mexico’s leadership and position within the international community on its promotion of a Green Fund as a financial mechanism with the ideal capacity to make visible the commitments undertaken by all countries to mitigate the effects of climate change.

I would like to thank the various members of the scientific community who contributed to this study with their support and participation, as well as the Faculty of Economics and the Center for Atmosphere Sciences of the National Autonomous University of Mexico; the Mario Molina Center; the National Institute of Ecology; the Inter-American Development Bank; the World Bank; the Economic Commission for Latin America and the Caribbean; the Government of the United Kingdom, and all of those who in their different capacities contributed to the successful execution of this work.

I would not wish to conclude leaving the impression that, from an economics point of view, the main actor in environmental conservation should be the government., via the implementation of public policy. It is true that the government has an important role to play and should shoulder its responsibility in this regard, but all of its efforts will be unfruitful unless the private sector, and
particularly business, does not internalize as an integral part of its productive activity and business strategy, the importance of conserving and improving the environment.

It is unsurprising that various businesses in developed economies have substantially increased their market value as a result of making their own growth fully compatible with the harmonious development of the environment.

Therefore, I take this opportunity to invite Mexican businesses to do the same: establish business strategies which are fully compatible with conserving and improving the environment.

Carring today for our shared home, with our sights set on the wellbeing of future generations, is the best investment that we can make.

Many thanks.
Introduction

Climate change is one of the great challenges of the twenty first century. Currently available scientific evidence confirms the relationship between a variety of human activities, such as burning fossil fuels for energy and converting forest to other land uses, and the growing level of emissions of greenhouse gases (GHG). In addition, there is overwhelming evidence showing a close relationship between the continuous increase of GHG emissions and their effect on climate; in particular, a gradual increase in mean temperature, alterations to rainfall patterns, changes in the frequency and intensity of extreme weather events, a reduction in the extent of ice and snow cover and an increase in mean sea level. In the coming decades, humanity will have to confront the simultaneous challenges of adapting to the impacts of new climatic conditions, while implementing a global strategy of mitigation.

The global climate is a public good and, as such, climate change –from an economics point of view- represents the biggest negative global externality (Stern, 2007) which, given it’s magnitude, will largely determine the characteristics and conditions of economic growth during this century. The predicted impacts and adaptation processes will be, without doubt, impressive and incremental as the century progresses, affecting a variety of economic activities including agriculture, water services, land use change, biodiversity, tourism, infrastructure and public health.

The development of new technological options which promote low carbon intensity, together with the economic costs of mitigation processes will be particularly significant in the energy sector, transport and forest conservation, modifying current development patterns.

Climate change will have a growing impact on the economic evolution of specific countries and regions. In this context, it must be recognized that those impacts and changes in behavior already occurring and which are attributable to climate change have led to various processes of adaptation and mitigation which have not always been efficient, either in economic terms or –especially- in terms of sustainable development.

The economic analysis of climate change is, however, an extremely complex issue, whose very characteristics condition and limit the kind of study undertaken, and in which the following are among the salient features:

1. Climate change is a global phenomenon but is manifest in very diverse ways among regions, with important asymmetrical effects. This implies significant differences in the way in which a global study is undertaken compared to a regional study. For example, the close relationship between the processes of mitigation and adaptation which exist at global level breaks down at regional level. Moreover, in general it seems that the developed countries which contribute the greater share of GHG emissions simultaneously suffer the least economic impacts and have greater available capacities for adaptation and mitigation. In contrast, least developed nations contribute less to GHG emissions but are more susceptible to climate change impacts and have less available capacity for adaptation and mitigation.
These conditions make constructing a global consensus on combating climate change extremely complex and indicate the importance of having in-depth regional studies available which can contribute to shaping each country’s participation.

2. **Climate change is a continuous and long term phenomenon, with a high level of uncertainty, for which long term economic scenarios must be built.** The phenomenon of climate change does indeed embrace a high degree of uncertainty given the very heterogeneous mix of variables involved; climatic, economic, social, political, demographic and even international politics; also, specific regional impacts, the timescales and magnitude of the impacts associated with the processes of mitigation and adaptation, not forgetting the range of feedback mechanisms these involve. In this context, constructing prospective scenarios of the evolution of Mexico’s economy over the course of the next century, so as to identify a baseline with which to compare and contrast the impacts and processes of mitigation and adaptation to climate change in Mexico, are an indispensable requirement. Nevertheless, this exercise cannot be considered as a forecast; this would be comparable to believing that it would have been possible, at the start of the nineteenth century, to make predictions about the Mexican economy today, including a definition of the current composition of the energy sector. A high level of uncertainty also exists with regard to key variables such as technologies, relative prices and the trends within relevant economic sectors, and it should also be recognized that in many cases the very processes of mitigation and adaptation will modify the final outcomes. Nevertheless, it can be argued that these scenarios contain relevant information about the regular patterns of the Mexican economy and the possible long term consequences associated with the maintenance of the established trends of climate change. In this sense, the estimations presented here should be considered only as prospective scenarios with data within orders of magnitude, without representing precise projections. Moreover, it should be recognized that to the complexity of the phenomenon should be added the relative scarcity of reliable information. Of course, more rigorous and precise studies will permit a more in-depth analysis of the results presented here, and their validation or modification.

3. **Climate change implies a high level of risk and, in this sense, it becomes – from the perspective of an economic analysis – a process in which risk should be appropriately managed.** This implies recognizing that, over and above the precise economic values that can be assigned to climatic impacts, it is necessary to conserve resources and avoid irreversible losses, for example in biodiversity, and appropriately manage the risk of a catastrophic event with a low probability of occurrence, or possible effects from feedback mechanisms. Appropriate identification of risk levels and the assignation of adequate weightings therefore require a combination of solid economic analysis and the taking of informed decisions, including the weighing up of certain ethical principles. This is evident, for example, in selecting discounted interest rates or in the decision to avoid irreversible loss of biodiversity.
The principle objectives of this study is to identify, analyze and quantify the economic costs of climate change for Mexico and, on the basis of the results, propose and recommend appropriate measures for public policy, both for adaptation and mitigation. The results presented in this work certainly allow two fundamental facts to be identified: Firstly, that climate change has significant impacts on Mexico’s economy, and secondly that the costs of inaction are higher than the costs of participating in an equitable international agreement that recognizes common but differentiated responsibilities among nations. From the economic perspective, it is more efficient to act than to leave the problem to future generations, aside from any ethical considerations of such a choice.

The study was undertaken during 2008 within a relatively brief space of time and with some considerable limitations in terms of information. This represented a challenge reflected throughout the document in the shape of several deficiencies which those of us involved in the research would be the first to acknowledge. Even so, this work attempts to contribute to better informed decision making for public policy on a theme of vital importance. As such, it represents a first step which will assuredly be complemented, corrected and made more in depth by later work. As a matter of course, the usual caveats apply with regard to errors and omissions in the study, for which none of the participating institutions are responsible. In addition, it is probable that several researchers will not find their viewpoints represented in this final version of the study. Despite having defended them eloquently for the duration of the work. I recognize my responsibility in this respect, and inspire of this, I am confident that this work will contribute, to some extent, to a better understanding of the phenomenon of climate change in Mexico and towards building a solid strategy for addressing it.

The study “The economics of climate change in Mexico” has been undertaken at the request of, and with funding from, the Ministries of Finance and Environment and Natural Resources. Financial assistance was also given by the British Government and the Inter-American Development Bank. Valuable assistance with the administration of these resources was received through the participation of the Association of Former Pupils of the Faculty of Economics of UNAM, presided over by Ambassador Jorge Eduardo Navarrete. Assistance was also provided by the World Bank and the Economic Commission for Latin America and the Caribbean of the United Nations. The Faculty of Economics of UNAM afforded me important institutional backing and its Director, Dr. Roberto Escalante also contributed with comments and suggestions. The directors and personnel of the Mario Molina Center, the National Institute of Ecology and the Center for Atmosphere Sciences of UNAM, also participated. For the process of undertaking the work involved an Advisory Committee was established, comprising Francisco Barnés, Julia Carabias, Fausto Henández, Enrique Lendo, Mario Molina, Enrique Provencio, Gabriel Quadri and José Sarukhán, to all of whom I extend my thanks for their comments, contributions and observations. The support of the institutions under whose aegis this work was undertaken was also fundamental, particularly from their respective civil servants, but I would particularly like to thank the participation of Juan Rafael Elvira Quesada, Minister of the Environment and Natural Resources, Fernando Tudela Abad, Under Minister for Environmental Planning and Policy and Roberto Cabral, Adjunct Director General of Strategic Financing, both of the aforementioned Ministry; of Ricardo Ochoa Rodríguez, head of the International Financial Affairs Unit of the Ministry of Finance, and of Adrian Fernández Bremauntz, President of the National Institute of Ecology. The United Kingdom’s Ambassador to Mexico, Giles Paxman, was an enthusiastic promoter of this study, and his staff of great help.
I should also like to acknowledge the great willingness to discuss the issues addressed in this study by several members of the Technical Secretary of the Social Cabinet of the Presidency of the Republic, SHCP, SEMARNAT, INE, the Mario Molina Center, IADB, World Bank and ECLAC. I should particularly like to thank the time and valuable comments of Alicia Bárcena, Juan Carlos Belausteguiigoitia, Juan Pablo Bonilla, Fernando Cuevas, Carlos Raúl Delgado, Claudia Grayeb, Rodolfo Lacy, Julie Lennox, Juan Mata, Liliana Meza, Rosa Elena Montes de Oca, Carlos Muñoz Piña, Celia Piguerón, Silvia Rodríguez, Leonora Rojas and José Luis Samaniego.

Furthermore, I should like to thank the support, comments and suggestions of the Stern team for the realization of this study, in particular Sir Nicholas Stern, Chris Taylor and Dimitri Sengelis. Many researchers participated in this study, among whom María Esther Álvarez, Allan Beltrán, Héctor Bravo, Karina Caballero, Karla Caballero, Horacio Catalán, Yanet Domínguez, Francisco Estrada Porrúa, Jimmy Ferrer, Manuel García, Carlos Gay, Alejandro Guevara, Fausto Hernández, Ma. Eugenia Ibarrarán, Luis Jaramillo, Ramón Lepez, Víctor Magaña, Carlos Muñoz Piña, Federico Navarrete, Jaime Olivares, Ma. del Carmen Palafax, Enrique Provencio, Fernando Rello, Erika Rojas, Luis Sánchez, Juan Manuel Torres and Eduardo Vega deserve special mention. Finally, I should mention that Maerle, Saskia and Jasper gave particular meaning to this study.
Climate change is one of the great challenges of the twenty first century. Currently available scientific evidence confirms the relationship between a variety of human activities, such as burning fossil fuels for energy and converting forest to other land uses, and the growing level of emissions of greenhouse gasses (GHG). Overwhelming evidence exists which shows a close relationship between the continues increase of GHG emissions and their effect on climate; in particular, a gradual increase in mean temperature, alterations to rainfall patterns, changes in the frequency and intensity of extreme weather events, a reduction in the extent of ice and snow cover and an increase in mean sea level.

The consequences of these climatic changes are certainly significant and, given their magnitude, will determine the characteristics and conditions of economic development over the next century. In the coming decades, humanity will have to confront the simultaneous challenges of adapting to the impacts of new climatic conditions, while implementing a global strategy of mitigation. The economic analyses of climate change is, however, an extremely complex issue, whose very characteristic conditions and limit the kind of study undertaken, and in which the following are among the salient features:

1. **Climate change is a global phenomenon and represents, from the perspective of economics, the greatest negative externality (Stern, 2007), albeit with important asymmetrical effects.** Climate is a global public good and as such climate change is the result of a negative externality the causes and consequences of which are global, but differentiated and heterogeneous among nations, and indeed asymmetrical within given climatic parameters. In general, it seems that the developed countries which contribute the greater share of GHG emissions simultaneously suffer the least economic impacts and have greater available capacities for adaptation and mitigation. In contrast, least developed nations contribute less to GHG emissions but are more susceptible to climate change impacts and have less available capacity for adaptation and mitigation. These conditions make constructing a global consensus on combating climate change extremely complex and indicate the importance of having in depth regional studies available which can contribute to shaping each country’s participation.

2. **Climate change is a continuous and long term phenomenon, with a high level of uncertainty, for which long term economic scenarios must be built.** The future tendency of the climate change phenomenon will be the result of the complex interaction of a heterogeneous array of variables, both climatic as well as economic, social, political, demographic and even international politics; they also include the complex matrix of inter-relationships between the climatic impacts and the subsequent strategies of adaptation and mitigation. In this context, constructing prospective scenarios of the evolution of Mexico’s economy over the course of the next century, so as to identify a baseline with which to compare and contrast the impacts and processes of mitigation and adaptation to climate change in Mexico, are an indispensable requirement. Nevertheless, this exercise cannot be
considered as a forecast; this would be comparable to believing that it would have been possible, at the start of the nineteenth century, to make predictions about the Mexican economy today. Nevertheless, it can be argued that these scenarios contain relevant information about the regular patterns of the Mexican economy and the possible long term consequences associated with the maintenance of the established trends of climate change. In this sense, the estimations presented here should be considered only as prospective scenarios with data within orders of magnitude, without representing precise projections. Moreover, it should be recognized that to the complexity of the phenomenon should be added the relative scarcity of reliable information. Of course, more rigorous and precise studies will permit a more in depth analysis of the results presented here, and their validation or modification.

3. **Climate change is a phenomenon with a high level of risk, including the probability of catastrophic events and important feedback effects.** Over and above the precise economic values that can be assigned to climatic impacts, it is necessary to conserve resources and avoid irreversible losses, for example in biodiversity, and appropriately manage the risk of a catastrophic event, even if it presents a low probability of occurrence, or more intense climatic events produced by feedback mechanisms. Identification of risk levels and the assignation of adequate weightings requires a combination of solid economic analysis and the taking of informed decisions, including the weighing up of certain ethical principles. This is evident, for example, in selecting discounted interest rates.

The main conclusions of “The economics of climate change in Mexico” study are:

1. **Climate change has and will continue to have significant, increasing and non-lineal impacts in time and on the Mexican economy.** The predicted impacts and adaptation processes will be, without doubt, impressive and will grow as the century progresses, affecting a variety of economic activities including agriculture, water services, land use change, biodiversity, tourism, infrastructure and public health. Technological options together with the economic costs of mitigation processes will be particularly significant in the energy sector and transport, which will modify current development patterns. Significant negative impacts which do not have a direct economic value also exist, and are unacceptable, such as biodiversity loss. The economic consequences of climate change for Mexico are regionally heterogeneous, and indeed some temporary gains may accrue to some regions as a consequence of climate change. Nevertheless, the estimates for Mexico as a whole show that the negative economic consequences in the long term outweigh any gains in the short term, and also that tolerance limits exist. In general, it is found that the economic costs\(^1\) of climatic impacts by 2100 are at least three times greater than the costs of mitigating our emissions by 50%. For example, in one of the scenarios considered it was found that with an annual discount rate of 4% climatic impacts reach, on average, 6.21%\(^{\text{\footnotesize\textsuperscript{1}}}\)

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\(^{\text{1}}\) The estimation of these costs includes a set of assumptions such as discount rates, and that cost reduction processes due to technological innovation or some form of optimization strategy will not develop.
of current GDP while the costs of mitigating emissions by 50% represent 0.70% and 2.21% of GDP, at 10 and 30 US dollars per ton of carbon respectively.

2. Taken together, the results demonstrate that the costs of inaction are higher than the costs of participating in an equitable international agreement that recognizes the common but differentiated responsibilities of countries, and that immediate and decisive action is indispensable to reduce the worst impacts of climate change. In this sense, from an economics perspective it is much more efficient to act than to leave the problem for future generations, leaving aside the ethical considerations of such a choice. The economic costs of climate change to Mexico are certainly very high with a temperature rise of more than 2-3°C. Moreover, available evidence suggests that the adaptation processes currently under way in the Mexican economy are important for reducing climatic impacts, but are insufficient once certain climatic thresholds are crossed, and indeed are causing, in some cases, additional negative externalities such as the over-exploitation of the country’s aquifers. Current climatic projections suggest that in an inertia scenario levels of CO\textsubscript{2} concentrations in the atmosphere will reach at least 550ppm and 650ppm in 2050 and 2100 respectively. A concentration of 550ppm will, with a probability of 99% and 69% respectively, lead to temperature increments of 2 or 3 degrees, while a concentration of 650ppm increases in temperature of 3 or 4 degrees will occur with a probability of 94% and 58% respectively. In contrast, stabilizing emissions at 450ppm will be conducive to a temperature increase of 2 or 3 degrees, with probabilities of 78% and 18% respectively. In this context, the present century will inevitably witness climatic impacts, but it is still possible to significantly reduce the possibility of the most costly climate change outcomes, working from an international strategy for GHG stabilization.

3. The construction of a strategy of mitigation and adaptation to climate change in Mexico must recognize the need to utilize an array of policy options continuously and with long term vision. Recognizing the importance of building a relative pricing structure consistent with the aim of sustainable development is indispensable. That is, relative pricing should adequately reflect the presence of negative externalities caused by the consumption of certain goods; these pricings should also recognize the importance of adequately valuing those aspects which are currently outside the market, such as biodiversity. An adequate pricing structure is fundamental to controlling excessive consumption, improving resource management and for supporting technological innovation and diffusion. In this context, it is fundamental to explore the role of pricing for certain public goods and services such as energy, fuel and water, with the long term in mind, and without sidelining social considerations. Thus, from the public sector standpoint, it is paramount to have a consistent strategy of public spending and subsidies which supports adequate price signaling. It is, for example, important to stop supporting the inefficient expansion of the farming sector. The response sensitivities of price changes to different levels of demand for the goods analyzed in this study, such as different kinds of energy, fuel and water, are still inelastic. This is the consequence of the interaction of a set of diverse factors, including the lack of adequate substitute or alternative goods, as with the dilemma of public and private transport, and the lack of a long term price signaling strategy, or simple market failure. It is,
of course, vital that these obstacles be gradually removed. However, the realignment of relative prices to support sustainable development with the current levels of inelasticity of demand could be highly problematic, leading to important market distortions and negative social consequences in the short term, which could hamper reaching the desired objectives. This implies the need to support market mechanisms with regulations which mimic economic incentives. It is possible to implement a graduated strategy, based on the realignment of relative prices on a ramp trajectory, supporting the process with regulations and spending which generate greater response sensitivity to price signaling, cushion the negative social impacts and limit or keep to a minimum imminent damage where price signals remain insufficient, such as with biodiversity.

4. **Over the next few years, the Mexican economy—like the rest of the world’s economies—will have to move onto a trajectory of low carbon-intensity growth, at the same time as implementing adaptation processes to minimize the impacts of climate change.** The monetary and financial resources needed for so doing are certainly significant, and of course alternative uses for these resources do exist, including infrastructure development, a social welfare system and the education system, all of which are also essential for sustainable development. In some cases, economies of scale exist between different targets, which should be taken advantage of, however, designing a strategy in which internal resources are complemented by external resources will also be necessary. The Mexican economy should then undertake several mitigation and adaptation activities, within the bounds of its possibilities, thereby contributing to a global solution to climate change in accordance with the need to act with a sense of responsibility. However, it is evident that additional resources will be required to achieve more ambitious targets. Thus, Mexico should, in the short term, seek to use those international resources now available through various funds and organizations, at the same time as contributing to the development of multilateral institutions which will permit the consolidation of the necessary sources of financial support.

5. **Solving climate change implies correcting the conditions which brought about this huge negative externality, which requires the consolidation of an international carbon market, either through the direct levying of carbon taxes, the use of a system of tradable carbon permits, or directly through the setting out of regulations for that purpose, or indeed a hybrid system combining several of these mechanisms.** It is fundamental that Mexico makes progress on the creation of a carbon market in which the manner of integration with other countries can be defined, including via current trade agreements. In addition, the importance of changing habits and patterns of production, distribution and consumption should also be recognized, as should decisive support for innovation and diffusion of new technologies which reduce carbon intensity, the elimination of institutional barriers and the building of a new environmental culture.
The challenges presented by climate change are evidently of impressive magnitude, and in many cases the impacts of them are now inevitable. The fundamental strategic decision thus consists not in recognizing the need to confront the inevitable, but in discovering the best way of doing so.
1. Climate change

1.1 Climate change: International evidence.

The Intergovernmental Panel on Climate Change’s Fourth Assessment Report (AR4) establishes four scientific conclusions (IPCC 2007):

1. There is unequivocal warming of the global climate system (Graph 1a).

2. The increase in atmospheric greenhouse gas concentrations shows a marked rise from 1850 associated with the industrialization process, causing an increase in mean global temperatures and other climatic effects (Graph 1b).

3. Global warming means an increase in the temperature of the planet, most probably between 1.1 and 4.5 degrees centigrade, although more pessimistic predictions indicate an increase of six degrees, and a rise of mean sea level of between 28 and 43 centimeters by the end of this century, as well as important changes in rainfall patterns and in extreme weather events.

4. Climate change is now having a discernible effect on many physical and biological systems.

Graph 1. Trends in greenhouse gas emissions over the last 2000 years (a) and in mean average global temperature between 1850 and 2000 (b)
These four conclusions translate, in practice, into what the IPCC scientists themselves call patterns associated to climate change: melting of polar ice caps, which will cause a rise in sea level and the flooding and destruction of some coastal areas; presence of rainfall in times and places previously without rain; more intense and prolonged droughts in other regions; extinction of many plant and animal species; increase in disease occurrence; increase in the intensity of extreme weather events such as tropical cyclones.

Anthropogenic activities and some natural processes are the direct and indirect causes of change in the climate system. Over the last several decades the increase in the concentration\(^2\) of GHG is the dominant factor in radioactive forcing (IPCC 2007). Thus, for the most part the observed increase in mean global temperatures since the middle of the twentieth century has very probably been caused by the increased concentration of anthropogenic GHG. Available evidence indicates an average rate of warming of 0.13°C ± 0.03°C per decade during the last 50 years, and double that rate during the last ten years (Graph 2a). Intense rainfall has also increased alarmingly since 1950 (Graph 2b), even in regions where rainfall was scarce. On the other hand, droughts have also increased since 1970, particularly in the tropics and subtropics, where they are correlated to reduced rainfall and higher temperatures.

The evidence available on the Cryosphere (ice caps and glaciers) indicates an important reduction in the ice caps, particularly in the northern hemisphere, between 1966 and 2005, especially in spring, with a 5% annual reduction in cover registered since the 1980’s (Graph 2c). Ice melt in the northern hemisphere is causing variations in sea level. In the oceans, climate change is reflected in changes in sea water temperature and salinity. Readings indicate that changes in the temperature of the oceans began half way through the twentieth century with a measurable warming occurring at 700 meters depth with respect to the ocean surface. In terms of sea level itself, which has been measured since 1860, the mean global rate of increase has been 3.1 ± 0.7 mm per annum between 1993 and 2003 (Graph 2d).

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\(^2\) The present concentration of a given greenhouse gas in the atmosphere is the net result of its past emissions and eliminations from the atmosphere.
The association between economic activities, GHG emissions and climate change allows the construction of diverse emissions scenarios, with distinct economic and social assumptions and their corresponding climatic consequences (Table 1) among which is an expected range of global warming of between 0.3°C for a scenario of constant levels of GHG emissions, rising to 6.4°C for the highest case emissions scenario (A1FI), with a dispersion between models and average realizations of between 0.6°C and 4.0°C. In the case of rainfall, the projections indicate a decreasing tendency in large parts of the subtropics, although these projections display a greater dispersion between models and realizations (Figure 1). The differences between models and realizations (modeling experiments which begin with different sets of initial conditions) permit a first approximate calculation of the level of uncertainty in the climate change scenarios. Thus, there is almost no uncertainty that the planet will undergo an increase in mean temperature, although
significant uncertainty persists with regard to projections of rainfall at the regional level and other climatic events.

**Table 1.**

Projected mean global surface warming and sea level increase towards the end of the 21st Century

<table>
<thead>
<tr>
<th>Case</th>
<th>Temperature changes (°C by 2090–2099 relative to 1980–1999)*</th>
<th>Sea level increment (m by 2090–2099 relative to 1980–1999)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concentrations during the constant 2000 year</td>
<td>0.6 (0.3 – 0.9)</td>
<td>NA</td>
</tr>
<tr>
<td>Scenario B1</td>
<td>1.8 (1.1 – 2.9)</td>
<td>0.18 – 0.38</td>
</tr>
<tr>
<td>Scenario A1T</td>
<td>2.4 (1.4 – 3.8)</td>
<td>0.20 – 0.45</td>
</tr>
<tr>
<td>Scenario B2</td>
<td>2.4 (1.4 – 3.8)</td>
<td>0.20 – 0.43</td>
</tr>
<tr>
<td>Scenario A1B</td>
<td>2.8 (1.7 – 4.4)</td>
<td>0.21 – 0.48</td>
</tr>
<tr>
<td>Scenario A2</td>
<td>3.4 (2.0 – 5.4)</td>
<td>0.23 – 0.51</td>
</tr>
<tr>
<td>Scenario A1FI</td>
<td>4.0 (2.4 – 6.4)</td>
<td>0.26 – 0.59</td>
</tr>
</tbody>
</table>

Notes: *These estimates are assessed from a hierarchy of models that includes a simple climate model, several Earth System Models of Intermediate Complexity (EMIC), and a large number of models Atmosphere-Ocean General Circulation (MCMAO). The constant composition for 2000 is derived only from MCMAO. Excluding rapid change, dynamic future in the flow of ice.

**Figure 1. Projections of world temperature and rainfall**

![Figure 1. Projections of world temperature and rainfall](image-url)
### IPCC climate change scenarios

1. The family of trends and scenarios **A1** describes the future world with rapid economic growth, a world population reaching its maximum level by the middle of the century and subsequently dropping gradually, and a rapid uptake of new, more efficient technologies. Its most distinctive traits are regional convergences, capacity building and social and cultural interactions, accompanied by a notable reduction of regional differences in terms of income per person.

2. The family of trends and scenarios **A2** describes a very heterogeneous future world. Its most distinctive traits are self-sufficiency and the maintenance of local entities. Fertility patterns at regional level converge very slowly, such that world population continues to expand. Economic growth is still mostly centered on regional hubs, such that patterns of GDP per person and technological change are more fragmented and slower than for other scenarios.

3. The family of trends and scenarios **B1** describes a converging world with a global population which reaches a maximum towards mid-century and subsequently begins to contract, but with rapid changes in economic structures geared towards services and information, coupled with a less intensive use of materials, the introduction of clean technologies and a more efficient use of resources. Pre-eminence is given to finding global solutions to the world’s problems, in order to attain economic, social and environmental sustainability, as well as improved equality, but without additional initiatives relating to climate change.

4. The family of trends and scenarios **B2** describes a world in which local solutions to economic, social and environmental sustainability predominate. It is a world whose population grows at a lower rate than in scenario A2, with intermediate levels of economic development and with slower, more diverse technological changes than for scenarios B1 and A1. While this scenario is also oriented towards environmental protection and social equality, this is centered mostly at the local and regional level.

### 1.2 Climate change in Mexico: Evidence and projections

The climate is the product of constant and complex interactions between the atmosphere, the oceans, the polar ice caps, the continents, planetary life and human economic activities. There are many forms of climate variability and consequently making projections based on such variety is a complex task, more so for specific regions. There are several alternatives for simulating and projecting future climate, notable among which are the General Circulation Models and the application of stochastic models, such as in the case of temperature (Figure 2). This second option is particularly important for identifying the components of the temperature trends series while...
accounting for both climate changes as a phenomenon and simple observed anomalies which could explain the series volatility. It should be acknowledged, however, that an important level of uncertainty still persists in these models, particularly for long term projections.

Analysis of temperature and rainfall time series for Mexico with ARIMA models and single root tests allows confirmation of a gradual rise in temperature and a more oscillatory behavior for rainfall patterns. Based on these results, it is possible to obtain mean temperature projections by state for 2050 and 2100. Given that the models use the trends registered over the last four decades, they can be used as a conservative baseline trajectory to analyze the impacts of climate change in Mexico.

Time series methodology thus allows predictions of future temperature trends to be made, but these are only a guide, being too restrictive compared to more general methodologies like the General Atmosphere-Ocean Circulation Models, which can show more pronounced climatic trends. Indeed, changes in climate can be the product of variations in internal climatic processes, such as atmospheric and/or oceanic instability, or extreme radioactive forcing resulting from variations in solar activity, or changes in atmospheric composition resulting from sea surface temperature or land use changes, to which GHG emissions to the atmosphere from human activities are an additional factor.
Taking these factors into account, the most likely climate scenarios were constructed using data from the Center for Atmosphere Science of UNAM, using General Circulation Models (GCMs), and techniques which permit increased spatial resolution for projections to the end of the present century (Figure 3), principally for mean temperature and rainfall variables. The scenarios are, of course, only a representation of how the climate in Mexico might look in the future, in the context of global climate change, having an inherent level of uncertainty which is reflected in the dispersion of the simulations. Thus, the measure of dispersion indicates the average suggested by the models, that change will occur in a given direction, while some models and projections suggest that the value will be the mean plus or minus the value of the dispersion range. Even so, uncertainty is inherent in any projection of the future. In this sense, and as with any problem in which risk management includes an element of uncertainty, preventive action should be taken when the level of risk is deemed to be unacceptable. The main results obtained for Mexico for the end of this century are:

- In scenario A2, projected mean average temperature change is between 2.5 and 4.0°C, with a range of variation between 1.0 and 2.5°C, depending on the region, northwestern Mexico witnessing the highest increases.
- In scenario A1B an average rise of between 1.5 and 3.0°C is reported, with a variation of between 0.5 and 1.5°C.
- In scenario B1, temperature rise is between 1 and 2°C with a dispersion of projections of between 0.5 and 1.0°C.
- Practically all the model runs indicate an increase in mean temperature, with highest warming in the north and northwest of Mexico.
- In scenario A2, average annual rainfall across the country could diminish by some 11%, with a range of spatial variation in the assemblage of between –5.7% and –17.8%.
- In scenario A1B, rainfall reduction could be –8.7% with a variation of –15% to –3.5%. The dispersion between scenarios of up to 45% indicates that several models project an increase in rainfall of up to 10%. It is for this reason that greater uncertainty surrounds the future direction of change in rainfall.
- In scenario B1 the results also show a general drop in rainfall of around –6%, with a variation of between –8.3% and –3.5%, although as in other scenarios, some models (a minority) suggest that rainfall could increase.
- In general, therefore, the results show a large dispersion in projections of percentage variation in rainfall. It is worth mentioning that under scenario A2, states in the north of Mexico show a considerable percentage reduction in rainfall.
The methodology applied in this study to relate climatic events with economic trends is based on the analysis of, on the one hand, the impacts associated with climate change, including vulnerability and adaptation processes and, on the other, consideration Mexico’s contribution to GHG emissions and mitigation processes. In this context, the economic analysis of climate change requires that baseline scenarios (business as usual or BAU) be developed in which the impact of climate change is not, initially, included, and subsequently, scenarios in which climate change is taken into account. The differences between these scenarios will therefore indicate the impact of climate change. In this same sense, an inertia scenario for emissions was constructed and contrasted with the respective mitigation strategies.
2. Recent trends and prospects for the Mexican economy

The construction, simulation and projection of economic, sectoral and demographic scenarios linked to energy, regional and environmental scenarios is a complex task with high levels of uncertainty. In particular, the factors explaining the rhythms of growth of whole economies are multiple and include both supply and demand as well as internal and external shocks. The available evidence shows that GDP in Mexico follows a process of economic growth with fluctuations around an ascending trend (Graph 3) (Hodrick and Prescott, 1997; Blanchard, 1997). In addition, the observed average growth rate of the Mexican economy has diminished with time while the cyclical volatility has increased.
These growth rates can, fairly simply, be approximated through a trimodal frequency distribution which contains three large-scale scenarios. In effect, the growth rate shows a higher frequency (50% of all cases) in the range of a 2 to 5% rate of annual growth, with growth rates above 5% and second place, while the lowest probability growth rates, below 2%, are associated with the decade of 1980 and the 1995 crisis. In this context, the average long term expected growth rate for the Mexican economy is 3.5% with a 60% probability range. The sectoral analysis, as with the national one, is resumed in Table 2

### Table 2.

**Base scenario for GDP growth considering a 60% probability**

<table>
<thead>
<tr>
<th>Scenario probability</th>
<th>Lower limit</th>
<th>Mean</th>
<th>Upper limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>National GDP</td>
<td>2.9</td>
<td>3.5</td>
<td>4.3</td>
</tr>
<tr>
<td>Agriculture and livestock sector GDP</td>
<td>1.6</td>
<td>2.2</td>
<td>2.8</td>
</tr>
<tr>
<td>Industrial GDP</td>
<td>2.1</td>
<td>2.8</td>
<td>3.4</td>
</tr>
<tr>
<td>Services GDP</td>
<td>2.4</td>
<td>3.7</td>
<td>5.1</td>
</tr>
</tbody>
</table>

3 The distributions of probability are not necessarily consistent in the sectoral scenarios.
In addition, a simple, small-scale econometric model was constructed to identify possible feedback mechanisms and for processing some basic scenarios (Figure 4). The population scenarios were obtained directly from the National Population Council (CONAPO) and extrapolated to 2100, allowing per capita GDP to be projected.
3. Main impacts of climate change on Mexico

3.1 Farming sector

The agriculture and livestock sector represents one of main activities of Mexican economy, since it is involved in GDP rates, direct and indirect job generation and is connected to incomes of economic agents at rural areas. Evidence available suggests that development of this agriculture and livestock sector depends on invested capital, input combination, fertilizers, technology, irrigation, type of risk management, pesticides, employment, CO\textsubscript{2} level of emissions and soil characteristics; however, climate factors are included. In this context, climate change is deemed as a stochastic phenomena (Doering, et al, 2002); thus, in this sense, the fact of identifying any specific impacts becomes quite complex since, for instance, average temperature runs to the right without completely modifying weather but under extreme circumstances (Graph 5). Besides, climate impacts might be quite specific and be determined by their connection with seeding and harvesting periods.

![Graph 5. Impacts on changes in the mean, the variance and the mean probability of occurrence of specific climate types](image)

International evidence available regarding climate change impacts within the farm sector is really complex and different, but can be summarized as follows:

1. CO\textsubscript{2} increasing rates have a positive impact in the production and performance of farm sector, at least within given ranges.
2. An increase in temperature initially has a positive impact both in production and performance; however, beyond certain temperature limits, these impacts turn negative. Changes on rainfall patterns represent an important impact against the production and performance of the farm sector that can also be represented as a non-linear function similar to temperature.
3. In most of empiric outcomes it has been observed that temperature changes are quite more important that those related to rain.

4. Specific impacts strongly depend on agro-climate, types of soil and CO\textsubscript{2} sensitivity, adding a level of uncertainty to projections.

Three models were applied in the present farm sector survey that will allow to identify climate change impacts pertaining to information available in Mexico, even though there are, of course, a great amount of possible models running alternative and more specific data. These three models do confirm the climate change impacts in Mexico; even though they differ in respect to the specific extent of impacts. However, it turns necessary to make progress in respect to more detailed estimations per regions, increasing the total possible variables.

1. **Production function model**: The present model corresponds to production factors including, *whenever information is available*, labor, capital, seed provision, fertilizers and other inputs; furthermore, both weather and irrigation quota resources are incorporated (Fleischer *et al.*, 2008). These were models estimated for Mexico, going from the general to the specific scope, measuring the constant features, trend, irrigation and climate variables, per products at domestic level and per state, a Laspeyres index was then developed for the cyclic and perennial products as well as for the two different seasons of the year. Empiric evidence for Mexico shows a temperature and performance and/or production concave ratio (Graph 6a), where temperature initially stimulates the growth of crops to, eventually, reduce it (Doering *et al.*, 2002). Water also has a non-linear effect in respect to agriculture and livestock production and performance (Graph 6b). These are solid outcomes that are repeated in the set of estimations accomplished beyond specific values.

2. **Ricardian model** (Deschenes and Greenstone, 2006; Mendelsohn *et al.*, 1994). This model is founded in the assumption that farmland value reflects land productivity; therefore, climate variations affecting productivity might be taken through agriculture incomes.
3. **Conditional heteroscedasticity model** (Engle, 1982). This model estimates the increasing volatility of series related to more uncertainty and risk in the sector, partially due to more volatile climate conditions (Just, 1974).

Outcomes obtained allow diverse inferences in respect to farm production and climate change impacts:

1. Farm performance and production depend on a climate under heterogeneous impact. Moreover, each and every productive cycle and product yield different temperature and rainfall response comparisons, even per region (Graphs 7a and 7b). In the case of maize, for example (Graphs 8a and 8b).

2. The whole analysis of climate effects shows that, within certain ranges, it is possible to compensate the raise of temperature with a greater amount of water (Graph 7c). However, this is a limited and non sustainable procedure in the long term due to the fact negative external factors arises associated to over exploitation of water resources.
Graph 7. Climate change impacts on agricultural productivity

a) Performance of production index for diverse temperature rates

Spring-Summer

Fall-Winter

Cyclic crops

Perennial crops

b) Performance of production index for diverse rainfall levels

Spring-Summer

Fall-Winter

Cyclic crops

Perennial crops

c) Production index: rainfall and temperature rates

Production index

Rainfall rates

Temperature rates

Rainfall rates

Temperature rates

Production index

Rainfall rates

Temperature rates

Rainfall rates

Temperature rates
3. Theoretical performance for each state analyzed with the temperature rates of the year 2006 is described in (Graph 8c) in which it can be observed there is a relatively similar behavior between both cases, but for the remarkably exception of the States of Sinaloa and Nayarit where the said performance exceeded estimated projections because of
temperature. This might be as result of having a better irrigation infrastructure and technology demonstrating the importance of adaptation procedures.

4. Irrigation analyses were applied to each index and products of models, under diverse climate change scenarios projected to up to the year 2100. (Graph 8d) shows that IPCC climate scenarios intersect until the year 2050; however, afterwards, they split again; suggesting then that, selected climate scenarios will turn fundamental on the second half of the century. Moreover, farm performance is foreseen to sustain an important collapse in 2100. Of course, this is merely hypothetical since it is assumed that the remaining conditions will remain constant.
5. Both production and, in general, all farm activities follow a stochastic behavior, that is, important fluctuations have occurred; implying, therefore, a level of uncertainty and risk (Just, 1974). Therefore, the farm GDP growth rate can be directly described as a stationary stochastic process, whether around a deterministic or stochastic and unchanging trend. Such fluctuations are related to socioeconomic factors and climate events, and even to impacts in connection to instrumented public policies. Evidence suggests (through a GARCH or TGARCH model) (Engle, 1982) that this farm GDP growth rate has a variable volatility that is modified in time (Graph 9) and that the well known “leverage effect” is present (Brooks, 2002) in the sense that bad news tend to increase such volatility. That is to say, contractions on farm activities provoke increments to dispersion of growth rates generating, in consequence, a higher risk level. This farm GDP course refers to risk prevention procedures not intending to maximize profits but to protect against a catastrophic loss and an asymmetric peril through diversification of crops and the group of economic activities (Graph 9). In this case, instrumentation of public policies intended to contribute to maximize production will be inefficient if the need of production diversification is not observed to manage the farm production inherent risk.
3.2 Water resources

Water is a fundamental resource for life and, of course, for all economic activities. Water resources in the country are scarce and quite heterogeneously distributed per regions. Water consumption is mainly applied to agriculture and livestock sector, housing and industrial purposes and is also quite heterogeneously distributed all over the country (Graph 10).

![Graph 10. Current water consumption in Mexico](image)

Climate change directly affects both the demand and availability of water, representing significant economic costs (Figure 5). Base demand lines were established through estimating the consumption nationwide and per states, regarding the three sectors available (population supply, farming and industrial use). Estimations obtained indicate that water consumption is directly related to income levels, the population and relative water prices.
Estimations accomplished through co-integrating methods show differences as per sectors (residential, farm and industrial consumption); although, in general, income flexibility in respect of unit and price flexibility at a -0.2 and -0.4 ratio is observed. Additionally, regarding human consumption, this is mostly applicable to the population development. In general, it must be underlined that the greater price flexibility is found within the industrial sector (Graph 11).
Water demand projections by 2100 show a significant increment; even when climate change impacts are not being considered (Graph 12).
Climate change impacts in respect to water resources in the country were carried out considering the impact of temperature on water supply and demand. Thus, following a cross section model, water demand in respect to temperature was estimated, dealing with each sector (house, farm and industrial consumption), finding a positive temperature effect in water consumption. Through this, it was possible to identify the consumption increment in connection with temperature (Graph 13).

In respect to water supply, it is hard to identify the possible impact of temperature against natural availability of water resources since a great deal of parameters associated to the hydrologic cycle have influence. To estimating climate change impact against water availability, there are diverse models applicable. In this case, rain, evaporation and temperature ratio were considered. Results obtained show that availability of the resource keeps a positive connection with rain levels while temperature rates register a negative flexibility, indicating that availability decreases as long as temperature raises. These are consistent outcomes; however, precautions shall be taken, since the
above represent merely an estimation of natural phenomena (Graph 14). Outcomes also show a significant increment of water stress by the year 2100, in particular at certain regions in the north of the country (Graph 14), having an effect in vulnerability index (Graph 15). This turns quite concerning if it is considered these areas will be deeply affected due to temperature raises. Current water costs per region and per sector evidence that in the search of meeting this additional differential of water supply and demand provoked by climate change will represent substantial economic costs.
3.3 Land use change and vegetative cover

Land use tends to be one of most relevant issues in environmental policy discussions worldwide and is a core topic in estimation of climate change scenarios. The survey on vegetation loss allows us to know process trends of huge relevance such as deforestation, plant exhaustion, desertification and loss of biodiversity.

This analysis was obtained from a model of transition probabilities elaborated with inventories of the years 1976 and 2000 for Mexico, together with the corresponding conversion rates (Table 3). It is there realized that transformation from primary forest and rain forest vegetation into pasture lands is the main cause of deforestation, followed by transformation from tree cover into crop lands.
Table 3.
Probability matrix of vegetative cover change between 1976 and 2000
(thousands of hectares)

<table>
<thead>
<tr>
<th>1976</th>
<th>forests</th>
<th>rainforests</th>
<th>scrublands</th>
<th>absorbent vegetation</th>
<th>Other vegetative types</th>
<th>natural pasture lands</th>
<th>induced pasture lands</th>
<th>Crop lands</th>
<th>Other vegetative cover</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>forests</td>
<td>0.9062</td>
<td>0.0078</td>
<td>0.0026</td>
<td>0.0000</td>
<td>0.0001</td>
<td>0.0037</td>
<td>0.0559</td>
<td>0.0236</td>
<td>0.0001</td>
<td>1.0000</td>
</tr>
<tr>
<td>rainforests</td>
<td>0.0157</td>
<td>0.8244</td>
<td>0.0032</td>
<td>0.0012</td>
<td>0.0004</td>
<td>0.0011</td>
<td>0.0865</td>
<td>0.0663</td>
<td>0.0011</td>
<td>1.0000</td>
</tr>
<tr>
<td>scrublands</td>
<td>0.0027</td>
<td>0.0023</td>
<td>0.9401</td>
<td>0.0003</td>
<td>0.0056</td>
<td>0.0029</td>
<td>0.257</td>
<td>0.0198</td>
<td>0.0007</td>
<td>1.0000</td>
</tr>
<tr>
<td>absorbent vegetation</td>
<td>0.0002</td>
<td>0.0348</td>
<td>0.0061</td>
<td>0.8977</td>
<td>0.0142</td>
<td>0.0006</td>
<td>0.0236</td>
<td>0.0220</td>
<td>0.0008</td>
<td>1.0000</td>
</tr>
<tr>
<td>Other vegetative types</td>
<td>0.0008</td>
<td>0.0014</td>
<td>0.1139</td>
<td>0.0077</td>
<td>0.8389</td>
<td>0.0011</td>
<td>0.0112</td>
<td>0.0239</td>
<td>0.0010</td>
<td>1.0000</td>
</tr>
<tr>
<td>natural pasture lands</td>
<td>0.0144</td>
<td>0.0012</td>
<td>0.0144</td>
<td>0.0001</td>
<td>0.0014</td>
<td>0.8255</td>
<td>0.0986</td>
<td>0.0436</td>
<td>0.0008</td>
<td>1.0000</td>
</tr>
<tr>
<td>induced pasture lands</td>
<td>0.0139</td>
<td>0.0297</td>
<td>0.0185</td>
<td>0.0025</td>
<td>0.0013</td>
<td>0.0028</td>
<td>0.8610</td>
<td>0.0677</td>
<td>0.0027</td>
<td>1.0000</td>
</tr>
<tr>
<td>Crop lands</td>
<td>0.0093</td>
<td>0.0225</td>
<td>0.0130</td>
<td>0.0007</td>
<td>0.0021</td>
<td>0.0042</td>
<td>0.0251</td>
<td>0.9162</td>
<td>0.0069</td>
<td>1.0000</td>
</tr>
<tr>
<td>Other vegetative cover</td>
<td>0.0050</td>
<td>0.0099</td>
<td>0.0027</td>
<td>0.0001</td>
<td>0.0006</td>
<td>0.1452</td>
<td>0.0078</td>
<td>0.0257</td>
<td>0.8120</td>
<td>1.0000</td>
</tr>
<tr>
<td>Total</td>
<td>0.9988</td>
<td>0.9673</td>
<td>1.1422</td>
<td>0.7225</td>
<td>0.9066</td>
<td>0.7367</td>
<td>1.1916</td>
<td>1.3552</td>
<td>0.9790</td>
<td>1.0000</td>
</tr>
</tbody>
</table>

Source: Estimations derived from data presented in Velázquez et al., 2002.

Change model for land use was built through a hybrid model including Markov chains (Brooks,) based on transition probabilities form one state to another. Such probabilities might assume to be continuous (regarding the base scenario), or vary according to indirect or immediate cause origins (climate change scenarios). Outcomes obtained through the model of transition probabilities present the expected trend (Graph 16) for the cover in forests, rainforests, crop land and induced pasture land categories, estimated from this transition model. This means that there is an increment on crop lands in detriment of forest and rain forest areas. This could partially compensate the loss of crop yields.
Outcomes obtained from simulation models for climate change by 2091 show slight variations in respect to projection of base line for certain formations. Under any climate change scenario it is outlined that there is a lower reduction of tree surfaces (forests and rain forests) (Graph 17) where, apparently, scrub lands are the most vulnerable formations due to extreme conditions in which these appear to be and because of their extent within the country since they are located in limited rain and hot temperature regions (Graph 17). The above is partially due to the fact that the climate change scenario reduces land use change incentives of forests, rain forests and mangrove forests. Regarding costs, it is quite probable that great scrub land, natural pasture land and halophytic vegetation extensions will be lost, that, undoubtedly, represent a huge biodiversity value, but that, compared against wood products and services like Carbon capture represent a lower impact if compared against the benefits from reducing the deforestation rate. Economic impacts from these effects are shaded considering fire and extreme events occurred to plant cover. That is to say, climate change will increase fire rates in forests that will represent additional losses to this coverage.
3.4. Biodiversity

Biodiversity is a fundamental asset that contributes with human welfare through the diverse ecosystem goods and services (Figure 6) providing and having an intrinsic value (Millennium Ecosystem Assessment, 2005). These services contribute in different ways with production economic, distribution and consumption processes that, in this sense contain an unquestionable economic value. However, the said value is not fully reflected in market prices and, in most cases, no value has been assigned to such ecosystem services. Therefore, biodiversity is overexploited and its intrinsic relevance is not taken in consideration.
Influence of human activities in ecosystems is quite relevant since their systemic availability, structure and behaviors are modified. Today, there is a great amount of species and ecosystems in danger of extinction; furthermore, natural recovery of these ecosystems without the human assistance is not feasible because the natural adaptation capacity or resilience has been remarkably reduced in the last decades (IPCC, 2007). Current and/or expected impacts of climate change, regarding biodiversity, in the following decades are substantial, including changes to the size and allocation of populations, range changes, phenology changes, evolution and even extinction.

Mexico is one of the megadiverse countries having around 60 or 70% of total biodiversity in the world (Mittermeier and Goett Sch, 1992; Conabio, 1998). Evidence available in this respect is shown in Table 4.

**Table 4.**

**Climate change effects on ecosystems in Mexico**

<table>
<thead>
<tr>
<th>Ecosystem</th>
<th>Effect</th>
<th>Region</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1.3 to 3 degrees increment: 2-18% mammals, 2-8% birds, and 1-11% butterflies tend to extinction</td>
<td></td>
<td>Thomas <em>et al</em>., 2004a, Peterson, <em>et al</em>., 2002</td>
</tr>
<tr>
<td></td>
<td>2.2 to 4 degrees increment: 2-20% mammals, 3-8% birds, and 3-15% butterflies tend to extinction</td>
<td></td>
<td>Erasmus <em>et al</em>., 2002</td>
</tr>
<tr>
<td>Arid areas</td>
<td>Desertification due to changes in rainfall patterns and raise or temperature</td>
<td>North of the country</td>
<td>Lozano, 2004</td>
</tr>
</tbody>
</table>
### THE ECONOMICS OF CLIMATE CHANGE

<table>
<thead>
<tr>
<th>Ecosystem</th>
<th>Effect</th>
<th>Region</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arid areas</td>
<td>Extreme drought</td>
<td>Baja California, Sonora, Coast of Oaxaca and Guerrero, Michoacán, Campeche and Yucatán</td>
<td>Magaña et al., 2004</td>
</tr>
<tr>
<td>Forests</td>
<td>Reduction of coniferous forest surface. Loss of tropical rain forests</td>
<td></td>
<td>Villers y Trejo, 2004</td>
</tr>
<tr>
<td>Forests</td>
<td>Loss of up to 40% of fauna due to ecological unbalance</td>
<td></td>
<td>Peterson, et al., 2002, 1999, 2001</td>
</tr>
<tr>
<td>Coastal areas</td>
<td>46.2% of sea shores is susceptible to increment of ocean levels</td>
<td>Gulf of Mexico</td>
<td>Ortiz y Méndez, 1999</td>
</tr>
<tr>
<td>Coastal areas</td>
<td>Increment of ocean level has influence on erosion, flood and salinisation of land, surface waters and phreatic surfaces</td>
<td></td>
<td>Ortiz y Méndez, 1999</td>
</tr>
<tr>
<td>Coastal areas</td>
<td>Land salinisation</td>
<td></td>
<td>Sanjurjo 2006, Tejeda y Rodríguez 2006</td>
</tr>
<tr>
<td>Marine areas</td>
<td>Potential impacts against fishing activities, such as shrimp fishing</td>
<td>Gulf of Mexico</td>
<td>Park, 1991</td>
</tr>
<tr>
<td>Marine areas</td>
<td>Regarding a 1 to 3°C increment by 2080, coral reefs and mangrove forests are threatened to sustaining the risk of extinction of numerous species</td>
<td></td>
<td>Cahoon y Hensel, 2002</td>
</tr>
<tr>
<td>Rivers</td>
<td>Floods</td>
<td>Grijalva River mouth in Tabasco and Coatzacoalcos and Pánuco Rivers in Veracruz</td>
<td>Ortiz y Méndez, 2000</td>
</tr>
<tr>
<td>Fresh water</td>
<td>General increment to primary production rates, decomposition of organic matter and nutrients cycle; reduction to quality water standards and to adequate habitat in Summer; reduction of organic matter storage and loss of organisms; shorter flooding periods at riverside wetlands; changes in drainage rate of estuaries.</td>
<td>Inland Gulf of Mexico</td>
<td>Mulholand, et al., 1997</td>
</tr>
</tbody>
</table>

Biodiversity economic cost estimation associated to climate change requires an economic assessment subject to diverse limitations and criticisms. Unfortunately, information available for Mexico limits the valuation alternatives. In this case, it was then chosen to, only, economically and directly asses the environmental services that biodiversity provides in terms of Bioprospecting, species preservation (in general) game animals, tourism and the aesthetic forest value. Valuation obtained is pretty poor, however, it responds to the general scarce economic value granted to biodiversity in our days, being a complete challenge for the future.

Analysis of climate change impact on biodiversity and, from it, on the product was modeled based on a potential biodiversity index established upon climate variables and territory variables per federal entity and following a Ricardian model. Biodiversity was included endogenous variable and, afterwards, biodiversity index was included as an additional variable to explain the farm production. Outcomes obtained show the loss of biodiversity estimated for Mexico is significant and will increase in time (Graph 18 and Table 5) that, in turn will have negative impacts against farm
production. However, it must be acknowledged that this contribution is greatly accomplished out of market, being not reported in terms of costs or monetary incomes.

Present biodiversity value estimation and, in turn, of economic losses show that structure of present prices offer an off market subsidy for the group of economic activities. In consequence, biodiversity over exploitation and destruction is sustained without directly being reflected in direct and significant economic losses.

3.5 Extreme weather: Hurricanes and ENSO

Evidence available worldwide shows there is a strong correlation between raise of temperature, increment in hurricane intensity and rise in ocean levels. Likewise, it is already known that a raise of 3° to temperature will generate wind speed in windstorms to increase to up to 15% to 20% (Stern, 2007). This suggests that windstorm costs will increase to the third power in respect to wind speed rates (Stern, 2007). Evidence available in Mexico shows there are regular patterns within such extreme events so there are 25 municipalities exhibiting the greatest historical vulnerability rates out of the 153 coastal municipalities of the country. These are the regions where the highest potential economic and social costs regarding a larger amount or higher intensity of hurricane events can be estimated (Table 6). Additionally, hurricane economic costs estimated have reached, during the worst hurricane season, 0.59% of GDP in 2005 that, in average, between 1997 and 2005 represents 0.12% of GDP of that period of time. It must be underlined that potential costs due to deaths caused by hurricanes are not included.
In this way, it is estimated that these 25 municipalities most vulnerable to tropical storms and hurricanes, a population of more than 4 million 273 thousand inhabitants, its most significant real estate patrimony, estimated in more than one million thirty seven thousand inhabited houses (whether owned or leased⁴) and an agriculture and livestock sector production of US$ 977,662 thousand in farming, US$ 459,677 thousand in livestock production and US$ 2,905, 553 thousand in tourism are under absolute total risk conditions. The challenge is then to establish the infrastructure required to reducing impact while part of the population and economic activities is transferred towards safer areas.

Conservation of coral reefs, mangroves, other coastal wetlands and diverse ecosystems common of this coastal-marine interface is becoming, more than ever, into essential natural barriers to retaining future tropical storms and hurricane events. This shall be an ecologic and socioeconomic priority of the group of public policies to facing global warming scenarios in situ, and to launching new ways of regional development through fulfillment of mitigation/adaptation actions. It shall also be considered that the existence of extreme events related to weather phenomena known as El Niño, and the related La Niña which may cause considerable losses in specific year periods even though it is quite complex any future evolution be forecasted.

### 3.6. Tourism and natural disasters

Tourism is fundamental for the economic growth of diverse regions of the country; including a significant impact. Moreover, an important ratio of this tourism sector has effects on ecosystems. Impacts of climate change against tourism are diverse. These are summarized in Table 7.

### Table 7.

<table>
<thead>
<tr>
<th>Impact</th>
<th>Implications against tourism</th>
</tr>
</thead>
<tbody>
<tr>
<td>Warmer temperatures</td>
<td>Affections to seasonality standards, tourist thermal stress, cooling costs, changes to vegetation and wildlife, population of insects and their distribution, spread of infectious diseases</td>
</tr>
<tr>
<td>Reduction of snow levels and icecap glacier volume</td>
<td>Lack of snow at destinations at, in and for the practice of winter sports, cost increments, shorter winter sport seasons, reduction of landscaping aesthetic.</td>
</tr>
<tr>
<td>Increment to frequency and intensity of extreme rainstorms</td>
<td>Risks against tourist facilities; increase of insurance coverage/ coverage exclusions, costs due to Business</td>
</tr>
</tbody>
</table>

⁴ Assuming these are private properties
## THE ECONOMICS OF CLIMATE CHANGE

<table>
<thead>
<tr>
<th>Event Description</th>
<th>Impact</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rainfall reduction and evaporation increment at certain regions</td>
<td>Interruption: Water shortage, water disputes between the tourist sector and others, desertification, increment of forest fires threatening infrastructure and affecting the demand.</td>
</tr>
<tr>
<td>Increment of rainstorm index at certain regions</td>
<td>Floods, damages to historic and cultural architecture, damages to tourist infrastructure, affections to seasonality standards</td>
</tr>
<tr>
<td>Increment of ocean levels</td>
<td>Coastal erosion, loss of beach, higher costs incurred in to protect and maintain the marine borders</td>
</tr>
<tr>
<td>Increment to sea surface temperature</td>
<td>Coral bleaching increment and marine resource exhaustion as well as damages to aesthetic to diving and snorkeling destinations</td>
</tr>
<tr>
<td>Changes to marine and land biodiversity</td>
<td>Loss of natural attractions and species in situ, higher risk of sustaining diseases from tropical and subtropical countries</td>
</tr>
<tr>
<td>Major and more frequent forest fires</td>
<td>Loss of natural attractions, increment of flood risks, damages to tourism infrastructure</td>
</tr>
<tr>
<td>Soil changes (for instance, humidity, erosion and acidity levels)</td>
<td>Loss of archaeological property and other natural resources, having an impact against destinations</td>
</tr>
</tbody>
</table>

Source: UNWTO (2008)

Cost estimations of climate change regarding tourism demand were estimated through an international tourism model that includes the GDP of USA, the actual exchange rate standards the Mexican stock index and temperature rates as introduction of extreme events. Main outcomes obtained evidence the presence of a stable co-integrating focus of demand that allows a reasonable simulation of foreign tourist demand Graph 19.
Therefore, climate changes against tourism demand reduce its expansion rhythm, as can be noticed in Graph 20. In any case, this shall be softened by diversifying tourist destinations; for instance, promoting additional destinations at colonial cities or magic destinations, and not only beach locations.

3.7. Health impacts

Climate change also has significant consequences against the health of population; either by temperature changes and rainfall, or through extreme events. Nonetheless, these effects normally arise through indirect channels such as quality of air and water, quality and amount of food, agriculture and livestock and ecosystems and infrastructure. This analysis was based on responses and application of meta-analysis technique about exposure to Ozone concentrations, exposure to PM$_{10}$ particles and heat waves (Figure 7). Outcomes obtained show that climate change will increase geographical limits of contagious diseases and will provoke health affections associated to the heat waves referred. However, there is still an important volatility and uncertainty level in respect to expected impacts, as shown in (Figure 8). In this sense, outcomes shall be carefully considered.
THE ECONOMICS OF CLIMATE CHANGE

Figure 7. Analysis for Mexico

- Exposure to ozone
- Exposure to particles < 10 μm (PM₁₀)
- Heat waves
- Meta-analysis
- Health impacts

Figure 8. Impacts of heat waves on metropolitan areas

Combined estimation for health effects associated to heat waves and malaria

<table>
<thead>
<tr>
<th></th>
<th>Heat wave death rate</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Model</td>
</tr>
<tr>
<td>Fixed effect</td>
<td>1.67</td>
</tr>
<tr>
<td>Random effect</td>
<td>6.85</td>
</tr>
<tr>
<td>Malaria mortality</td>
<td>Model</td>
</tr>
<tr>
<td>Fixed effect</td>
<td>1.33</td>
</tr>
<tr>
<td>Random effect</td>
<td>2.01</td>
</tr>
<tr>
<td>Mortalidad Malaria</td>
<td>Model</td>
</tr>
<tr>
<td>Fixed effect</td>
<td>1.59</td>
</tr>
<tr>
<td>Random effect</td>
<td>2.44</td>
</tr>
</tbody>
</table>

Source:
Elaborated from outcomes obtained from meta-analysis report.

Increment of the risk of malaria morbidity associated to environmental and social-demographic characteristics

Risk of death due to heat waves in three metropolitan areas of the Republic of Mexico

<table>
<thead>
<tr>
<th>Metropolitan area</th>
<th>Additional population at risk</th>
<th>Aggregated growth (%) 2010 2100</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mexico City</td>
<td>2010</td>
<td>2050</td>
</tr>
<tr>
<td>Guadalajara</td>
<td>8.900</td>
<td>21.507</td>
</tr>
<tr>
<td>Monterrey</td>
<td>2.88</td>
<td>6.611</td>
</tr>
<tr>
<td>Total</td>
<td>13.794</td>
<td>32.79</td>
</tr>
</tbody>
</table>

Source:
Elaborated from outcomes obtained from meta-analysis report and population projections.
4. Mitigation options

4.1. Energy

Energy is an essential asset in every economy. However, it also represents one of the main sources of different greenhouse emissions (GEI). Therefore, there is a strong relation between the incomes and the energy consumption of an economy. Nonetheless, in the last few years there has been a certain amount of energy disengagement and decarbonization in the Mexican economy, which should increase. The development of scenarios in this sector was carried out based on the specification and estimation of several econometric demand models of the different types of energy and accounting identities (Figure 9).

The estimations of the energy demand show it basically responds to the income and its resilience capability to prices (Table 8). This lack of resilience demonstrates there still are few alternatives and the need to develop a culture to improve energy consumption management.
Table 8.
Standardized equations of national energy demand and by sectors, 1966 – 2006

<table>
<thead>
<tr>
<th>Coefficient</th>
<th>$\beta_0$</th>
<th>$\beta_1$</th>
<th>$\beta_2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$c_{ne}$</td>
<td>-15.892</td>
<td>1.170</td>
<td>-0.156</td>
</tr>
<tr>
<td>$c_{ei}$</td>
<td>-7.441</td>
<td>0.881</td>
<td>-0.158</td>
</tr>
<tr>
<td>$c_{ea}$</td>
<td>-11.979</td>
<td>0.865</td>
<td>-0.251</td>
</tr>
<tr>
<td>$c_{el}$</td>
<td>-8.432</td>
<td>0.792</td>
<td>-0.328</td>
</tr>
<tr>
<td>$c_{er}$</td>
<td>-4.975</td>
<td>0.550</td>
<td>-0.236</td>
</tr>
<tr>
<td>$c_{et}$</td>
<td>-10.597</td>
<td>0.760</td>
<td>-0.222</td>
</tr>
<tr>
<td>$c_{sc}$</td>
<td>-12.916</td>
<td>1.049</td>
<td>-0.397</td>
</tr>
</tbody>
</table>


The results on the expected track record of the national energy consumption, based on the basic scenario, show an annual growth rate of 2.4% from 2008 to 2100. The simulations performed with the basic scenario of economic growth reflect that the independent application of a price increase, at a reasonable level, and slight energy disengagement are insufficient to control the demand increase according to the estimated elasticity levels (Graph 21). Hence, only a combined strategy of price signals and regulations is able to control an increase in energy demand (Graph 22). In the long run, the need to apply a specific policy for price signals to gain importance in the Mexican economy must be recognized.
Transportation is an essential activity in modern economies. However, there are external negative factors related to transportation. For example, automotive transportation is considered as one of the largest generators of GEI and different pollutants, which have important effects in terms of environmental and health costs. The estimations performed show that income resilience rates are close to one or even slightly higher, while price resilience rates are low. All this reflects a combination of circumstances, such as: public transportation not being a good substitute of private transportation and the urban development options. Nevertheless, it seems important to combine price policies with some regulations like emissions or performance standards aligned to price strategy and capable of reflecting the proper economic incentives to control or regulate the increasing demand of gasoline (Figure 10).
4.2 Mitigation strategies for Mexico

There are several alternate mitigation strategies for Mexico, which depend on the emissions objectives to achieve and the time the mitigation process starts. Within this context, it is necessary to consider that delaying the stabilization process implies increasing the future mitigation rates, which significantly increases the costs and risks (Graph 23 and Table 9). It is important to mention that Mexico, in the international context, must acknowledge the economic benefits of reaching an international mitigation agreement that recognizes the common responsibility stating different commitments by country, and Mexico shall make the proper contribution.
Defining the mitigation strategy can be done through the formalization of the relationship between emissions, energy consumption, product and population that can be made based on the renowned identity of Kaya (1989) or IPAT (Equation (1)). This identity could make us think that the increase of emissions is mainly due to population and per capita GDP, while its reduction must be related to an energy disengagement and decarbonization process. The scenarios simulated with this identity show an important increase in the inertial scenario (Graph 24). Therefore it is necessary to acknowledge that the Mexican economy will have to make significant efforts to achieve more ambitious mitigation goals that will only be possible through the proper internal and external financing.

\[
\triangle \text{CO}_2 = \left[ \triangle \text{POP} \right] + \left[ \frac{\triangle \text{GDP}}{\text{POP}} \right] + \left[ \frac{\triangle \text{ENERG}}{\text{GDP}} \right] + \left[ \triangle \text{CO}_2 \right]
\]
The economic evaluation of the costs of mitigation is a very complex and highly uncertain task. Mitigation costs depend on factors such as the strategies internationally designed and agreed, including their rhythm and intensity, technology availability, its costs and promotion channels, the changes in the productive structure and its relation to energy consumption, substitution options, marginal costs curves and demand resilience rates, including the price per carbon ton. In this job we use as an approximate cost estimate a general model of computable balance calibrated for Mexico (Bravo, 2008), and estimations combining a microeconomic and structural focus to develop abatement costs (Quadri, 2008; Johnson, 2009; Molina, 2009). These results are just an indication of the possible options, but demonstrate it is possible to design an abatement wedge strategy to meet the abatement goals defined and estimate it probable economic cost (Quadri, 2008) (Graph 25).
Johnson, Alatorre, Romo and Liu (2009) (World Bank) (Graph 26), the Mario Molina Centre (MMC) (Graph 27a, 27b and 27c), estimated several abatement cost curves that clearly show the best mitigation strategies by sector. In this way it is possible to identify an optimum mitigation strategy arranging the mitigations measures by sector based on their costs. Therefore, a mitigation strategy in Mexico must consider the costs reductions that can be obtained from applying a sequential reduction by sector. However, it must consider the significant persistent differences between the abatement curves, which are endogenous to relative price modifications and their application depends basically on the proposed mitigation strategy.
Graph 26. Abatement costs curve

Net benefits-net costs (in US Dollars/ton CO₂)

Accrued mitigation, 2009-2030 [Mton CO₂e]
Graph 27. Marginal costs curves for abatement in the mitigation scenario, 2030

a) Electric sector

b) Iron and steel sector
According to the BAU scenario (E1), obtained from the IPAT model\(^5\), the CO\(_2\) emissions for 2100 could be up to 2,077 million tons, and 1,045 million tons for 2050. The reductions costs per ton of CO\(_2\) of the sectors were conciliated with two extreme scenarios of 10 and 30 dollars per ton. The projected mitigation rates are higher than the current rates, but are achievable since they have already been registered during short periods of time, have the proper international financing and an efficient monitoring and follow-up strategy is applied.

\(^5\) According supposed restrictions on the deforestation rate.
5. The costs of inaction and the benefits of mitigation

5.1 Economic valuation of climate change on Mexico

Quantifying the impacts of climate change is a complex task and requires combining scientific and economic models in a consistent way, the generation of economic scenarios on a very broad time horizon and the recognition that an important margin of uncertainty exists in the results obtained and that significant risks exist which are particularly difficult to evaluate. Also, it is necessary to consider factors which do not have a recognizable market value, but which are still fundamental, such as the loss of biodiversity. In addition, intense debate currently exists on defining the discount interest rate to be applied (Stern, 2007; Nordhaus, 2008). Despite this, from the viewpoint of public policy and society in general, quantifying the costs of climate change is still a particularly useful exercise insomuch as it allows options and alternatives to be identified, and the most efficient development strategies possible to be constructed to meet the challenges of climate change.

The valuation of the total costs and benefits of climate change in Mexico are summarized in Table 10, which separates market costs from non-market costs. This valuation is, of course, very sensitive to the suppositions utilized such as discount rates or the rate of economic growth. In any case, it allows us to clearly appreciate that the costs caused by the impacts are greater than those incurred by Mexico subscribing to an international agreement on mitigation. Thus, the total costs of climate change accumulated by the year 2100, applying a discount rate of 4%, are the equivalent of around 6.2% of GDP, excluding livestock production, extreme weather events, sea level rise and non-market costs in terms of biodiversity and human lives.

### Table 10.
#### Total costs of climate change to the Mexican economy in 2050 and 2100.

<table>
<thead>
<tr>
<th>sector</th>
<th>0.5% rate of discount</th>
<th>2% rate of discount</th>
<th>4% rate of discount</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>B1</td>
<td>A1B</td>
<td>A2</td>
</tr>
<tr>
<td>Agriculture</td>
<td>2.11</td>
<td>2.83</td>
<td>2.40</td>
</tr>
<tr>
<td>Water</td>
<td>7.59</td>
<td>7.59</td>
<td>7.59</td>
</tr>
<tr>
<td>Land use</td>
<td>0.17</td>
<td>0.37</td>
<td>0.57</td>
</tr>
<tr>
<td>Biodiversity</td>
<td>0.02</td>
<td>0.05</td>
<td>0.02</td>
</tr>
<tr>
<td>Foreign tourism</td>
<td>0.01</td>
<td>0.01</td>
<td>0.01</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>9.00%</strong></td>
<td><strong>10.84%</strong></td>
<td><strong>10.00%</strong></td>
</tr>
<tr>
<td>Livestock</td>
<td>1.10</td>
<td>1.44</td>
<td>1.24</td>
</tr>
<tr>
<td>Indirect biodiversity</td>
<td>0.23</td>
<td>0.42</td>
<td>0.16</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>11.22%</strong></td>
<td><strong>12.7</strong></td>
<td><strong>12.01%</strong></td>
</tr>
</tbody>
</table>
For their part, the cost of mitigating emissions by 50% by the year 2100, relative to 2002, with a discount rate of 4%, are summarized in (Table 11). These costs are between 0.7% and 2.2% of GDP, depending on the value of a ton of carbon. The costs of mitigating emissions by 50% on 2002 levels by the year 2050 are also shown (Table 12). The mitigation costs estimated probably represent the uppermost limit, given that no procedure for cost minimization was applied, such as through using abatement cost curves or by estimating cost reductions derived from technological innovation.

### Table 11.
Total cost of CO₂ emissions reductions by 50% of 2002 levels by 2100

<table>
<thead>
<tr>
<th>Costs</th>
<th>0.5% GDP</th>
<th>2% GDP</th>
<th>4% GDP</th>
</tr>
</thead>
<tbody>
<tr>
<td>9.56 US Dlls. per ton</td>
<td>2.10</td>
<td>1.20</td>
<td>0.70</td>
</tr>
<tr>
<td>30 US Dlls. per ton</td>
<td>6.60</td>
<td>3.76</td>
<td>2.21</td>
</tr>
</tbody>
</table>

### Table 12.
Total cost of CO₂ emissions reductions by 50% of 2002 levels by 2050

<table>
<thead>
<tr>
<th>Costs</th>
<th>0.5% GDP</th>
<th>2% GDP</th>
<th>4% GDP</th>
</tr>
</thead>
<tbody>
<tr>
<td>9.56 US Dlls. per ton</td>
<td>1.03</td>
<td>0.77</td>
<td>0.56</td>
</tr>
<tr>
<td>30 US Dlls. per ton</td>
<td>3.24</td>
<td>2.43</td>
<td>1.75</td>
</tr>
</tbody>
</table>

---

6 Cost obtained from Stern (2007)
The estimates of costs and benefits presented in this section are, of course, only indicative. That is to say that the construction of scenarios over a 100 year timescale is obviously an extremely complex task with a high degree of uncertainty and which, in any case, can only suggest possible trajectories. Nevertheless, for every case it was observed that the costs of inaction are greater than the costs of mitigation, given the supposition that an international agreement on mitigation exists and that it is convenient for Mexico to participate in a global strategy of climate change abatement.

5.2 Climate change and public policy in Mexico

Mexico should press with even greater vigor, for the consolidation of a global strategy to coordinate actions and public policies designed to mitigate and adapt to climate change. In this context, despite the advances made on particular issues, Mexico still has a wide margin within which to improve environmental planning and regulation. The evidence of environmental deterioration in Mexico, including climate impacts, suggests among other things, the need to use public policy to decisively reverse this situation. Climate change is a phenomenon with a high level of risk, including the probability of catastrophic events and important feedback mechanisms. In this sense, over and above the economic values that can be assigned to climatic impacts or the processes of mitigation, it is necessary to avoid irreversible losses—such as of biodiversity—and properly manage the risk of a catastrophic event, even where its probability of actually occurring is very low, and more intense weather events caused by feedback mechanisms.

The construction of a strategy of mitigation and adaptation to climate change in Mexico must recognize the need to utilize an array of policy options continuously and with long term vision. Recognizing the importance of building a relative pricing structure consistent with the aim of sustainable development is indispensable. That is, relative pricing should adequately reflect the presence of negative externalities caused by the consumption of certain goods; these pricings should also recognize the importance of adequately valuing those aspects which are currently outside the market, such as biodiversity. An adequate pricing structure is fundamental to controlling excessive consumption, improving resource management and for supporting technological innovation and diffusion. In this context, it is fundamental to explore the role of pricing for certain public goods and services such as energy, fuel and water, with the long term in mind, and without sideling social considerations. Thus, from the public sector standpoint, it is paramount to have a consistent strategy of public spending and subsidies which supports adequate price signaling. It is, for example, important to stop supporting the inefficient expansion of the farming sector. The response sensitivities of price changes to different levels of demand for the goods analyzed in this study, such as different kinds of energy, fuel and water, are still inelastic. This is the consequence of the interaction of a set of diverse factors, including the lack of adequate substitute or alternative goods, as with the dilemma of public and private transport, and the lack of a long term price signaling strategy, or simple market failure. It is, of course, vital that these obstacles be gradually removed. However, the realignment of relative prices to support sustainable development with the current levels of inelasticity of demand could be highly problematic, leading to important market distortions and negative social consequences in the short term, which could hamper reaching the desired objectives. This implies the need to support market mechanisms with regulations which
mimetic economic incentives. It is possible to implement a graduated strategy, based on the realignment of relative prices on a ramp trajectory, supporting the process with regulations and spending which generate greater response sensitivity to price signaling, cushion the negative social impacts and limit or keep to a minimum imminent damage where price signals remain insufficient, such as with biodiversity. It is therefore paramount to combine the use of environmental regulation with economic instruments. This nevertheless requires appropriately identifying those cases in which one or the other of these tools has the best chance of yielding the desired results. In the text, several different areas and activities are listed which will allow for an improved dynamic between these two instruments.

It should also be recognized that planning in Mexico’s environmental sector must be supported by a series of quantifiable indicators and targets. In this sense, Mexico demonstrates some important progress on the environmental front, but this is still insufficient to halt the persistent decline in environmental quality. This demonstrates the need to make greater progress on improving the complementarity of the distinct available policy tools. Thus, Mexico’s mitigation strategy should take account of the following considerations:

- The existence of externalities and of the costs of mitigation assume a relation between economic and environmental policies which transcend the failures of coordination and integration that have thus far prevailed in Mexico. The application of economic instruments to achieve environmental ends has been mostly casuistic, despite the advantages shown by the use of such instruments, and also despite the fact that their use has been envisaged in the legislation in some form or another, since the last decade of the twentieth century.

- The modification of energy prices and the application of market mechanisms will not, by themselves, resolve the need to mitigate emissions, but without their use it will also certainly not be possible to reach the mitigation targets required by the climate change strategy. Change, both in the conception and in the operation of economic-environmental policies, particularly those of a fiscal type related to energy consumption, must be considered as a priority.

- Reinforcement of the regulatory framework must necessarily include granting more attributions to the agencies that should ideally be involved with verifying compliance with national standards and laws. Agencies such as CONUEE and PROFEPÁ, or even SEDESOL and SEMARNAT themselves, will have problems in doing anything other than setting out recommendations, as long as they have to confront the weightier dictates of other sectors.

Mexico has striven hard to build an environmental policy to address the challenges of climate change. The Mexican government has identified the need to reduce emissions of GHG without affecting economic growth and development. As a part of this process, the Mexican authorities have now made public the intention to voluntarily reduce national emissions by 50% by 2050, taking 2002 as the baseline year. This target is conditioned by certain financial and technological
conditions, and in general on the international community fulfilling its commitments and granting adequate cooperation. The economic analysis carried out permits the identification of a *per capita* emissions target, which can itself be transposed to specific targets for emissions from energy to GDP and from emissions to energy at the national level and by sector, based on the IPAT model (Table 13). This thereby allows the construction of a monitoring strategy by economic sector, facilitating the verification of results.

**Table 13.**
Annual rate of (%) change of CO$_2$/GDP, CO$_2$/POP and CO$_2$/Energy requirements for reducing emissions by 50% by 2050

<table>
<thead>
<tr>
<th>Ratio</th>
<th>2002-2010</th>
<th>2010-2020</th>
<th>2020-2030</th>
<th>2030-2040</th>
<th>2040-2050</th>
</tr>
</thead>
<tbody>
<tr>
<td>CO$_2$ (1)/GDP</td>
<td>-4.57%</td>
<td>-4.77%</td>
<td>-4.64%</td>
<td>-4.86%</td>
<td>-4.91%</td>
</tr>
<tr>
<td>CO$_2$ (2)/GDP</td>
<td>-4.58%</td>
<td>-4.71%</td>
<td>-4.76%</td>
<td>-4.87%</td>
<td>-4.81%</td>
</tr>
<tr>
<td>CO$_2$ (1)/POP</td>
<td>-2.09%</td>
<td>-2.04%</td>
<td>-1.82%</td>
<td>-1.65%</td>
<td>-1.39%</td>
</tr>
<tr>
<td>CO$_2$ (2)/POP</td>
<td>-2.09%</td>
<td>-2.03%</td>
<td>-1.82%</td>
<td>-1.65%</td>
<td>-1.40%</td>
</tr>
<tr>
<td>CO$_2$ (1)/ENERG</td>
<td>-4.43%</td>
<td>-4.15%</td>
<td>-4.21%</td>
<td>-4.82%</td>
<td>-4.82%</td>
</tr>
<tr>
<td>CO$_2$ (2)/ENERG</td>
<td>-4.43%</td>
<td>-4.15%</td>
<td>-4.21%</td>
<td>-4.82%</td>
<td>-4.82%</td>
</tr>
</tbody>
</table>

CO$_2$ (1) = Excluding waste and CO$_2$ (2) emissions = Total emissions

Achieving these targets will require the implementation of specific policies, such as:

**Energy**
- An important mitigation potential exists in the state owned companies (PEMEX, CFE and LFC). These can be tapped through several mechanisms, including enacting Standards to limit emissions, or through the setting up of a carbon market.
- Development of projects to realize the full potential of cogeneration (CHP), including a standard for connecting to the national electrical grid and commercializing energy.
- Include in the investment programs of the state owned companies of the energy sector, calculations of the externalities caused due to GHG emissions using the price per ton of carbon avoided through the use of alternative technologies.

**a.** Promote improved energy efficiency through:

- Establishing stricter Standards, inline with international standards, for household appliances and industrial equipment and machinery, backed by a program of certification which allows consumers greater awareness of the advantages and characteristics of the goods bought.
- Establish a fixed-date target to eliminate the production and use of incandescent light bulbs and develop programs to support low-income consumers, to provide long term certainty. Simultaneously, a national program to establish a fixed-date target to substitute incandescent bulbs in street lighting, should also be drawn up.

**b.** Modify the energy matrix to gear it towards a reliable, cheap and efficient energy supply with lower carbon content.
c. Update the legal and regulatory framework to provide incentives for energy generation from renewable sources, allowing investment from the private sector. Design a national strategy for electric energy generation from alternative, clean sources, including nuclear energy.

Gasoline consumption

- Changes in the prices (or taxes) of gasoline and automobiles to reflect the real cost of car use, including negative externalities.
- This measure should be accompanied by a policy of control geared towards increasing the average efficiency of the vehicle fleet.
- Make public transport more efficient, to provide a real substitute to private transport.
- Plan the production of third generation gasoline types.
- Draw up and implement stricter Standards for federal public transport, including limiting the useful life of vehicles and stricter verification programs.
- Develop and encourage clean transportation systems and low carbon intensity transport, such as railways, multi-modal systems and confined-lane urban transportation systems.

Deforestation and land-use change

- Halt the expansion of the agricultural frontier.
- Reformulate and extend the Ecological PROCAMPO Program, with a more defined focalization with clear mitigation criteria; align the economic incentives of public policies for rural areas.
- Support forestry plantations for protection.
- Protect forests from fires.
- Protect forests from disease and pests.
- Encourage the establishment of good quality forest plantations, including their adequate maintenance and replacement, with the purpose of producing industrial raw materials and reducing the pressure on natural forests.

Agricultural subsidies

- Gradually phase out tariff 09 which subsidizes water use in farming and implicitly encourages the unsustainable use of aquifers and inefficient irrigation technologies. Other proposals are:
  1. Develop programs for the sustainable use of natural resources, particularly water.
  2. Programs to gradually internalize the costs of pumping water to irrigated cropland.
  3. Temporary Compensation schemes for farmers most affected.
Carbon Market

Solving climate change requires the consolidation of an international carbon market, either through the direct levying of carbon taxes, the use of a system of tradable carbon permits, or directly through the setting out of regulations for that purpose, or indeed a hybrid system combining several of these mechanisms. In this sense, it is fundamental that Mexico makes progress on the creation of a carbon market in which the manner of integration with other countries can be defined, including via current trade agreements. To that end, the following proposals:

- Develop a system of tradable carbon permits for Mexico.
- Establish a price for carbon.
- Design and implement regulations to support the creation and efficient operation of this market.

The importance of changing habits and patterns of production, distribution and consumption should also be recognized, as should decisive support for innovation and diffusion of new technologies which reduce carbon intensity, the elimination of institutional barriers and the building of a new environmental culture.

Adaptation

The process of adaptation is a fundamental component of an evaluation of the impacts of climate change, and as such it is also a fundamental element of the strategy to tackle climate change. Adaptation processes have significant costs, but there are also important costs associated with not enacting them. For example, a successful adaptation process can reduce the impacts of climate change by more than half. Climate impacts are, however, very diverse, as a result of which adaptation processes are extremely complex and difficult to identify. Indeed, the projections made suggest that the scale of adjustments necessary in the future are very considerable. But adaptation will not be sufficient to resolve all the problems caused by climate change: it may reduce the costs of climate change, but it cannot control its impacts.

For building an efficient and successful adaptation process the following considerations apply:

1. Adaptation is efficient in those cases where the benefits exceed the costs. Unfortunately, with the prevailing relative pricing structure the private sector can seek what appears to be an efficient form of adaptation at the individual level, but it will not include its own negative externalities.
2. Adaptation is carried out under a high level of uncertainty, which increases costs and reduces its efficiency relative to the lack of timely and long term information.

In this context, it is necessary to design an efficient adaptation strategy which considers:
The farming sector

a. Changes in farming practices:
   • Introduction of high yielding varieties.
   • Research on cultivars resistant to flooding, high temperatures and drought, and their dissemination.
   • New irrigation schemes for cultivated arid lands.
   • Appropriate use of fertilizers.
   • Implementation of a system to control crop and livestock pests and diseases.
   • Reduce the pollution effects on soil and surface water produced by the indiscriminate use of pesticides and herbicides.
   • Move the most climate sensitive farming practices on Mexico’s Altiplane and wetter regions, without having a significant impact on land use change.
   • Make more widespread use of crop and livestock insurance based on meteorological indices. Such insurance policies allow farmers to better manage risks, while encouraging them to invest in farming activities requiring a higher initial investment.
   • Provide, via government agencies, the necessary information on climate change to an adequate standard.
   • Apply international standards to the use of agrochemicals.
   • Foment agroforestry, agro-silviculture and silvo-pastoralism, and encourage the cultivation of perennial crops on marginal land. Encourage zero cultivation.

The forestry sector

a. Forestry plantations for protection: To control processes of erosion, regulate hydrology, capture carbon and reduce vulnerability to the effects of climate change
b. Protection of forests against fires: issue guidelines and implement actions of prevention and control, to reduce the occurrence and impact of forest fires.

c. Forest protection from pests and disease.

d. Encourage the establishment of commercial forestry plantations with adequate maintenance and replacement, to supply high quality industrial raw materials, thereby removing pressure to exploit natural forests.

e. Halt deforestation.

Water resources

a. Improve water management.
b. Control demand for water by making more efficient use of the resource.
c. Construct adequate infrastructure, better able to contribute to improved water management.
Biodiversity

a. Some ecosystems have limited options for adaptation (such as coral reefs in high latitude and altitudes), given their sensitivity and/or exposure to climate change. For some of these (including coral reefs), adaptation options might be limited to simply removing other stressors (such as pollution or sediment runoff).

b. Long term strategies which could contribute to biodiversity adaptation are concentrated mostly on expansion of protected areas to try to reduce pressures on ecosystems vulnerable to climate change. As such, the maintenance and development of the protected areas program is needed, to include biological corridors, soil conservation, ecosystem management and in situ conservation and monitoring. It is especially important to restore and maintain better connectivity within and between protected areas in the face of climate change, which implies that the creation and maintenance of biological corridors for biodiversity adaptation is a priority.

c. It is also necessary to reduce and manage stresses on species and ecosystems, over and above those directly attributable to climate change itself, such as fragmentation, deforestation and deterioration, over exploitation, desertification and pollution (e.g. acid deposition).

d. A policy of taxation on added ecological value could contribute to the conservation of forests and biodiversity.

Tourism

a. Technical measures: recycle water, collection of rain water, desalinization plants, structured tariffs on water consumption, cyclone resistant buildings, weather forecasts and early warning systems.

b. Administrative measures: water conservation plans, product and market diversification, regional diversification of firms, diversion of clients from impact zones, encourage environmentally sustainable management in private sector firms (with certification), and adjustment of insurance policy premiums.

c. Education: information and education on water conservation for employees and guests, campaigns to save water.

Extreme weather events and coasts

a. Develop infrastructure to ameliorate climatic impacts.

b. Adequate preparation and readiness to provide assistance in the event of extreme weather.

c. Develop a strategy to relocate population, industry and infrastructure away from risk areas.

Public health

a. Implement specific policy measures to reduce risk to sectors of the population most vulnerable to the impacts of climate change, particularly in large cities, and to the spread of infectious and contagious disease in rural areas.
Industry

a. Promote technological innovation.
b. Establish costs to include negative externalities.
c. Implement systems of fiscal incentives for businesses investing in technological transformation, relative to their emissions reductions.

Construction

- Establish Standards for public buildings to substitute incandescent bulbs and light fittings.
- Develop regulations for house building which incorporate criteria on the use of materials, including heat insulation, installations which save energy, adequate waste deposition, systems to capture and treat waste water. These should also include financial support through measures such as "green mortgages" and trust funds for energy saving.
- Strengthen regulations for “green” buildings, in terms of energy consumption, waste deposition, water consumption, and waste and effluent management.
- Improve and control waste management.

Over the next few years, the Mexican economy –like the rest of the world’s economies- will have to move onto a trajectory of low carbon-intensity growth, at the same time as implementing adaptation processes to minimize the impacts of climate change. The monetary and financial resources needed for so doing are certainly significant, and of course alternative uses for these resources do exist, including infrastructure development, a social welfare system and the education system, all of which are also essential for sustainable development. In some cases, economies of scale exist between different targets, which should be taken advantage of, however, designing a strategy in which internal resources are complemented by external resources will also be necessary. The Mexican economy should then undertake several mitigation and adaptation activities, within the bounds of its possibilities, thereby contributing to a global solution to climate change in accordance with the need to act with a sense of responsibility. However, it is evident that additional resources will be required to achieve more ambitious targets. Thus, Mexico should, in the short term, seek to use those international resources now available through various funds and organizations, at the same time as contributing to the development of multilateral institutions which will permit the consolidation of the necessary sources of financial support.

The challenges presented by climate change are evidently of impressive magnitude, and in many cases the impacts of them are now inevitable. The fundamental strategic decision thus consists not in recognizing the need to confront the inevitable, but in discovering the best way of doing so.
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