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A critique of The Economics of Climate Change in Mexico

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Abstract: This paper revises some relevant aspects of The Economics of Climate Change in Mexico (ECCM), one of the most important documents for supporting national decision-making regarding the climate change international negotiations. In addition to pointing out some important methodological inadequacies, this paper shows that the ECCM's main results are questionable. Even though this study was inspired on the Stern Review and benefited from the support of original members of the Stern team, the ECCM is not consistent with the world portrayed in the Stern Review in many aspects, particularly regarding the importance of climate change impacts. The estimates of the costs of climate change for Mexico are so low that can hardly be considered to be consistent with the previous studies that have been reported in the literature concerning regional and global scales. Furthermore, it is shown that the document's main conclusion is not supported even by the estimates of the costs of the impacts of climate change and of the mitigation strategies that are presented in it. It is argued that this document has important deficiencies that do not make it adequate for supporting decision-making. In addition, the ECCM has inspired other reports regarding the economics of climate change in Central and Latin America, and as is shown here, their results are also questionable. This raises further reasons for concern because these national documents are building a regional view of what climate change could imply for Latin America that severely underestimates the importance of this phenomenon.

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1. Introduction

Climate change may turn into one of the most important environmental problem that humanity will face in this century (IPCC, 2007a,b,c; Stern, 2006). In addition, in many aspects it has become obvious that there is a void of knowledge and of tools for answering some of the most relevant questions this phenomenon poses and for interpreting the available information as well as for managing the uncertainty (IPCC, 2007a,b,c; Ackerman, 2008; Schneider, 2001; Grübler and Nakicenovic, 2001; Tol, 2009; Gay and Estrada, 2010). Climate change has brought important methodological challenges for a great number of disciplines (and their integration) that are needed for its study: from climate modeling, to impact and vulnerability assessments, to mitigation and adaptation options, and to policy- and decision-making, among others. The economic valuation of its impacts and of adaptation and mitigation strategies has shown to be particularly challenging and there has been serious questioning regarding the applicability of standard economic tools and theory (Ackerman, 2008; Martínez-Alier, 2001; Weitzman, 2010).

Although the science and economics of climate change have evolved greatly over the last three decades or so, they are still at an early stage of development and the methods and information that are being created should be carefully evaluated, constantly revised and corrected when necessary, always striving for the building of sound scientific knowledge. In this context of uncertainty, scarce information and limited applicability of the current methodologies, scientific and technical rigor should be a necessary condition for creating the foundation on which decision-making can rely.

Paradoxically, some of the most relevant sources of information for supporting decision making are the national documents financed through different government agencies on issues that the government thinks are of prime importance. These documents are part of what has been called the "grey literature", which in most cases has no formal academic recognition and do not go through a peer-review process. In many cases the aim of these documents is not to summarize the available scientific knowledge that is reported on specialized journals but to conduct original research. The outcome is that, at the end, research results are offered for supporting decision making without being previously evaluated. This is particularly true for developing countries.

In 2009 the Government of Mexico published the Economics of Climate Change in Mexico (SEMARNAT and SHCP, 2009; hereafter ECCM) which is a synopsis of the study that was co-produced by Mexico's Environmental and Natural Resources (SEMARNAT) and Finance

(SHCP) Ministries and that was co-founded by the UK Department for International Development and the Inter-American Development Bank[1]. It is also acknowledged in the document that the study benefited from the support of members of the original Stern Review team and from Lord Stern of Brentford himself.

In the preface of the ECCM (SEMARNAT and SHCP, 2009), written by Nicholas Stern, it is stated that the ECCM provides strong evidence that under unabated climate change Mexico "will suffer significant economic costs" as a consequence of this phenomenon. Furthermore, Stern asserts that the fact that the Mexican Government supported the ECCM indicates that "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 will lead to a wide range of business opportunities for growth and development". The key conclusion of the study is that the costs of inaction are almost three times larger than those of mitigation and that therefore strong mitigation actions (50% emissions reduction in 2100 with respect to 2002) represent "a sound public investment" if an international stabilization agreement is achieved.

Do the estimates presented in the ECCM support these statements and conclusions? The main objective of this paper is to analyze the results of the report and compare them with previous national and international studies. Some methodological issues are also pointed out and discussed, but a thorough methodological revision is not possible because, in many cases, a full description of the methodologies used in the document is not available.

In the final section of this paper, the discussion is extended to other reports on the economics of climate change that are available for Latin America that were inspired by the ECCM.

2. Discussion

2.1 Climate change scenarios

According to the synopsis of the ECCM, two methodologies were applied for generating climate change scenarios: one based on time-series forecast models and the other based on the output of general circulation models and on statistical downscaling techniques.[2] The latter scenario is considered as the "most likely" in the synopsis of the ECCM. Nevertheless, Estrada et al. (2011) showed that the downscaling methodology that was applied for the ECCM and other national climate change documents of Mexico is flawed to the point that all

[1] The full report of the Economics of Climate Change in Mexico (SEMARNAT and SHCP, 2010) was released in July 2010, prior to the COP 16 meeting in Cancun, Mexico.
[2] For a description of the downscaling methodology that was used for the ECCM see Magaña and Caetano, 2007; Zermeño, 2008; Magaña, 2010.

documents based on such scenarios should be revised and should not be used for supporting decision making until then. This downscaling methodology replaces the physics embedded in the original scenarios produced by general circulation models (GCM), and produces random spatial patterns and magnitudes of change that are not physically consistent. These regional scenarios are not consistent with the original GCM output and exclude the climate change signal that was originally contained in them. These scenarios will not be discussed further here and the interested reader is referred to Estrada et al. (2011).

The time series approach is based on fitting ARIMA models to temperature and precipitation series and on producing forecasts for these variables for almost a 100-year horizon. Although the time-series analysis of climate variables is very useful for understanding their evolution and how climate change has affected them, it is clear that using ARIMA models for producing such long-range forecasts cannot be considered a useful method for constructing a "conservative baseline trajectory to analyze the impacts of climate change in Mexico" as was intended in the ECCM (SEMARNAT and SHCP, 2009, page 26). There are strong theoretical and empirical reasons that make ARIMA models not suitable for such long-term forecasts, particularly in the case of non-stationary time series (Greene, 2007; Diebold, 2007; Pindyck, and Rubinfeld, 1998). Parameter instability and the omission of forcing variables that are the main drivers of climate are only two examples why these time series models are not suitable for projecting climate change.

The changes in temperature and precipitation variables under climate change depend mostly on the future evolution of external forcing factors and this information is clearly missing from time-series models. In addition, these forecasts cannot warrant physical consistency between the different variables and regions, or even physical plausibility. Can these projections be consistent with the evolution of local, regional and global temperature and precipitation series during this century? These projections are neither statistically nor physically satisfactory and should not be used as an input for constructing impact assessments nor for supporting decision-making. It is important to consider that the use of ARIMA models for projecting climate change for the next 100 years would have not survived a peer-review process.

Both approaches used for generating climate change scenarios mentioned above are based on inadequate methodologies and are not representative of the state of the art in climate modeling.

In the full version of the ECCM (SEMARNAT and SHCP, 2010), a third set of climate change scenarios are presented. These scenarios were produced by the Centro de Ciencias de la Atmósfera of the Universidad Nacional Autónoma de México according to the demands of the ECCM team: state level spatial resolution with no downscaling, annual temperature and precipitation scenarios from 22 general circulation models and for the A1B, A2 and B1 emissions scenarios (Estrada et al., 2008, see also Conde et al. 2011). Apparently these scenarios were not used as extensively as the other two. They are not even mentioned in the synopsis of the ECCM and most of the analyses presented in the document rely on monthly or seasonal (not annual) temperature and precipitation projections. For these reasons, these scenarios are not discussed here.

Finally, the climate simulations used in the ECCM do not include any stabilization scenario (of emissions, concentrations, or climate), and as is mentioned in the following sections, nor the document provides estimates on how much the costs of climate change would be reduced under a particular stabilization scenario, making it hard to determine what would be convenient for the country in terms of mitigation policy, which is the main issue the ECCM tries to address.[3]

2.2 Socioeconomic scenarios for 2008-2100

As in the case of climate variables, the projection of socioeconomic variables for long-term horizons such as the ones needed for the study of climate change impacts is undoubtedly a difficult enterprise that is beyond what common short-term statistical forecast methodologies can offer (see, for example, Nakicenovic et al., 2000). These projections are characterized by the presence of significant epistemic uncertainty and this is one of the main reasons for developing scenarios, which have shown to be an adequate tool for supporting decision-making under this type of uncertainty (Nakicenovic et al., 2000; Jefferson, 1983; Schwartz, 1991). Scenarios are not composed by a set of simple independent forecasts of some variables of interest nor are based on simply extrapolating current trends[4]. Scenarios are generally constructed as a set of internally consistent projections of interrelated variables that portray alternative images of what could occur in the future and, in most cases, are the result of the quantification of hypothetical paths of development or storylines. One of the most prominent examples of the construction of scenarios in climate change can be found in the Special Report on Emissions Scenarios (SRES) of the IPCC (Nakicenovic et al., 2000).

In the next paragraphs the methodology for constructing the socioeconomic scenarios in the ECCM is presented and discussed. As is shown below, none of the socioeconomic projections constructed for the ECCM display any of the desirable characteristics of scenarios. It is important to note that population and economic projections in the ECCM are independent from each other and are not consistent with the global and regional population, economic,

[3] As shown in the next sections, the answer to this question could be approximated if the A1B and B1 scenarios are interpreted as surrogate stabilization scenarios. If these scenarios are interpreted as proxies for stabilization scenarios, the main conclusions of the ECCM are completely reversed.
[4] Both of these approaches can lead to inconsistent results that do not correspond to, for example, any available economic growth theory (see, for example Nakicenovik et al., 2000).

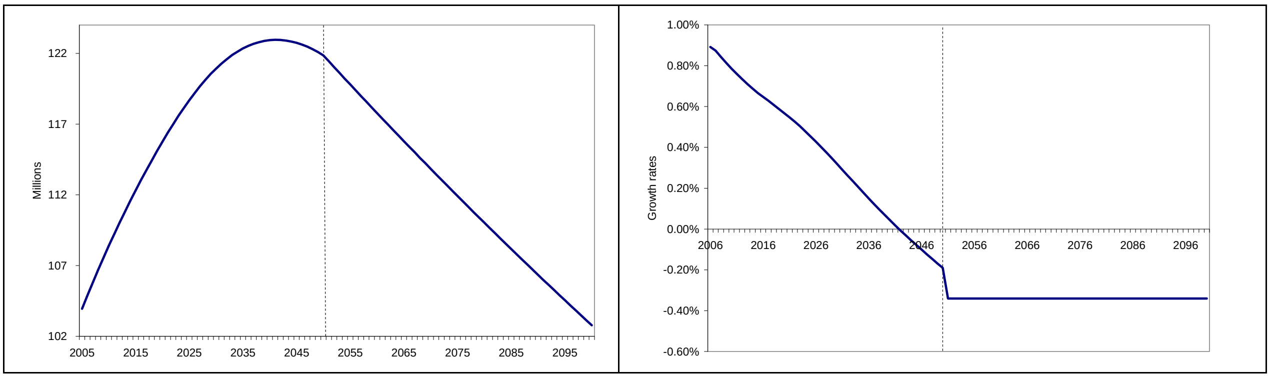
technology, energy and emissions scenarios used to construct climate change scenarios in the study (A2, A1B and B1).

2.2.1 Population projection

Population growth in the ECCM is based on one of the National Population Council (CONAPO) projections that is available for the period 2005-2050[5]. The ECCM extrapolated this projection to year 2100 using an arbitrary constant annual growth rate of -0.34%, which leads to a total population in 2100 similar to the one observed in 2004. This population projection is shown in Figure 1 panel a.

As can be seen from Figure 1 panel b, the CONAPO population projection shows annual rates of growth that decrease almost linearly from 0.89% in 2005 to -0.19% in 2050. Nevertheless, the ECCM extrapolation imposes a sudden and substantial decrease in the rate of growth of population (almost two times lower than the minimum value in the CONAPO projection) starting in 2051. No reason is offered in the ECCM to justify the use of this value, nor for explaining what it means in terms of population dynamics, fertility and mortality rates. This simple extrapolation breaks the internal consistency and the underlying demographic dynamics of the original CONAPO projection. As a result, the ECCM and CONAPO population projections in the ECCM are hardly consistent with each other.

Figure 1. ECCM's population projection for Mexico.
Panel a) shows the mean population and panel b) the population growth rates.



2.2.2 GDP projections

The ECCM uses two different approaches for generating GDP projections that are based on statistical techniques that would be more proper for short-term forecasting, if applied correctly.

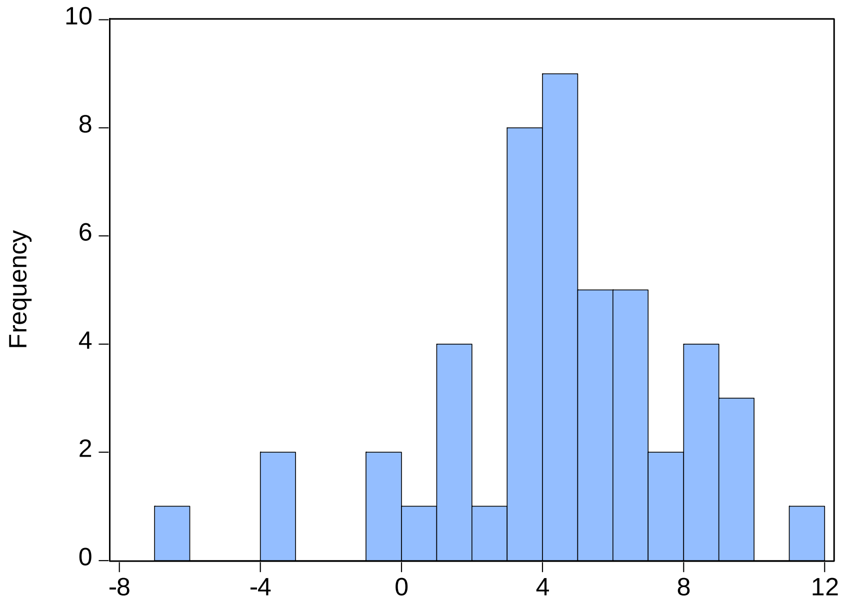
The first approach used for producing the GDP projections (national and by sector) consists in constructing a histogram using the observed time series of GDP rates of growth from 1960

[5] The methodological document for these population projections is available at http://www.conapo.gob.mx/00cifras/proy/Proy05-50.pdf

to 2007. In the ECCM it is stated that the rates of growth of the national GDP of Mexico and of its economic sectors follow trimodal frequency distributions. Again, no arguments are offered for supporting this claim.

There are neither theoretical reasons nor empirical evidence for assuming that all these rates should follow a trimodal distribution. As can be seen from Figure 2, for the same sample period the national GDP growth rates are clearly unimodal with a mode of 4.46. When constructing the histograms in the ECCM, the GDP growth rates (national and sector level) were arbitrarily forced into only three bins (less than 2%; between 2% and 5%; more than 5%) and were erroneously interpreted as "trimodal distributions". These projections are based on conceptual errors on how to construct and to interpret a histogram. Most introductory statistical textbooks warn about this type of misconceptions and provide guidance regarding the proper use and limitations of descriptive statistical plots such as the histogram (see, for example, Newbold, 1994). Besides, there are other major problems regarding this approach for generating GDP scenarios such as stationarity and the fact that relative frequencies can be interpreted as probabilities only under certain conditions. These conditions are not fulfilled by the GDP time series analyzed in the ECCM.

Figure 2. Histogram of national GDP growth rates for the period



As it is mentioned in the ECCM, a structural change occurred around 1982 that led to lower and more volatile growth rates of the Mexican economy. This structural change responds mainly to changes in the national and international macroeconomic context including the breakdown of the Import-Substitution Industrialization model and Mexico joining the economic globalization process, the oil boom and crises of the 1970-80's as well as the rapid increase of Mexico's public debt. The economic growth process in Mexico is different before and after the 1982 structural change and cannot be considered as being produced by the same data generating process, as was done in the ECCM. Producing forecasts (or scenarios) by means of interpreting a histogram as a probability density function of these non-stationary time series is clearly inadequate from a statistical point of view, incorrect from an economic analysis perspective, and useless for any practical application. These results are a statistical artifact: the "probabilities" of higher or lower growth rates will artificially depend on, for example, on the pre- and post-break sub-sample size, and do not reflect in any way the probabilities of the true data generating process nor the economic processes behind them.

In addition, even if the GDP growth rates were stationary, interpreting the relative frequencies as probabilities with a sample of 48 observations is rather problematic (see, for example, Jaynes, 2003, 1957), and more so for trying to produce 100 year projections. This type of statistical modeling is descriptive and cannot represent the dynamics of economic growth nor is it based on possible scenarios regarding the evolution of its main drivers such as capital, population and technology, for example. Furthermore, as noted in the ECCM, given that these scenarios were produced independently from each other, there is no consistency between the GDP projections of the different economic sectors.

The second approach consists in estimating a simple, small-scale econometric model based on national and sector GDP which are estimated simultaneously.[6] This small-scale model, estimated using a sample of only 28 observations, is then used for forecasting almost a century of GDP evolution. For this purpose, the following assumptions were made regarding the evolution of the exogenous variables included in the GDP models for the period 2008-2100: the relative prices of energy and fuels will remain constant; the capital stock will increase at an annual constant rate of 4.5%; employment will increase at 1.5% annually; the exchange rate peso/dollar will increase 0.5% annually. Although these long-term projections are completely determined by these assumptions, no justification is offered on why these rates of growth were chosen. Under this set of assumptions, the mean rate of growth of the national GDP for the period 2008-2100 is estimated to be 3.5% and this is the final baseline scenario for the ECCM. No evidence is presented regarding the statistical adequacy, validity or forecasting performance of models.

While this type of modeling has proven useful for short-term prediction, it lacks of sufficient economic theory for trying to represent the evolution of the Mexican economy over such a long horizon. Again, most statistical and forecast textbooks warn about the use of time series models based on a very small sample and with many parameters to be estimated to produce even short-term forecasts (Diebold, 2007; Gujarati, 2002; Greene, 2008; Pindyck and Rubinfeld, 1998). Producing 100 years GDP projection is undoubtedly a task for which these models are not intended for. In such long-term economic projections, parameter instability in any statistical model and the occurrence of structural changes in the economy are undoubtedly expected to occur.

[6] In the ECCM (SEMARNAT and SHCP, 2010), the interested reader is referred to the corresponding annex for a complete description of the econometric model. Unfortunately such annex is missing from the document.

This is one of the reasons why the IPCC produced the SRES, which includes sets of scenarios regarding the evolution of emissions and their driving factors such as demographic, economic, technological, and energy consumption and supply, as well as their interactions. The SRES scenarios are neither simple extrapolations of current trends nor the product of statistical forecast models, instead they are based on four different and contrasting development storylines which explicitly include structural changes and they are designed to be internally consistent. These theoretical global and regional development paths were used to produce four families of scenarios (A1, A2, B1, B2) and then they were quantified using integrated assessment models from different modeling groups around the world. The spatial resolution of the original SRES scenarios has been improved and currently country level and 0.5ºx0.5º scenarios are available (Grübler et al., 2007).

As in the case of the statistical climate change scenarios based on ARIMA models mentioned above, both approaches for generating GDP scenarios are questionable. How can these projections (and the assumptions about their forcing factors) be valid under, and consistent with, the different global and regional emissions, climate, socioeconomic and technological IPCC scenarios used in the ECCM (A2, A1B, B1)? What does assuming constant relative prices of energy and fuels imply for resources availability and technology development and penetration? How can the assumptions in the ECCM be consistent with global and regional development scenarios? How can Mexico's scenarios be independent from global and regional economic, technological and demographic scenarios?

2.2.3 Are the ECCM socioeconomic projections consistent with the SRES scenarios used for generating the climate change scenarios in the ECCM?

As mentioned before, the SRES scenarios represent *divergent* global and regional development paths, yet in the ECCM there is only one set of independent GDP and population growth projections to be used in conjunction with the A2, A1B and B1 emissions and climate scenarios.[7] The SRES (Nakicenovic et al., 2000, page 316) recommends that, in order to avoid internal inconsistencies, the components of SRES scenarios should not be mixed, for example, population and economic development from different scenarios (and/or families) should not be combined, nor emissions with driving forces from different scenarios. It is clear that the use of only one set of socioeconomic scenario (which is independent from any SRES scenario) mixed with the A2, A1B and B1 ensures that internal inconsistencies are to be expected.

As shown in the next paragraphs, the occurrence of such inconsistencies follows directly from the description of the three SRES scenarios used in the ECCM and the ECCM socioeconomic scenarios. The SRES scenario families (A1, A2, B1, B2) represent four different demographic, social, economic, technological, and environmental development paths that

[7] Not only the ECCM's GDP and population projections are independent from one another, but are independent from any regional and global development paths (including GDP, population and technology, for example).

diverge in increasingly irreversible ways (Nakicenovic et al., 2000). The four families of the SRES are divided by two divergent trends: globalization (A1, B1) or regionalization (A2, B2) in development; and emphasis on economic (A1, A2) or environmental (B1, B2) values.

According to the SRES, the A1 family represents a world with very rapid economic growth with a global population that peaks in mid-century and then starts declining. The storyline used for the A1 family implies a high level of economic convergence between regions and significant investments in research and development that lead to the rapid introduction of new and more efficient technologies. Energy intensity improves considerably and technological progress permits to increase mineral and energy resources availability. These scenarios assume a drastic decrease in energy production costs. The A1B scenario is the marker scenario of this family and represents a balanced mix of fossil and non-fossil energy sources and includes large technological changes. Also, a significant diversification of energy sources occurs leading to a considerable decarbonization of the economy and to an increase in the participation of renewable/nuclear energy sources in the primary energy structure.

The A2 family portrays a "very heterogeneous world with a continuously increasing population and regionally oriented economic growth that is more fragmented and slower than in other storylines" (Nakicenovic et al., 2000). This family represents the upper bound with respect to population growth in the SRES, showing a continuous increase over the century. In this family, regional income convergence is very slow and technological change is lower in comparison with the A1 and B1 scenarios. The energy mix is highly dependent on resources availability in each region, and the global economy evolves from being highly dependent on oil to highly dependent on carbon, with a small increase in renewable and alternative energy sources.

The B1 family shares the population growth of the A1 family but describes "rapid changes in economic structures toward a service and information economy, with reductions in material intensity, and the introduction of clean and resource-efficient technologies" (Nakicenovic et al., 2000). This family assumes regional income, technological and educational convergence and high economic growth. Significant investments on research, development and diffusion of new technologies produce a smooth transition from an economy based on oil and gas to one based on non-fossil and cleaner technologies.

Considering the very different worlds these scenario families describe, it is clear that the GDP and population projections in the ECCM cannot be consistent with all of them. Furthermore, there is no reason for the ECCM projections to be consistent with any of the SRES since they were constructed independently and do not consider any information regarding possible regional or global development paths. Also, the set of assumptions (constant relative prices of energy and fuels; annual increase of capital of 4.5%; annual increase in employment of 1.5%; exchange rate peso/dollar will increase 0.5% annually) used for projecting GDP growth rates can hardly be considered as consistent with all (or any, as a matter of fact) of the SRES scenarios. The assumption of constant relative prices of energy and fuels is for sure not consistent with any of them: all SRES scenarios include different evolution of energy sources availability and a great deal of technological change that leads to changes in the global and regional economies from being dominantly based on oil and gas to other sources like coal or alternative cleaner energy sources. Changes in technology and energy sources availability would not permit relative prices to be constant over this century. Capital accumulation, employment and exchange rates depend, for example, on the macroeconomic, technological and demographic context, and the type of global and regional development. As such, it is not consistent to use the same set of assumptions for GDP projection under different SRES scenarios, as was done in the ECCM.

Figure 3 shows the SRES B1 and A2r GDP (panel a) and population (panel b) scenarios downscaled to country level (Grübler et al., 2007) and the ECCM projections.[8] As can be seen, the downscaled SRES scenarios for Mexico follow the basic general development pathways described above: the B1 leads to a low-population/high-GDP while the A2r to an increasing population over the present century and a slower economic development.

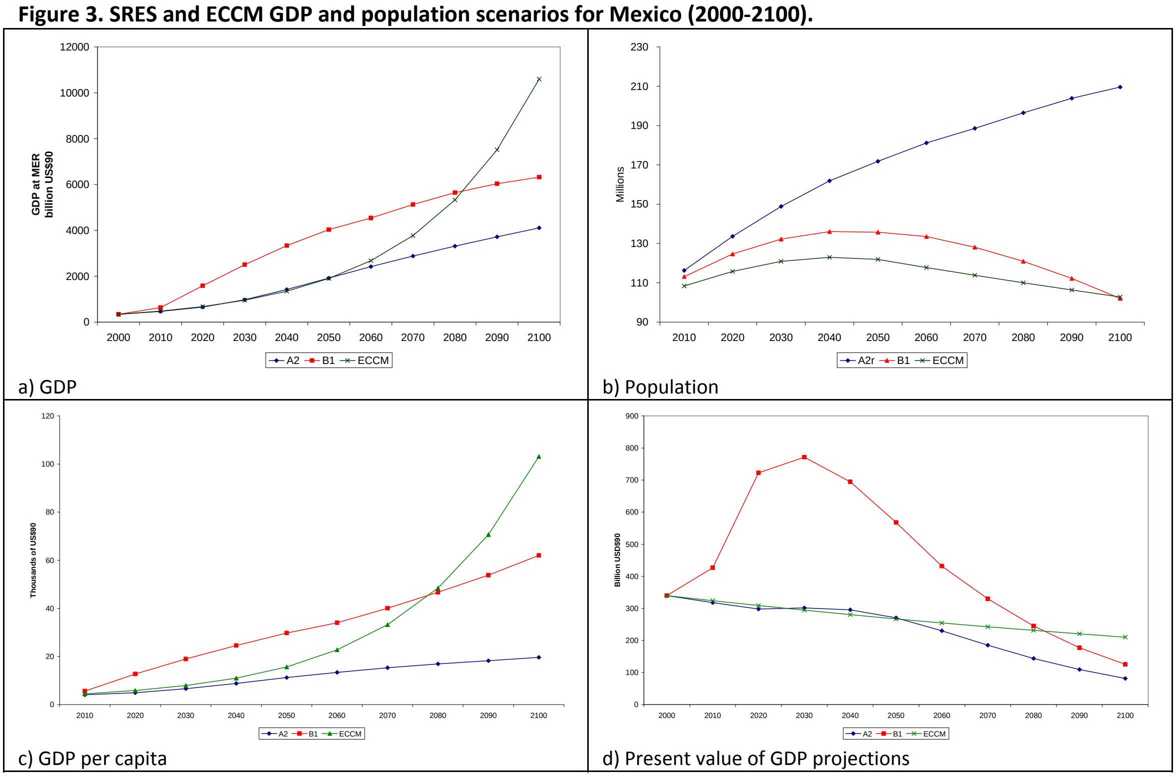
Note that the ECCM population projection is considerable lower for most of the century than the B1, which represents the lowest population projection included in the SRES. Nevertheless, they show a somewhat similar growth pattern: population peaks at the middle of the century and then starts decreasing. On the other hand, under the A2r scenario, population increases continuously over the century leading in 2100 to almost two times the population in the B1 and ECCM projections. This is a good example of the large contrasts between the different worlds portrayed by the SRES scenarios, and of why using a single set of projections in combination with different SRES scenarios (as was done in the ECCM) cannot lead to consistent results.

Figure 3 panel a shows the GDP projections for Mexico according to the SRES B1 and A2 and to ECCM. It can be seen that the economic growth projected by the ECCM is very different from the SRES scenarios trajectories. Both B1 and A2 scenarios show higher rates of growth in the first three to four decades and then economic growth slows down, which is a characteristic feature of economic development that has been observed: "economic growth is ceteris paribus higher for economies further away from the productivity frontier than for countries close to it" (Grübler et al., 2007, Barro and Sala-i-Martin, 2003). Economic growth rates are dependent on the stage of development. As such, developing countries show higher rates of growth and when they achieve industrialization, growth rates start to decrease and then in the post-industrialization stage these rates stabilize around a much lower value.

[8] The ECCM GDP projection was constructed using an annual 3.5% growth rate and the year 2000 GDP value for Mexico in Grübler et al. (2007). For this analysis we do not consider the A1 scenario family. According to Grübler et al. (2007), the A1 and B1 families are so similar in terms of population and GDP growth that the A1 can be very well approximated by the B1.

On the other hand, the ECCM projection is much more simple. This projection is based on exponential growth implying a slowly increasing GDP in the first half of the century similar to the A2 scenario and then shows a rapid increase for the second part of it, leading to GDP values higher than any of the SRES scenarios. Note that the mean GDP growth rate for the B1 and A2 scenarios is 3% and 2.5% respectively, much lower than the one used in the ECCM (3.5%). The mean growth rate of GDP per capita in the ECCM (3.6%) is twice as large as the growth rate in the A2 (1.8%) and 31% higher than the B1 growth rate (2.8%). By the end of the century, the ECCM GDP projection is about 70% larger than in the B1 and GDP per capita is also 66% larger (See Figure 3 panel c). It is worth remembering that the B1 (and A1) scenarios represent the upper bound of economic growth in the SRES. Also notice that economic development is very different under the B1 and ECCM projections. Consider for example Figure 3 panel d. This figure shows the present value of GDP for the A2, B1 and ECCM projections using a 4% discount rate, which is the same rate used in the ECCM. From this figure it can be seen that for almost any sequence of percentage of GDP lost as consequence of climate change that could be applied to both the B1 and ECCM projections, the present value of impacts will be noticeably lower in the ECCM. The valuation of the costs of climate change is very sensitive not only to the rate of growth that is imposed but also to the trajectory that the projection describes.

Figure 3. SRES and ECCM GDP and population scenarios for Mexico (2000-2100).



2.3 An analysis of the ECCM results.

In this section the main results of the ECCM are revised and it is shown that:

If the estimates of the impacts of climate change for Mexico presented in the ECCM were correct, the economic burden would not constitute an unprecedented shock to the Mexican economy; indeed it would be comparable to current GDP variability;

If the estimates in the ECCM were correct, the main conclusion of the ECCM (that Mexico should adopt strong mitigation actions) is not supported;

About 72% of the costs of climate change in the ECCM are insensitive to changes in climate variables, suggesting that these costs reflect something else than climate change;

It becomes apparent that the estimates of the costs of climate change in the ECCM are not consistent with previous studies;

The ECCM should be revised and should not be used for supporting decision-making until then.

2.3.1 Is ECCM consistent with previous estimates?

According to the ECCM estimates, is "climate change, if left unmanaged, a severe or insuperable challenge" to Mexico's growth and poverty reduction goals? Are the ECCM estimates consistent with previous estimates?

Table 1 presents the accumulated costs of climate change over this century for Mexico estimated in the ECCM, using a 4% consumption discount rate. In the ECCM results are also presented using two other discount rates: 0.5% and 2%. A 4% discount rate is low for an emerging economy. The ECCM scenario has GDP growing by 3.5% on average and population falling, producing a 3.6% per capita growth rate. Consider the Ramsey equation (Ramsey, 1928):

$$r = \delta + \eta g$$

where r is the discount rate; δ is the rate of pure time preference; η is the elasticity of the marginal utility of consumption; and g is the growth rate of per capita consumption. The growth rate of per capita consumption in the ECCM is 3.6%. If η=2, as suggested by some authors (see, for example, Dasgupta, 2006; Weitzman 2007), then a 4% consumption discount rate thus implies a pure rate of time preference of -3.1%. That is, future utility is deemed more important than current utility, a position that is defended by few philosophers (Davidson, 2006; see Broome, 1992, for a more widely accepted position) and that is at odds with observations (Frederick et al., 2002).

The ECCM emphasizes the results obtained using a 4% discount rate and the average of the A1B, A2 and B1 scenarios, although as discussed above, each of them describe very different worlds and taking an average of them is possibly meaningless. In this manner, the ECCM estimates the total accumulated costs of unabated climate change over this century to be equivalent to 6.2% of Mexico's current GDP (SEMARNAT and SHCP, 2009, page 65). It is important to notice that the ECCM results provide only point estimates and ignore their uncertainty.

Are these economic impacts something unprecedented for the Mexican economy that could compromise its growth over this century? Putting this figure into the context of the variability of the Mexican economy, one realizes that, according to the ECCM, the cost of all accumulated climate change impacts during this century would be smaller than the costs of the 2008-2009 crisis and would be comparable to those of other economic crises that have occurred in Mexico over the last 30 years. Consequently, the economic impacts of climate change would not represent an unprecedented shock to the Mexican economy, instead they would be similar to current GDP variability. As a matter of fact, during the last 30 years Mexico has experienced economic crises that would amount to several times all the estimated accumulated costs of unabated climate change during this century.

Thus, if the estimates of the ECCM were correct, then climate change should not be considered such a catastrophic phenomenon and such an enormous concern for the country. Of course, this is in stark contrast with the size of the potential impacts that have been obtained from the impact assessments studies that are available for Mexico (see, for example, Conde et al., 2011; Gay, 2000).

Furthermore, contrasting this figure with some of the global and regional estimates of the costs of climate change that are available (see Table 1 in Tol (2009) for a summary of the potential impact of climate change in GDP and the original papers of Frankhauser, 1995; Tol, 2009, 2002 a and b, 1995; Nordhaus and Boyer, 2000; Nordhaus, 1991; Plambeck and Hope 1996; Hope, 2006; Stern, 2006; among others) Mexico's vulnerability would be remarkably low in comparison with other countries of similar characteristics and even with the mean global estimates. In particular, the ECCM results are remarkably low in comparison with those of the Stern Review (SR). According to the SR, unabated climate change would be equivalent to loosing between 5% and 20% of global GDP each year and the developing countries will suffer even higher costs.

For the ECCM estimates to be consistent with the SR, the costs of climate change should be at least as large as the global average, taking into account that Mexico is a developing country. Using a 3.5% GDP growth rate and a 4% discount rate, the present value of the accumulated costs of climate change over this century in the ECCM (estimated in 6.2% of current GDP) would be equivalent to loosing 0.08% each year, which compared to the SR global estimates is insignificant. Conversely, loosing between 5% and 20% each year during this century would be equivalent to a present value ranging form 4.0 to 16 *times* current GDP. Clearly, the ECCM results cannot be considered to be consistent with the estimates presented in the SR. Furthermore, consider an impact function of the form

$$WI_{t,d,r} = \left(\Delta T_{t,r} / 2.5\right)^{POW} W_{d,r} GDP_{t,r} \qquad (1)$$

where $WI_{t,d,r}$ represents the economic impacts in time *t*, in the sector *d* (*d=1,2*; representing the economic and the noneconomic sectors, respectively) and in region *r*; $\Delta T_{t,r}$

is the increment in regional temperature with respect to its preindustrial value; POW is the exponent that determines the functional form of the impact function; and $W_{d,r}$ are regional multipliers to express the percentage of GDP lost for a benchmark warming of 2.5°C in each impact sector and region. These impact functions are very similar to those of the PAGE2002 (which was used in the SR to produce the estimates of the costs of global warming), except that it does not include the impacts associated to large-scale discontinuities. All parameters are represented as triangular probability distributions parameterized for Latin America as shown in Hope (2006), and the increase in regional temperature at the end of the century is represented by an uniform distribution covering a range from 2.5ºC to 4ºC (this is the range of increase in temperature for Mexico under the A2 scenario according to the ECCM). Temperature is assumed to increase linearly. Assuming that the Latin America parameters in Hope (2006) are representative for Mexico and conducting a simulation experiment of 1,000 realizations, the 5 and 95 percentiles of the accumulated costs of climate change are estimated to be equivalent to 38% and 160%, respectively[9], of Mexico's current GDP, with a mean value of 93% (using a 4% discount rate). This mean value represents about 15 times all the accumulated costs of climate change for Mexico estimated in the ECCM, while the 5 and 95 percentiles represent between 6 and 25 times the ECCM estimate. Evidently, these results portray very different futures and risk levels for the country and very different conclusions regarding decision- and policy-making might be optimal in each case.

Furthermore, even if the parameters in equation (1) are set to the impact values that correspond to the European Union, which is assumed in the PAGE2002 to be considerably less vulnerable than Latin America, the accumulated cost would be about 8 times larger in average than the ECCM estimate for Mexico, and between 4 and 13 times considering the 5 and 95 percentiles. As such, according to the ECCM Mexico's vulnerability to climate change would be so low that the country would suffer a small fraction of the economic impacts that could be expected for Europe. Therefore, the ECCM is not consistent with the SR results, having severely underestimated the economic impacts of climate change for Mexico.

Another integrated assessment models that have been used extensively for assessing the economic costs of climate change are the DICE model, and its regional version, the RICE model (Nordhaus and Boyer, 2000). Using the RICE99 impact functions as shown in Warren et al. (2006) and the "best estimate" value of 3.4ºC increase in global temperature for 2100 under the A2 emissions scenario (IPCC, 2007a), the economic costs of climate change for Mexico (classified in the Lower-Middle Income countries) would be equivalent to 99% of the country's current GDP, using a 4% discount rate. This figure represents 16 times the ECCM estimate. Again, even using the parameterizations of the impact functions for less vulnerable regions such as "Middle Income" and the world's average, the accumulated costs of climate change over this century would be equivalent to 14 and 6 times the ECCM estimate,

[9] These figures are equivalent to an annual loss of between 0.48% and 2.01%, while as mentioned above, the ECCM estimate represents an annual loss of only 0.078%

respectively. In this way, the ECCM estimate is so low that it is also not consistent with what can be obtained with the DICE/RICE99 model.

Table 1 in Tol (2009) shows the estimates of the welfare impact of climate change as an equivalent income gain or loss in percent GDP for different benchmark warmings ranging from 1ºC to 3ºC. It is important to notice that these estimates _do not_ represent the accumulated present value of the impacts of climate change during this century, but only the estimates of the welfare that would be lost for a certain increase in global temperatures. According to those estimates, for a warming of 2.5ºC South America would suffer damages equivalent to a 14.6% fall in income. This estimated loss is larger than those projected for the region by Hope (2006) and Nordhaus and Boyer (2000) using the PAGE and RICE models for a similar warming benchmark. If this benchmark estimate was used for approximating the present value of all accumulated costs of climate change for this region over this century, it would presumably amount to several times the ECCM estimate.

These severe differences in what climate change could imply for Mexico's economy stress the importance of revising the ECCM in order to avoid misinforming national decision-making.

Table 1 Accumulated costs of climate change over this century for Mexico. Modified from SEMARNAT and SHCP, 2009; SEMARNAT and SHCP, 2010

Scenario/ Sector	B1	A1B	A2	Average Scenario	Percentage of total costs
Agriculture	1.35%	1.91%	1.74%	1.67%	26.85%
Water	4.50%	4.50%	4.50%	4.50%	72.35%
Land use	-0.02%	-0.02%	-0.01%	-0.02%	-0.32%
Biodiversity	0.02%	0.05%	0.06%	0.04%	0.64%
Inbound tourism	0.02%	0.03%	0.03%	0.02%	0.32%
Total	5.86%	6.48%	6.32%	6.22%	100.00%

2.3.2 What do the ECCM cost estimates imply for the different sectors and for policy-making?

The last column of Table 1 shows the percentage of the total accumulated costs that each sector represents with respect to the "average scenario" estimate. Water and agriculture represent 99.2% of the total accumulated costs of climate change over this century, while land use, biodiversity and inbound tourism amount to less than 1%, representing a total net loss of only 0.04% of current GDP.

As can be seen from this column, the largest contribution to the accumulated costs of climate change over this century comes from the water sector, representing about 72% of the total accumulated costs. The economic valuation of the costs of climate change in the water sector is based on the difference between the costs of satisfying water demand under climate change conditions and the costs of satisfying water demand under a baseline scenario. The baseline scenario for water demand was estimated by means of econometric models using population, GDP and relative prices of water as independent variables. These variables were projected by means of forecasts from ARIMA models for a horizon of almost a century. Of course, these projections are also subject to the critiques discussed in the previous section. The estimates of how a temperature rise would impact water demand are based on cross-section econometric models.

What becomes apparent from Table 1 is that the accumulated costs of climate change in the water sector are insensitive to changes in climate variables, representing the 4.50% of Mexico's current GDP no matter which emission scenario is used (A1B, A2, B1). That is, although the A1B, A2 and B1 scenarios entail quite different changes in climate variables, the economic costs for this sector do not vary.

Interpreting B1 as a surrogate stabilization scenario (Swart et al., 2002; IPCC, 2007b), it is clear that the majority (72%) of the costs of climate change for Mexico would not be reduced at all even under a 550 ppm stabilization scenario (as approximated by the SRES B1): contrary to the ECCM's main policy recommendation, according to these estimates, assuming mitigation actions and participating in international mitigation efforts would not help reducing these costs at all. The insensitiveness to changes in climate variables suggests that the costs associated to the water sector may reflect something else than climate change. If these costs are not related to climate variables or to climate change, then what do they represent? Unfortunately the description of the methodology used in the ECCM is too limited to identify possible errors that could have led to these results. Another possible explanation could be that the costs were estimated only for one emissions scenario and were considered to be valid for the other two emissions scenarios. If this is the case, it was certainly a poor decision because it renders useless any comparison regarding the total costs associated to different emissions scenarios, particularly considering that this sector represents more than 70% of all costs of climate change.

According to Table 1, climate change would represent net benefits for the land use sector, being particularly favorable for forests and rain forests. The modeling was done by means of Markov chains based on an observed transition matrix for the baseline scenario and a modified transition matrix that is assumed to reflect the effect of climate change on land use. The probabilities of this second transition matrix were estimated using logistic regressions using as explanatory variables state level GDP, temperature and precipitation and the shares of state area devoted to each of the different formations.

The ECCM offers mainly two justifications for supporting the statement that climate change would be beneficial for forest and rain forest areas: 1) it is assumed that a decrease in deforestation of forest and rain forest areas (in comparison to the baseline) will occur due to a significant reduction in agricultural productivity caused by climate change. Such a decrease in agricultural productivity is supposed to reduce the incentives for converting forest and rain forest areas to agricultural and livestock lands; 2) according to their results, changes in climate variables associated to climate change appear to provide more suitable conditions for forest and rain forest growth.

The reduction in deforestation of forest and rain forest areas is *assumed* to be caused by a reduction in agricultural productivity, but this is not a conclusion obtained from the model. Agricultural productivity is not an explanatory (nor a dependent) variable included in the model, and the ECCM results for the agricultural sector are independent of the estimations conducted for the land use sector.

Furthermore, according to the ECCM estimates, the area devoted to agricultural production is expected to increase (not to decrease) with climate change, indicating that there would be indeed incentives for extending agricultural area. In the ECCM it is argued that this result is not at odds with the projected reduction in deforestation due to climate change, because agricultural expansion would occur in other areas that would be severely affected by climate change. These areas are currently occupied by other formations such as natural grasslands, palm tree, halophilic, gypsophila vegetation and costal dunes, for which climate conditions would become too extreme[10]. This affirmation can hardly be supported since, for example, most of the soils associated to these types of formations are not suitable for agricultural production due to their salinity, among other factors. There are several factors besides climate that determine the aptitude of different areas for agriculture (as well as for any other land use) such as topography, slope, type of soil, altitude among many others (see for example, Doria et al., 2006; Jones, 1986). These factors should be considered when projecting the aptitude for agricultural production of different regions under climate change conditions (see Monterroso et al., 2011 for an example of maize production in Mexico).

With respect to the ECCM's finding that climate change appears to provide more suitable conditions for forest and rain forest growth in Mexico, it contradicts the results obtained by previous studies that are grounded in biological and ecological concepts. According to these studies, the impacts of climate change on forest and rain forest in Mexico will cause strong reductions in the area suitable for these formations. For example, under climate change conditions, by 2050 almost 50% of the vegetation cover in Mexico is expected to change and large losses of forest and rain forest areas are projected (INE-SEMARNAT, 2007, Trejo et al., 2011; Gómez et al., 2011;Gay, 2000). That is, climate change is expected to contribute to the reduction of suitable areas for forest and rain forest in Mexico.

As has been discussed at length in the economic literature, the valuation of nature and its services is particularly challenging, usually leading to estimates that do not reflect its value and has proven to be ethically questionable (Ackerman, 2008; Martínez-Alier, 2001). Granting that this is undoubtedly a difficulty task, the estimates presented in the ECCM are nevertheless disturbing, particularly considering that Mexico is a megadiverse country. For example, the ECCM estimates that under the A2 scenario Mexico would lose 45% of its

[10] Would not these "too extreme" climate conditions be too extreme also for agriculture?

biodiversity and as can be seen from Table 1, the economic costs of losing almost half of Mexico's biodiversity are estimated to be equivalent to only 0.06% of the country's current GDP.

If these estimates are taken at face value, then Mexico's expenditure in environmental protection and more directly on biodiversity preservation are to be considered unjustifiable. During the 1990's decade the country spent on average 0.37%[11] of national annual GDP in environmental protection and in the 2000's decade this percentage increased to about 0.5%[12]; these annual figures represent, respectively, 6 and 8 times all the accumulated costs of climate change during this century in terms of losses in biodiversity. Furthermore, suppose that the government will continue to spend 0.5% of Mexico's annual GDP during this century in environmental protection and assume that only a small fraction, say 1%, of this figure goes directly to preservation of biodiversity. Using the same GDP growth and discount rates of the ECCM, Mexico would end up spending about 5.6 times more protecting biodiversity than what the ECCM values losing almost half of the country's biodiversity. If the ECCM estimates are reasonable, why should the country keep spending so much money on something it is worth so little?

A similar reasoning can be applied to the estimates of the costs associated to the agricultural sector presented in Table 1. Although in the ECCM it is argued that the impacts on agriculture would be severe, making it the second sector with the largest losses, all the impacts in this sector accumulated over the century are estimated to represent only 1.7% of current GDP.

It can be easily shown that this figure does not seem to reflect the importance that the agricultural sector has for the country. The Federal Government of Mexico has many assistance programs for supporting agricultural production, particularly small producers. PROCAMPO is one of the most important programs to which significant economic resources are devoted. In 2010, PROCAMPO's budget amounted to 0.2% of Mexico's GDP (SAGARPA, 2010). Using the same discount and GDP growth rates of the ECCM and assuming that the government will continue to dedicate the same fraction of annual GDP to PROCAMPO, all the accumulated costs of climate change during this century in the agricultural sector would be similar to what the government would spend over just ten years in PROCAMPO, which is just one of the social programs devoted to agricultural production. Now, if the government spends the same fraction of annual GDP in PROCAMPO each year during this century, the money that would be spent on it would be equivalent to *more than two times* the present value of the *total* accumulated costs of climate change for Mexico as estimated in the ECCM (including all sectors in Table 1).[13]

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[11] http://www2.ine.gob.mx/publicaciones/gacetas/245/roberto.html
[12] http://dgcnesyp.inegi.org.mx/cgi-win/bdieintsi.exe/Consultar
[13] The accumulated costs over this century of PROCAMPO would represent a present value of 13.52% of current GDP.

In addition, it is worth noticing some of the econometric modeling deficiencies in the agricultural sector analysis presented in the ECCM. For example, the ECCM (SEMARNAT and SHCP, 2010) presents a risk analysis of the agricultural sector based on GARCH type models for agricultural GDP and for maize yields. The two GARCH models that are shown for illustrating the importance of estimating the effects of volatility on agricultural activities are statistically inadequate due to a very basic error. As is well known, the coefficients of the conditional variance equation must be non-negative to ensure that the variance is non-negative with probability one (see, for example, Bollerslev, 1986). Nelson and Cao (1992) showed that these non-negative constraints can sometimes be relaxed, but for the case of GARCH(1,2), such as the one shown in the ECCM (SEMARNAT and SHCP, 2010, page 141), the first ARCH term must be greater than zero. This condition is not satisfied in the ECCM, given that this coefficient is negative. In the case of the TARCH model (SEMARNAT and SHCP, 2010 page 139), the first ARCH term is also negative, violating again the non-negative constraints. As a result, both models are unacceptable because they do not ensure the variances of these processes to be non-negative.

Finally, it is important to note that the ECCM provides recommendations for each sector with the aim of reducing the potential impacts of climate change. It is easy to see that, at least for the biodiversity and tourism sectors, the proposed adaptation actions (for example, strong investments on infrastructure) that it recommends are very likely to represent several times the costs of the impacts of climate change in these sectors.

2.3.3 Is the ECCM's main conclusion supported by its own figures?

The main conclusion of the ECCM is that all the accumulated costs over this century of unabated climate change (6.2% of Mexico's current GDP) are at least about three times larger than those of mitigation, which are estimated to be in the range of 0.7% to 2.2% of Mexico's current GDP. From this figures, the ECCM derives a policy recommendation for adopting significant mitigation actions (50% emissions reduction in 2100 with respect to 2002) and states that this represents an excellent public investment if an international stabilization agreement is achieved. First of all, it is worth noticing that the ECCM never specifies which stabilization agreement it is referring to (450, 550, 750 ppm or any other stabilization level). Furthermore, as mentioned before, the climate simulations used in the ECCM do not include any stabilization scenario nor it provides estimates on how much the costs of climate change would be reduced under a particular stabilization scenario, making it hard to determine what would be convenient for the country in terms of mitigation policy.

In addition, this policy recommendation is based on a serious misunderstanding of how to compare the costs and benefits of climate change: "clearly, the fact that the costs associated to the impacts of climate change are larger to those of mitigation processes is a sound reason to support an international agreement for reducing greenhouse gases" (SEMARNAT and SHCP, 2010 page 394). Evidently, this comparison of costs is not relevant for deciding whether adopting a mitigation effort is convenient for the country or not. Regardless of how large are the costs of climate change impacts with respect to those of mitigation, one cannot conclude in favor or against participating in a mitigation agreement based on this information. The quantities that should be compared are the benefits of an international mitigation agreement in terms of avoided impacts to the costs of participating in a particular international mitigation effort. Consequently, the argument on which the main policy recommendation of the ECCM is based on is unjustified.

Analyzing the results of the ECCM (Table 1) it can be easily shown that the main conclusion of the report can hardly be supported. The estimated accumulated costs of climate change during this century for Mexico (as a percentage of Mexico's current GDP) are 6.3%, 6.5% and 5.9% for the A2, A1B and B1, respectively. As such, the costs of climate change for the country seem to be highly insensitive to the very different emissions and atmospheric concentrations of GHG that each SRES scenario entail. This is mainly due to the fact that the costs from the water sector, which represent 72% of the total costs, are completely insensitive to different emissions/climate scenarios. As a result, no matter which emissions scenario is used, the accumulated costs would be around 6% of current GDP.

Although the SRES scenarios do not represent stabilization scenarios, it has been proposed that some of them can be used as substitutes for stabilization scenarios given their similarities in trajectories (Swart et al., 2002; IPCC, 2007b). Under this interpretation the B1 scenario can be used as a substitute for a 550 ppm stabilization scenario, which is considered as a possible goal for the international climate change negotiations.

Using this interpretation of the SRES scenarios, it is straightforward to show that the benefits for Mexico in terms of avoided impacts of a "550 ppm stabilization" scenario would be of only 0.4% of Mexico's current GDP, in comparison to the ECCM's inaction scenario. That is, the costs of climate change would not go to zero as would be needed for the ECCM's conclusion to be valid. Then, contrary to what is stated in the ECCM, under such stabilization target, investing in mitigation would not be economically justifiable because its costs would represent roughly between 2 and 6 times those of the avoided impacts. Evidently, this has strong implications for defining what the optimal mitigation policy for Mexico would be and reverses the main conclusion of the ECCM. If the ECCM is used for defining Mexico's position, then the most rational action for the country would be not to invest on mitigation even if an international stabilization agreement is achieved, but only on adaptation measures.

2.3.4 Further reasons for concern: Building of a regional view of the economics of climate change.

The ECCM has served as a model for estimating the costs of climate change in Central and Latin America (ECLAC, 2010a; ECLAC, 2010b; ECLAC, 2010c; ECLAC, 2009) and members of the ECCM team provided their assistance for producing these studies. As argued below, the results of these reports are building a regional view of what could be the economic consequences of climate change that seriously underestimates them and that in turn will misguide regional and national decision-making. As could be expected, the methodological approach and results can be as severely questioned as has been done in this paper with the ECCM's.

Table 2 presents the total accumulated costs of climate change during this century estimated for Central America and for Uruguay, Chile and Mexico (ECLAC, 2010a; ECLAC, 2010b; ECLAC, 2010c; ECLAC, 2009; SEMARNAT and SHCP, 2009). As can be seen from this table, the estimates of the accumulated costs of climate change over this century are comparable in magnitude to that of the ECCM. The largest economic costs would occur in Uruguay and Chile and the costs of climate change for Central America are surprisingly low, even though Central America has shown to be particularly vulnerable to climate and weather events (IPCC, 2007b). Using the corresponding GDP growth rates estimated in each of these studies and a 4% discount rate, the worst-off country in the region (Uruguay) would lose between 0.2% and 0.5% annually, which represents between 1/5 and 1/2 the mean annual loss that can be obtained for the region using equation (1) and about 1/6 the annual loss estimated using the RICE99 impact function. Furthermore, the worst-off country in Central America (Nicaragua) would lose 0.2% annually. All these estimates represent a small fraction of those that would be obtained using equation (1) and the RICE99 impact function. Again, none of these estimates are neither comparable nor consistent with the SR and other peer-reviewed estimates of the costs of climate change (see for example Tol, 2009 and the references therein).

Table 2. Total accumulated costs of climate change during this century estimated for Central America and for Uruguay, Chile and Mexico. A2 emission scenario. Figures represent the net present value as a percentage of 2008 GDP.

Country	Percentage of 2008 GDP	Country	Percentage of 2008 GDP
Belize	14.5	Uruguay	23.2 (50.2)
Costa Rica	7.17	Chile	33.38 (48.07)
El Salvador	7.16	Mexico	6.32 (7.86)
Guatemala	9.9		
Honduras	12.3		
Nicaragua	14.6		
Panama	5.7		
Central America	8.5		
Figures in parentheses represent the sum of direct and indirect accumulated costs of climate change over this century.			

Latin America, along with Africa and South Asia, is usually considered as one of the most vulnerable regions to climate change (IPCC, 2007b; Hope, 2006; Tol, 2009; Stern, 2006) and therefore, the worst economic impacts of climate change are expected to occur in such regions (in comparison to their own national GDP). Nevertheless, if the estimates of the accumulated costs of climate change during this century presented in Table 2 are interpreted correctly, climate change should not be considered such a catastrophic phenomenon for the region and, in consequence, for the world, contrary to what is concluded in the corresponding reports. Clearly the accumulated costs of climate change presented in tables 1 and 2 cannot represent the costs that are expected from what is considered to be the most important environmental problem that humankind will face in this century.

After carefully analyzing them, we believe that it is unfortunate that the results in tables 1 and 2 (and the incorrect interpretation that complements them in the corresponding reports) are used for guiding national decision-making. But what is even more worrying is that the sum of these studies, all of them supported by national and international agencies, is building a regional view of what climate change could imply for the region based on "grey literature" that has strong methodological and conceptual deficiencies. As stated in Estrada et al. (2011) given the influence that this type of documents can have on a wide variety of decision-makers and social agents, as well as for developing national and international public policy, their review process should be at least as rigorous as it is for scientific publications.

3. Conclusions

Climate change may be one the most important environmental problems that humankind will face in this century. It is larger, more complex and more uncertain than any other environmental problem and represents the largest market failure in the history of man (Tol, 2009; Stern, 2006). The climate projections for this century suggest that climate change will have significant impacts over resources that are closely related to human welfare in a way that could reduce considerably the economic growth perspectives of developing countries (Stern, 2006; IPCC, 2007b; Tol, 2009; Ackerman, 2008).

Climate change impact assessment studies have shown that Mexico and Latin America as a whole may be particularly vulnerable to this phenomenon, partly because of its geographical location and the associated changes in climate variables that can be expected to occur, and because the prevailing socioeconomic conditions and large inequalities regarding income distribution, access to educational and technical resources as well as to social assistance programs. The World Bank’s Global Convention for Risk Reduction (GFDRR, 2009) has estimated that approximately 71% of Mexico's GDP is exposed to the impacts of climate change.

In this paper it is shown that the ECCM fails to reflect the seriousness of the potential impacts of this phenomenon over the Mexican economy to the extent that the estimates of the costs of climate change are so low that they are not consistent with previous regional and global studies and are particularly at odds with the Stern Review, although this was the report which inspired the ECCM. According to the ECCM estimates, the total accumulated costs of climate change during this century for Mexico would be smaller than the 2008-2009 crisis and similar in magnitude to other economic crises that the country has faced in the last three decades. It is also shown that the ECCM has serious technical and conceptual deficiencies, making it not adequate to support national decision- and policy-making as it was intended to.

The ECCM main policy recommendation is based on a misunderstanding of what are the elements in a basic cost-benefit analysis. The costs of climate change impacts are misinterpreted as the benefits of participating in an international mitigation agreement and then compared to mitigation costs. This is clearly wrong since the comparison should be between the benefits of participating in such agreement would be the avoided impacts associated to a particular stabilization scenario and the costs of participating in such mitigation scenario.

Contrary to its main policy recommendation, the correct interpretation of the ECCM results indicates that participating in an international mitigation effort would not be economically justifiable because its costs could represent roughly between 2 and 6 times the benefits of the avoided impacts. Evidently, this has strong implications for defining what the optimal mitigation policy for Mexico would be and reverses the main conclusion of the ECCM. Moreover, it is rather disturbing the most important policy recommendation in one of the most relevant climate change national documents of Mexico is given so lightly, being based on a misunderstanding of basic concepts and that ends up not being supported even by their own estimates.

Similar results are found analyzing other reports regarding the economics of climate change in Central and Latin America that were inspired on the ECCM and for which members of the ECCM team provided their technical support. This raises further reasons for concern because these national documents are building a regional view of what climate change could imply for the Latin America that severely underestimates the importance of this phenomenon, at least in comparison with what has been published in the peer-reviewed literature.

The results in this paper and those in Estrada et al. (2011) point to the need of rethinking how national climate change documents are evaluated. These documents are meant to be some of the most prominent sources of information for supporting national decision making on issues that the government thinks are of prime importance, but paradoxically in most cases have no formal academic revision and do not go through a peer-review process. At the end, research results are offered for supporting decision making without being previously evaluated.

Instead, we believe that the review process for these documents should be at least as rigorous as it is for scientific publications and that the information that is being created should constantly revised and corrected when necessary. In addition, although climate change study is characterized by deep uncertainty, scarce information and in many cases limited scientific knowledge and methodologies, this by no means should be an excuse for relaxing academic standards particularly when research results aim to support decision-making. On the contrary, scientific and technical rigor should be the basis for creating scientific knowledge on which decision-making can rely.

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