A contribution to the study of the economic causes and consequences of climate change:

Estrada Porrua, F.

2015

15 *The Economics of Climate Change in Mexico*: Implications for National/Regional Policy

This chapter critically reviews the recent Mexican government study on 'the Economics of Climate Change in Mexico' (ECCM), which has largely influenced Mexico's stance on climate change issues and international negotiations. While recognizing the importance of such government-supported national studies as a first attempt to provide estimates on the anticipated costs of climate change, there is scope to strengthen the underlying analysis. We discuss how some of the key policy recommendations of ECCM are weakly supported by its analysis, point out methodological weaknesses of the report and indicate inconsistencies with the approach adopted in the Stern Review. Furthermore, we discuss how the estimated costs are likely to severely under-represent future climate change damages in the case of Mexico and deter drastic mitigation and adaptation efforts. New estimates of the costs of climate change are presented based on the impact functions of two Integrated Assessment Models.

15.1 Introduction

Climate change may turn into one of the most important environmental problems that humanity will face in this century (IPCC-WGI, 2007; IPCC-WGII, 2007; IPCC-WGIII, 2007; Stern, 2006). In addition, there is often a void of knowledge and tools for answering some of the most relevant questions this phenomenon poses and for interpreting the available information and managing the uncertainty (IPCC-WGI, 2007; IPCC-WGII, 2007; IPCC-WGIII, 2007; Ackerman, 2008; 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

This chapter was published as Estrada F, Papyrakis E, Tol RSJ, Gay-García C (2013) The economics of climate change in Mexico: implications for national/regional policy. Climate Policy 13(6), 738-750. DOI 10.1080/14693062.2013.813806

challenging and there has been serious questioning regarding the applicability of standard economic tools and theory (Ackerman, 2008; Martínez-Alier, 2001; Weitzman, 2010). Consequently, the methods and information that are developed should be carefully evaluated and regularly updated when necessary in the pursuit of sound scientific knowledge and well-informed decision-making.

Some of the most relevant sources of information for supporting decision-making are the national documents financed through different government agencies on issues considered of prime importance. These documents are part of what is typically called the "grey literature", often with less emphasis on scientific and technical rigor, limited academic recognition and a lack of quality control through a peer-review, particularly in the case of developing countries. In 2009 the Government of Mexico published the 'Economics of Climate Change in Mexico' report (SEMARNAT and SHCP, 2010; SEMARNAT and SHCP, 2009; hereafter ECCM) which was co-produced by Mexico's Ministries of Environment and Natural Resources (SEMARNAT) and Finance (SHCP) and co-funded by the UK Department for International Development and the Inter-American Development Bank. It is also acknowledged in the document that the study benefited from the support of members of the original Stern Review team.

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". 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 also that (mitigation) action 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, therefore, strong mitigation effort (with a halving of emissions by 2100 compared to 2002 levels) represents a sound public investment if an international stabilization agreement is achieved. In this paper we critically examine whether the estimates presented in the ECCM support these statements and conclusions.

Further reasons for concern arise due to the development of a regional perspective based on other national studies inspired by the ECCM (ECLAC, 2010a; ECLAC, 2010b; ECLAC, 2010c; ECLAC, 2009). The economic consequences of climate change in such documents are likely to be underestimated, potentially misguiding regional and national decision-making regarding the need for adopting adaptation and mitigation strategies.

We recognize the importance of such government-supported national studies as a first attempt to provide estimates on the anticipated costs of climate change (particularly given the current data, technical and methodological challenges) but we also believe that there is a need to strengthen the underlying analysis wherever inconsistencies are identified. Although our discussion focuses on the ECCM, the reflection we present can extend more broadly to other national documents (commissioned by government agencies) and in different policy domains. We make use of the ECCM report as our case study in order to highlight the broader need for strengthening the analysis of national climate documents (and hence ensuring they properly support national policy-making) – we hope that some of the suggestions we provide in terms of refining the ECCM analysis should also be relevant for improving many other national documents that attempt to measure welfare impacts and define the extent of optimal government intervention.

The remaining of this paper is structured as follows: Section 15.2 presents a critical evaluation of the climate change and economic scenarios generated for the ECCM. Section 15.3 analyzes the key results and conclusions in the ECCM. The accumulated costs of climate change in the ECCM are compared to the regional and global results that are available in the literature and to new estimates that were produced for this chapter using the impact functions of two of the most commonly used Integrated Assessment Models. The results of other Latin American national studies are also briefly discussed. Section 15.4 concludes.

15.2 A critical evaluation of the ECCM scenarios

15.2.1 Climate change scenarios (2008-2100)

According to the ECCM, two approaches were applied for generating climate change scenarios: one based on time-series forecast models and another based on the output of general circulation models and statistical downscaling techniques (Magaña, 2010). The latter set of scenarios is considered as the "most likely" in the report. Estrada et al. (2012a) brought attention to the methodological flaws associated with the statistical downscaling techniques that were applied for the ECCM and other national climate change documents of Mexico. This downscaling methodology replaces the physics embedded in the original scenarios produced by general circulation models with random spatial patterns and magnitudes of change that are not physically consistent[68].

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 following specifications 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 mentioned in any other part of the ECCM report and most of the analysis presented in the document relies on monthly or seasonal (not annual) temperature and precipitation projections. Accordingly, these scenarios are not discussed here.

The time-series approach of the ECCM is based on fitting ARIMA models to temperature/precipitation series in order to produce forecasts for almost a 100-year horizon. Although the time-series analysis of climate variables is useful for understanding their evolution and how climate change has affected them (e.g., Gay et al., 2009), using ARIMA models for producing such long-range forecasts might not be the best methodological means for a "conservative baseline trajectory to analyze the impacts of climate change in Mexico" as was intended in the ECCM (SEMARNAT and SHCP, 2009, page 15). There are strong theoretical and empirical reasons that make

[68] These scenarios will not be discussed further here and the reader is referred to Estrada et al. (2012; 2013).

time-series models unsuitable for such long-term forecasts, particularly in the case of non-stationary series (Diebold, 2007; Pindyck, and Rubinfeld, 1998). Furthermore, the change in temperature and precipitation variables under climate change also depends on the future evolution of external forcing factors and this information is clearly missing from the ECCM's time-series models.

15.2.2 GDP scenarios (2008-2100)

GDP projections are of particular interest, given that some of the metrics used for expressing the costs of climate change directly depend on the rate of growth. The metric used by ECCM expresses the present value of all accumulated costs during this century as a share of GDP in the initial year. This metric is highly dependent on the growth rate because: 1) the impacts are scaled by the growth of the economy (or sector) and therefore are larger/smaller for higher/lower growth rates and, 2) the present value of all accumulated costs over the century is divided by a fixed quantity (base year GDP) that will be comparatively smaller for higher growth rates.

ECCM uses two approaches for generating GDP projections that are based on statistical techniques that would be, though, more appropriate for descriptive purposes or short-term forecasting:

1) Use of histograms of the observed time series of GDP growth rates (1960-2007) for constructing future GDP projections (national and by sector). ECCM states that the rates of growth of the national GDP and of its economic sectors follow trimodal frequency distributions, although there is no explicit justification (in terms of theoretical reasons or empirical evidence) provided for this choice. We show in Figure 15.1 that the national GDP growth rates are clearly unimodal (mode value of 4.46). When constructing the histograms in the ECCM, the GDP growth rates were arbitrarily forced into three bins (less than 2%; between 2% and 5%; more than 5%) and were erroneously interpreted as "trimodal probability distributions" (see Newbold (1994) for a discussion on conceptual errors associated with interpretations of histograms). On this basis, the ECCM argues that the "average long-term growth rate would be 3.5% with a 60% probability range" (SEMARNAT and SHCP, 2009, page 19). As mentioned in the ECCM, a structural

change occurred around 1982 that subsequently led to lower and more volatile growth rates of the Mexican economy. Producing forecasts (or scenarios) by means of interpreting a histogram as a probability density function of these non-stationary time series is problematic both from a statistical point of view, as well as from an economic analysis perspective, limiting hence its practical application. These forecasts are likely to be a statistical artifact: the "probabilities" of higher/lower growth rates will depend, for example, on the pre- and post-break sub-sample size, and will neither reflect the probabilities of the true data generating process nor the economic processes behind them.

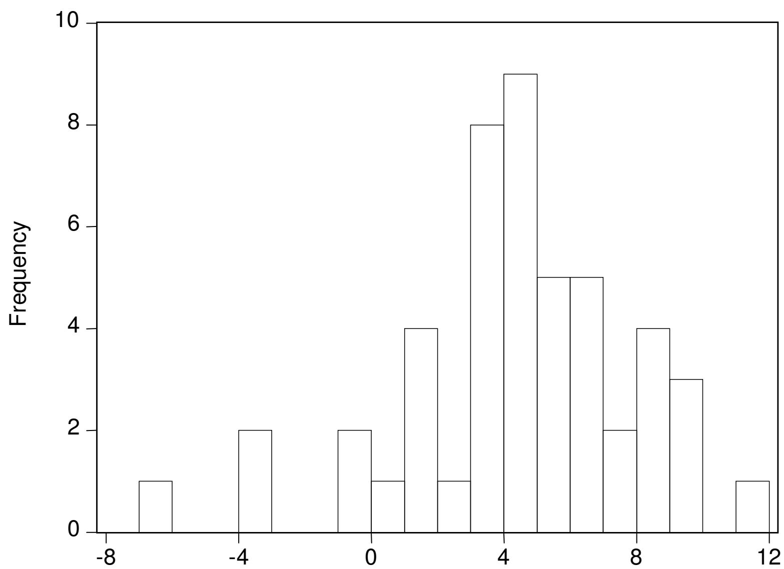

Figure 15.1. Histogram of national GDP growth rates for the period 1960-2007

2) In addition, the ECCM uses a small-scale econometric model for national and sectoral GDP. This simultaneous equation model, estimated using a sample of only 28 observations, is applied for forecasting almost a century of GDP evolution (SEMARNAT and SHCP, 2010, pages 68-69). The following assumptions were made regarding the evolution of the exogenous variables for the period 2008-2100: constant relative prices of energy and fuels; annual growth rates of 4.5% and 1.5% for the capital stock and employment respectively; annual increase of 0.5% of the peso/dollar exchange rate. It is important that the choice of these assumptions that determine long-term GDP projections would have been explicitly justified. Similarly, evidence on the validity, statistical adequacy and forecasting performance of the models would have

been explicitly spelled out. Furthermore, the use of time-series models based on such a small sample and with several parameters to be estimated is known to be problematic even for short-term forecasts (e.g., Diebold, 2007; Pindyck and Rubinfeld, 1998).

As in the case of climate variables, the projection of socioeconomic variables for long-term horizons is undoubtedly a difficult task beyond what common short-term statistical forecast methodologies can offer (Nakicenovic et al., 2000). Several alternative methodologies (e.g., theoretical-empirical growth models) have been discussed in the literature (IPCC-WGIII, 2007, chapter 2) and alternative options are readily available at country and sub-country levels (e.g., Grübler et al., 2007).

15.3 A critical evaluation of the findings in the ECCM report

15.3.1 Consistency of ECCM results with other studies

The ECCM provides estimates of the accumulated costs of climate change over this century for Mexico using three different discount rates (0.5%, 2% and 4%). The estimates based on the 4% discount rate are chosen for supporting the ECCM's main conclusions (SEMARNAT and SHCP, 2009, pages 55-56). Following the ECCM, we will mainly discuss these latter estimates. Nonetheless, the arguments we put forward hold irrespective of the discount rate chosen.

Table 15.1 presents the accumulated costs of climate change over this century for Mexico estimated in the ECCM (4% discount rate). The ECCM estimates the total accumulated costs of unabated climate change over this century to be equivalent to 6.22% of Mexico's current GDP (‘average scenario’ SEMARNAT and SHCP, 2009, pages 54-55). In terms of relative magnitudes one should note that the cost of all accumulated climate change impacts during this century according to the ECCM would be smaller than the costs of the 2008-2009 crisis and comparable to those of other economic crises that occurred in Mexico over the last 30 years[69]. In other words, the economic impacts of climate change would not represent an unprecedented shock to the Mexican economy. 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 (e.g, Conde et al., 2011; Gay, 2000).

Moreover, the ECCM states that the estimates of the costs of climate change are in general higher to those that have been produced in the developed countries (SEMARNAT, SHCP, 2010, page 385). Nevertheless, contrasting the ECCM figures with some of the global and regional estimates of the costs of climate change that are available and that were produced using a variety of methods (see Tol, 2009 for a review) reveals that Mexico's vulnerability would be remarkably low in comparison with other countries of similar characteristics and even with the mean global estimates, independently of the discount rate chosen.

In particular, the ECCM results are remarkably low in comparison with those of the Stern Review (SR), where unabated climate change corresponds to an annual GDP loss between 5% and 20% with the developing countries suffering disproportionately. 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. Assuming an annual 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 at 6.22% of current GDP) would correspond to a GDP loss of 0.08% each year (or 0.37% if the 0.5% discount rate estimates are used instead). To expand further, let us consider an impact function of the form:

$$WI_{t,d,r} = \left(\Delta T_{t,r} / 2.5\right)^{POW} W_{d,r} GDP_{t,r}, \qquad (15.1)$$

where $WI_{t,d,r}$ stands for the economic impacts in time *t*, sector *d* (*d=1,2*; denoting the economic and the non-economic sectors respectively) and region *r*; $\Delta T_{t,r}$ is the increment in regional temperature with respect to its pre-industrial level; POW is the

[69] If a 2% discount rate is used, then the cost of all accumulated climate change impacts during this century would be similar in magnitude to the observed income loss of the 1994-95 and 2008-2009 crises.

exponent that determines the functional form of the impact function; and $W_{d,r}$ are regional multipliers to express the percentage of GDP loss for a benchmark warming of 2.5°C in each sector and region. These impact functions correspond to the PAGE2002 model (used in the SR to produce the estimates of the costs of global warming), excluding 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 a uniform distribution covering a range from 2.5ºC to 4ºC (which is the range of expected temperature changes for Mexico under the A2 scenario according to the ECCM). 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 of Mexico's current GDP, with a mean value of 93% (using a 4% discount rate in line with the ECCM estimates). This mean value represents about 15 times all the accumulated costs of climate change for Mexico estimated in the ECCM. Evidently, these results portray very different risk levels for the country with obvious implications for appropriate climate policy-making.

Other integrated assessment models that have been used extensively for assessing the economic costs of climate change are the DICE model, and its regional variant, 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-WGI, 2007), the economic costs of climate change for Mexico (classified as a lower-middle income country) would be equivalent to 99% of the country's current GDP, using a 4% discount rate. This figure represents 16 times the ECCM estimate.

Tol (2009, Table 1) also provides estimates of the welfare impact of climate change as an equivalent income loss in GDP percentage terms for different global warming benchmarks ranging between 1-3ºC. 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, South America would suffer damages equivalent to a 14.6% fall in income for a warming of 2.5ºC. This further reinforces the need to revisit ECCM methodology and critically reflect on any inconsistencies with the general literature findings on climate change impacts.

Table 15.1. Accumulated costs of climate change over this century for Mexico.

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%**

Source: SEMARNAT, SHCP, 2009.

15.3.2 ECCM cost estimates across different sectors

The last column of Table 15.1 shows the percentage of the total accumulated costs as a result of global warming (with respect to the "average scenario" estimates) that can be attributed per sector. Water and agriculture jointly 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%. The largest contribution (72%) comes from the water sector representing the difference in the costs of satisfying water demand under climate change and a baseline scenario.

It is striking that the costs of climate change in the water sector are insensitive to changes in climate variables, representing 4.50% of Mexico's current GDP irrespective of the emission scenario chosen (A1B, A2, B1). This is also the case for the 550 ppm stabilization scenario (proxied by the B1 scenario; Swart et al., 2002). Contrary to the ECCM's main policy recommendation, according to these estimates, an increased mitigation effort will not translate into reduced climate change costs. A possible explanation of this insensitiveness to climate variables could be that the costs were estimated only for one emissions scenario and were considered to be valid for the other two. If this is the case, this assumption would need to be revisited because it hinders any comparison of costs across different emissions scenarios (particularly considering that this sector represents more than 70% of all climate change costs).

According to Table 15.1, climate change would create net benefits for the land use sector, being particularly favorable for forest cover. The modeling was conducted by means of Markov chains based on an observed transition matrix for the baseline scenario and a modified transition matrix that is assumed to capture the impacts of climate change on land use. The ECCM offers two main justifications for their findings: 1) due to a significant reduction in agricultural productivity, incentives for deforestation are expected to decrease and 2) changes in climate variables provide more suitable conditions for forest growth. This would, though, require further explanation given that agricultural productivity is neither an explanatory (nor a dependent) variable in the model, and the ECCM results for the agricultural sector are independent of the estimations conducted for the land use sector. Furthermore, the ECCM land-use change projections contradict this finding, predicting an increase in the overall area devoted to agricultural production with climate change. The ECCM argues that this result is not at odds with the projected reduction in deforestation due to climate change, not only because of "the natural tendency for expanding agricultural land, but also because extreme temperatures and lower precipitation cause that some formations cannot occupy certain regions" (SEMARNAT and SHCP, 2010, page 202) (ECCM refers to areas currently occupied by grasslands, palm tree, halophilic, gypsophila vegetation and costal dunes; however, these lands, are generally considered not apt for agricultural production). The ECCM estimates are, hence, in contrast with findings by several studies that predict large losses in vegetation and forest cover (up to 50%) by 2050 as a result of climate change (INE-SEMARNAT, 2007; Trejo et al., 2011; Gay, 2000).

As has been discussed at length in the economic literature, the valuation of nature and its services is particularly challenging, often leading to estimates that severely underestimate their true value. The ECCM report also likely undervalues these services, particularly for a country of such biological diversity. For example, the ECCM report estimates that despite a predicted loss of 45% of Mexico's biodiversity under the A2 scenario, the attributed loss in monetary terms corresponds to only 0.06% of current GDP (for a general discussion on challenges related to valuation of nature and its services see Ackerman, 2008 and Martínez-Alier, 2001). The ECCM correctly warns that these estimates should be carefully used and interpreted. Nevertheless, when estimating the total accumulated costs of climate change for Mexico —on which their main policy recommendation is based— the biodiversity estimate is added to the estimates from other sectors without any special weighting or treatment.

Such low estimates would not justify Mexico's current expenditure in environmental protection and more directly in biodiversity preservation. During the last decade the government spent on average 0.50% of national annual GDP in environmental protection (http://dgcnesyp.inegi.org.mx/cgi-win/bdieintsi.exe/Consultar). This annual figure represents 8 times all the accumulated costs of climate change during this century in terms of losses in biodiversity. The government spending on biodiversity over this century (assuming that the government continues to spend the same percentage of annual GDP in environmental protection and that a small fraction, say1%, of this figure goes directly to preservation of biodiversity) would end up being about 5.6 times larger than the estimated ECCM monetary damage attributed to Mexico's 45% biodiversity loss. Note that this result also holds when a different discount rate is chosen (e.g., with a 0.5% discount rate, the environmental protection spending would be 7 times larger than the estimated costs).

A similar reasoning can be applied to the cost estimates of the agricultural sector in Table 15.1. Although the ECCM claims that the impacts on agriculture would be severe, making it the sector with the second largest losses, all accumulated impacts over the century are estimated to represent only 1.7% of current GDP. On the other hand, the Federal Government of Mexico finances many assistance programs for supporting agricultural production, such as PROCAMPO, where 0.2% of Mexico's GDP is allocated (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 accumulated costs of climate change during this century in the agricultural sector would be comparable to what the government would spend over a decade in PROCAMPO (which is just one of the many social programs devoted to agricultural production). If the government spends the same fraction of annual GDP in PROCAMPO each year during this century, this amount would be equivalent to *more than twice* the present value of the *total* accumulated costs of climate change for Mexico as estimated in the ECCM. Note that using the 0.5% or 2% discount rate estimates, instead, would still present damages in the agricultural sector as a very modest GDP loss, significantly smaller than government expenditure in agricultural assistance programs.

15.3.3 ECCM climate change impact vs. mitigation costs

The ECCM's main conclusion is that all accumulated costs over this century of unabated climate change (6.22% of Mexico's current GDP) are 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 these 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. This is, though, not supported by the estimated costs of climate change, which are highly insensitive to climatic conditions (Table 15.1).

The benefits in terms of avoided impacts for example, in accordance with the "550 stabilization scenario" (proxied by the B1 scenario, Table 15.1) would be close to only 0.3% of current GDP. Comparing this estimate with the corresponding costs of mitigation would lead to a net loss in the range of 2 to 7 times the avoided impacts. Net losses are obtained also for the ECCM estimates based on 0.5% and 2% discount rates. Evidently, this has strong implications for defining what the optimal mitigation policy for Mexico would be and is in discord with the main conclusion of the ECCM.

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

The ECCM served as a model for estimating the costs of climate change in Central and South America (ECLAC, 2010a; ECLAC, 2010b; ECLAC, 2010c; ECLAC, 2009) and members of the ECCM team provided their assistance for producing these studies.

These studies were coordinated by the Economic Commission for Latin America and the Caribbean, and were supported by local governments and international development agencies such as the UK's Department for International Development, the Inter-American Development Bank and the Spanish and German international cooperation agencies, among others.

Table 15.2 presents the total accumulated costs of climate change during this century estimated for Central America, Uruguay, Chile and Mexico (ECLAC, 2010a; ECLAC, 2010b; ECLAC, 2010c; ECLAC, 2009; SEMARNAT and SHCP, 2009). As can be seen from this table, these estimates are comparable in magnitude to that of the ECCM. The largest economic costs would occur in Uruguay and Chile while the costs of climate change for Central America are surprisingly low, even though this region is expected to be particularly vulnerable to climate and weather events (IPCC-WGII, 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 (15.1) and about 1/6 the annual loss estimated using the RICE99 impact function. Furthermore, the worst-off country in Central America (Nicaragua) would only lose 0.2% annually. All these estimates represent a small fraction of those that would be obtained using equation (15.1) and the RICE99 impact function. There is, hence, a need to revisit the ECCM methodology in order to ensure that estimates are compatible and comparable to the ones found in the SR and other peer-reviewed studies on the costs of climate change (e.g. Tol, 2009 and the references therein).

Table 15.2. Total accumulated costs of climate change during this century (as a share of 2008 GDP) estimated for Central America and for Uruguay, Chile and Mexico

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**	6.22 (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.

Source: ECLAC, 2010a; ECLAC, 2010b; ECLAC, 2010c; ECLAC, 2009; SEMARNAT and SHCP, 2009, based on the A2 emission scenario

15.4 Conclusions

Estimating the costs of climate change is a daunting task, characterized by large uncertainty and methodological challenges that have already given rise to a rigorous academic debate. While recognizing the importance of these government-supported national studies in Mexico and other Latin-American countries as a first attempt to provide estimates on the potential costs of climate change (as well as the data, technical and methodological challenges faced by the ECCM and other local teams), the analysis behind such national documents needs to be further strengthened in order to accurately inform national/regional decision-making as originally intended to.

The ECCM is likely to underestimate the potential impacts of climate change over the Mexican economy by presenting monetised climate change damages as a fraction of corresponding estimates by previous regional and global studies (also those of the SR, the main inspiration to the ECCM study). While the ECCM recommends aggressive mitigation, there is an implicit inconsistency in the underlying estimations given that mitigation costs are calculated in the magnitude of 2 and 7 times that of the benefits of avoided impacts.

Similar results are found when analyzing other reports that look at the economics of climate change in Central and South America, and which were inspired by the ECCM. This raises further reasons for concern because these national documents are building a regional view of what climate change could imply for Latin America as a whole (and one that is likely to underestimate the importance of this phenomenon, at least in comparison with what has been published in the peer-reviewed literature and with the estimates that are presented in this paper). These national documents are potentially damaging for regional and international climate policy: 1) given that economic impacts of climate change are likely to be underestimated, these documents may lead to a diminished regional interest in promoting and participating in international mitigation agreements; 2) they may promote significantly lower investment in local and regional adaptation actions than what may have been otherwise considered optimal.

The results in this chapter point to the need of rethinking how to strengthen national climate change documents in terms of scientific rigor and critical evaluation. This is particularly important given the role of these documents as a prominent source of information for supporting national decision-making on climate change policies. The analysis behind the ECCM report, in particular, could be strengthened by a) revisiting the validity of its climate and GDP projections and b) elaborating on the estimates of climate change impacts and their comparability with results from other peer-reviewed studies as well as own estimates on the cost of mitigation. Two main recommendations can be drawn: 1) there is a need to support the creation/strengthening of national scientific bodies which ensure that research aiming to inform government policy is of the highest academic standards. Sound climate change science cannot be built based on "opportunity" financial occasions, when local and international funds become available nor can national decision-making rely on "express science" conducted for the occasion with often limited time frames and financial resources 2) It is important that there is a scientific peer review of national climate documents prior to their release, that can highlight any methodological or conceptual inconsistencies (similar to the ones identified in this chapter). This can be achieved by a) reinforcing the links between local and regional scientific/academic bodies and agencies that act as co-ordinating institutions and b) by increasing the coordinating agencies' technical and managerial capacities.