

LIABILITY AND COMPENSATION FOR CLIMATE CHANGE DAMAGES – A LEGAL AND ECONOMIC ASSESSMENT

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I. Introduction

Climate change has claimed its first victims as Tuvalu's entire population prepares for emigration. With rising sea levels, their homes and infrastructure become uninhabitable and unusable. As Leo Falcam, President of the Federated States of Micronesia put it, for those low lying islands in the Pacific and elsewhere "climate change is nothing less than a form of slow death."¹ And indeed, Tuvalu's inundation is only the first sign. Regardless of efforts undertaken to reduce anthropogenic climate change, mankind is committed to change. And while the impacts resulting from climate change are still relatively poorly understood, they could have severe implications for peoples and economies.

The question of who will pay the damage and compensate the refugees of tomorrow for the loss of their homelands, damages to their health and property as well as potential casualties has been posed many times – mainly in a moral context. This paper provides the question with a legal framework and presents some estimates of its economic implications.

Section II sets out what international law has on offer to tackle the issue of damages that are due to impacts of climate change. We argue that, despite remaining gaps and legal as well as factual problems, there will be a general obligation of industrialised nations under international law to compensate developing nations for damages resulting from anthropogenic climate change.

We will deal only with public international law, defined as the law between nation states as opposed to private international law, which tackles issues of law between persons of different jurisdictions. We will disregard any potential private liability by companies or individuals under either national or international law for future climate change damage inflicted on States or other natural persons or legal entities. This paper therefore does not prejudge the existence in law of such private liability, nor do we take any position regarding the possibility of damage claims in the various national jurisdictions.

Sections III provides an analysis of these impacts in economic terms. Section IV and V then sets out what general state responsibility for climate change damages would imply in economic terms for OECD countries. We note that we disregard emissions from land use changes and potential carbon sink enhancing measures.

¹ See <http://starbulletin.com/2001/08/19/editorial/special.html>

II. State Responsibility and environmental damage under international law

One of the basic rules of international law is that States shall not inflict damage on or violate the rights of other States. In environmental law, this rule is captured in the so-called "no harm principle" which in turn has its foundations in the principle of good neighbourliness between States formally equal under international law.² Principle 2 of the 1992 Rio Declaration reiterates this rule of customary international law, outlawing transboundary environmental injury: "*States have, the sovereign right to exploit their own resources pursuant to their own environmental and developmental policies, and the responsibility to ensure that activities within their jurisdiction or control do not cause damage to the environment of other States or of areas beyond the limits of national jurisdiction.*" (emphasis added).

Moreover, in international law, states are responsible for violations of public international law and are obliged to compensate the indirectly or directly affected states for the damage caused.³ This rule forms the basis of the law of state responsibility, a body of law, which has recently been codified by the International Law Commission (ILC)⁴, a UN body entrusted with promoting the codification and development of international law.⁵ While the rules developed by the ILC do not automatically represent international law but have to be accepted (e.g. ratified) by States, they can serve as a useful tool to examine the conditions and consequences of state responsibility for climate change damages.

The following section sets out the basic steps for establishing state responsibility. We proceed to discuss what kinds of damages such responsibility would encompass (II.2) to provide the basis for identifying and testing the applicable international law (II.3). While this paper is not the forum to discuss all legal problems associated with compensation claims for climate change damages, some other issues are flagged in section II.4.

II.1. General steps for establishing state responsibility

A claim for climate change damages under international must then involve the following steps: (i) Identifying the damaging activity attributable to a state; (ii) establishing a causal link between the activity and the damage; (iii) determining either a violation of international law or a violation of a duty of care (due diligence); which is (iv) owed to the damaged state. Step (v) in a court of law would be to quantify the damages caused and relate those back to the activity. We cannot tackle this last step in this paper.

Damaging Activity and Attribution

To hold states responsible for climate change damages, it is either necessary to identify a legally relevant behaviour by a state or to attribute the actions of private persons to the state. In terms of state behaviour, (i) allowing emissions of greenhouse gases per se or during a certain time, and (ii) not having put in place the regulatory means to arrest emissions over and above a certain threshold are both clearly legally relevant state actions or omissions.

² This principle is accepted in international law since the famous Trail Smelter Arbitration of 1941, Reports of International Arbitral Awards (RIAA) III, p1905 and (1939) 33 American Journal of International Law (AJIL) p132; (1941) 35 AJIL p684. See for further analysis Perrez (1996).

³ See the landmark case *Chorzów Factory*, Permanent Court of International Law (PCIL) Reports Ser.A Nr.7, (1927), p30 and for an in-depth analysis of the current state of the law of State Responsibility Tomuschat (1999).

⁴ The ILC's Draft Articles on State Responsibility are the first comprehensive codification of the law on state responsibility. Part I of the Articles was adopted after almost 50 years of discussion at the 53rd session of the ILC in August 2001 and the ILC suggested that states should adopt a convention on the topic. (A/CN.4/L.602/Rev.1 and <http://www.un.org/law/ilc/archives/statfra.htm>, for the final document). See for a commentary Crawford, et.al, 2001.

⁵ Article 13.1 of the UN Charta provides: "The General Assembly shall initiate studies and make recommendations for the purpose of: a. ...encouraging the progressive development of international law and its codification.". The text of the Statute of the International Law Commission can be obtained from <http://www.un.org/law/ilc/texts/statufra.htm>.

However, it could be argued that millions of private persons are responsible for greenhouse gas emissions and not the state.

The wording of Principle 2 Rio Declaration (see page 2) seems to be clear on this issue. It generally obliges states to ensure that no damage is done from their territory to other states, and does not differentiate between state and private conduct. Or, as expressed already in 1941 by the arbitrator in the *Trail Smelter* case: "A State owes at all times the duty to protect other states against injurious acts by individuals from within its jurisdiction".⁶ But many have argued that states cannot assume "full accountability for the actions of their citizens who, in the exercise of their human rights, are not subject to governmental control" (Tomuschat, 1999, p. 274).

The customary law rules are unclear on this issue, and the ILC Draft Articles on State Responsibility suggest that behaviour of private persons, for example private industry and energy utilities emitting greenhouse gases, cannot be regarded as conduct of a State (Articles 4 ff). But the majority of emitting activities are subject to a licensing or permit procedure, be it in the energy or transport sector. One could interpret Article 8 of the Draft Articles to imply that, as soon as an activity is permitted or licensed by a state ("under the control of ..."), the resulting behaviour is attributable to the state. This has been argued in particular with regard to ultra-hazardous activities (e.g., Handl, 1980; cf. Le Cahier, 1997). To argue that greenhouse gas emissions are not attributable to states would result in major inconsistencies. For example, it is undisputed that emissions from state-owned electricity plants or other industrial plant are attributable to the state. In some parts of the world, power plants are now fully privatised, in others the main CO₂ emitting sector is still under state direct control. There is no reason why international law would support exoneration of a state simply because of privatisation of the polluting activity. But more importantly, the discussion becomes academic if one accepts that monitoring and regulation of private person's conduct is still a prime function of states, a function states can fail to fulfil with the appropriate care. This must have also been the underlying argument for Canada to assume responsibility in the *Trail Smelter* case, where damage was caused by fumes from the "Consolidated Mining and Smelting Company of Canada, Limited", i.e. a private company.

Thus, as a result, at least the failure to stop, reduce or regulate emitting activities can trigger state responsibility.

Causation

It is useful to distinguish between general causation and specific causation, a distinction that is found in most domestic tort laws and to some extent also applicable in international law. The first type refers to a causal link between an activity and the general outcome. In our case, this concerns the general proof that anthropogenic greenhouse gas emissions change the radiative forcing in the atmosphere, which results in global warming, which then leads to impacts on ecosystems such as air temperature rise, sea level rise, shift of climatic zones etc. This causation chain will be further discussed below.

Specific causation requires the proof that a specific activity has caused a specific damage in order to put a "figure to a claim" and to link this to a particular actor. This link would be needed to issue specific damage awards. As mentioned before, we cannot deal with this issue here but will discuss general responsibility only.

The following scientific facts can be taken as given and will satisfy the requirements for general causation. First of all, there is almost universal international scientific consensus that anthropogenic emissions of greenhouse gases cause and have caused changes in the radiative forcing balance in the atmosphere, which causes climate change. In other words, already

⁶ See note 2, RIAA III, p1963

observed changes are not just due to natural climate variability (Santer *et al.*, 1996). Secondly, there is a high likelihood that global climate change will lead to impacts on ecosystems and human life. In fact, the IPCC has already found that recent regional changes in temperature have had discernible impacts on many physical and biological systems (Smith *et al.*, forthcoming). Thirdly, some damages will occur, regardless of reduction efforts undertaken by the international community in the framework of the UN Framework Convention on Climate Change (FCCC) or Kyoto Protocol.⁷

Moreover, there is relative certainty about the extent to which states as entities have contributed to emissions of greenhouse gases and there are scenarios attempting to reflect possible contributions for the future. For example, regarding historic emissions of carbon dioxide from fossil fuel combustion (1900-1990), Europe has contributed 28%, the USA 30%, Japan 4% and the former Soviet Union 14%, while Africa is responsible for only 3%, and South and Central America for only 4%.⁸ While it is impossible to attribute specific emissions of a specific country to specific impacts (or damages), there is a causal link between each ton of greenhouse gas emitted and the change in radiative forcing. Thus, even though the shares of contributions differ and only lead to the resulting changes in accumulation, they are equally causal in a legal sense.⁹

Climate science has also started to estimate damages from the impacts of climate change, thus providing some figures on an aggregate level that can be linked to the level of general causation. In this framework, we present impact estimates in Section III. One result of these assessments is that damage in developing countries is projected to be significant, while impacts in OECD might overall be positive. On the basis of these aggregate figures it would be possible to assign legal responsibility to countries on the basis of their contributions. While the figures in sections III to V relate to the OECD as a whole, it is also possible to differentiate between countries for the assigning of responsibilities for future damages.

Wrongdoing or due diligence

Once the damaging activity and causation has been established, there is usually a requirement in tort or liability law to show some kind of wrongdoing or violation of due diligence¹⁰. With regard to environmental damages in international law, there are two basic views: (i) a state has to violate a duty of care or a rule of international law to trigger responsibility or (ii) the causal link between damage and activity attributable to the state is enough to trigger responsibility and compensation duties.

View (i) is reflected in Article 1 of the ILC Draft Articles on State Responsibility. It simply states that "every internationally wrongful act" entails responsibility, while wrongful act is defined as a conduct that constitutes a breach of an international obligation (Article 2). When exactly an obligation is breached depends on the nature and character of the pertinent obligation, but for many international lawyers, there must always be a due diligence test. That means that state responsibility can only occur if the respective state has not acted with the appropriate care. In turn, the standard of "appropriate care" must be determined according to the actual circumstances and obligation in question.

This is the traditional view of state responsibility; it always includes some kind of fault on behalf of the state. However, there has been much discussion about direct or strict state

⁷As of August 2001, 185 States and the EC are Parties to the UNFCCC, which entered into force in 1994. The Kyoto Protocol is not yet in force, but 35 States have deposited their instruments of ratification or accession.

⁸WRI, Contributions to Global Warming, July 2001.

⁹This has been argued for acid rain by Ott and Paschke (1997). National tort law has developed different types of and preconditions for 'causation' that are applicable to international law only by analogy.

¹⁰Negligence is a behaviour which disregards the due diligence in a given case, i.e. deficient conduct. Due diligence must be defined individually in response to the pertinent situation or conduct.

responsibility, i.e. whether states should be liable for any damage caused by certain activities under their control regardless of negligence or fault (view (ii)) (see *inter alia*, Horbach, 1996; Arsanjani and Reisman, 1998; Lefeber, 1996; Okowa, 2000). This discussion was supported by the endeavour of the ILC to develop rules on damages caused by certain lawful but hazardous activities. This project is entitled "international liability" but its objective is essentially to suggest instances of non-fault-based state responsibility as well as general rules on the prevention of environmental damage.¹¹

There have also been attempts to apply the polluter pays principle, originally an economic allocation concept, between states. As a result, responsibility for environmental damages would be generated by the mere causation of damage. Interestingly, during the negotiations of the FCCC, it was suggested that the principle could serve as an appropriate legal framework to address issues of liability and compensation.¹² But so far, the legal content of the polluter pays principle remains unclear and it is doubtful whether it can be regarded as customary international law rule (Sands, 1995).

The reason for the debate and codification efforts are obvious: in the past 50 years it has become increasingly clear that certain activities, albeit lawful in domestic and international law, entail a great risk for the environment (such as transports of nuclear materials and waste, space objects, oil transport by ship, production of chemicals etc.). Many of these hazardous activities are subject to specific strict liability treaty regimes, which often impose liability on the private operators rather than the respective state. Some also establish direct state responsibility for potential damages, such as in the case of space objects. In many regimes where the private operator is primarily liable for harm caused, states also accept some form of residual responsibility, which implicitly shows the acceptance of the concept of non-fault or direct responsibility. For many commentators, it seems generally unjust that a polluter State can pollute and damage another State without having to make good the damage or injury caused, unless fault can be proven.

Applied to the topic of this paper, the divergence between the views is quite significant. Either, it suffices to show that a state has contributed to causing global warming and thus to its (adverse) impacts. This would mean that one could take into account all historical contributions, from all sources, and the question of burden sharing regarding the present and future costs for climate change damage and damage prevention would arise. Or, to trigger responsibility of a state, the state must have disregarded due diligence, i.e. the polluting activity or allowing the activity to take place must be shown to be negligent in some way. The challenge would then be to determine exactly what the standard of care or the threshold of negligence is in any given case.

This paper does not solve the question of whether damages from climate change might trigger direct state responsibility under international law. Rather, we present results for alternative legal findings, ranging from strict to fault-based responsibility.

Obligation towards a state

Finally, regarding the fourth element of the state responsibility test (obligation owed to a specific state), it is necessary to keep in mind that originally, public international law was mostly concerned with delimitating rights and duties of states, for example by defining state

¹¹ See for the set of articles on "International liability for injurious consequences arising out of acts not prohibited by international law" as adopted by the ILC Working Group in 1998: Official Records of the General Assembly, Fifty-first session, Supplement No.10 (A/51/10), annex 1, p.238, reproduced in: ILC Report 1998, Chapter 4, footnote 4 (can be viewed at www.un.org/law/ilc/reports/1998/chp4.html) and the set of articles adopted by the ILC at first reading; U.N. Doc. A/CN.4/L.519. See for a recent analysis Boyle (2000).

¹² See Report of the INC, 1st session 4-14 February 1991, UN Doc. A/AC.237/6, 6 f. and UN Doc. A/AC.237/Misc.1/Add.3 at 24, submission by Vanatu on behalf of AOSIS.

boundaries and establishing the law of treatment of aliens. Today, international law moves more and more towards a law of cooperation. Many multilateral treaties establish obligations that do not correspond with pre-existing rights of specific states but that are much rather owed to the international community as a whole. International environmental law, which in many instances protects global commons such as the oceans and the atmosphere, is the best example for such "*erga omnes*" obligations (an obligation which is owed to a multitude of states and can thus be invoked by these jointly or individually). We return to this issue in section II.3.

II.2. Different kinds of claims – costs for adaptation v residual damage

Having shown that it is, in principle, possible to apply international law of state responsibility to climate change damages, there is a need to identify the potential types of damage or costs.

To start with, an analysis of state responsibility should distinguish between climate change *mitigation*, *adaptation* to climate change and *residual* climate change *damages*. Mitigation is the prevention of anthropogenic climate change at the source by either reducing greenhouse gas emissions or enhancing sink capacities (terrestrial or other). Mitigation is the focus of the UN FCCC and the Kyoto Protocol. In the framework of a legal liability analysis for climate change damages, mitigation can be viewed as 'indirect' damage prevention, concerned with actually preventing a risk of damages from anthropogenic climate change. As such, the costs or obligations to mitigate climate change do not fall within the scope of this paper. However, mitigation obligations can form the basis for state responsibility claims (see section II.3.).

Adaptation on the other hand can be legally defined as direct damage prevention, as it can reduce residual damages. Residual damages occur when adaptation measures are not possible or are not carried out due to economic or technical constraints. For legal purposes, the obligation to directly prevent damages corresponds with the obligation to compensate for any damages done.¹³ Since humankind is committed to some climate change regardless of mitigation efforts, both are possible responses to a situation in which the rights or interests of states or/and individuals are affected because of ongoing and past activities (in this case: emissions of greenhouse gases). Therefore, if general legal responsibility for climate change damages is established, such obligation also covers adaptation measures (and costs) as direct damage prevention measures.

Note that we do not engage in a discussion about the legal definition of environmental damages and recoverable costs. The impacts and costs listed in section III and compensation calculated in section V do include some damages (e.g., ecological damages) that might not be recoverable in a legal sense. However, since the estimates used are highly uncertain anyway and differentiation of cost categories would be beyond this paper, we operate on the assumption that most of the damages calculated would be recoverable.

II.3. Testing the Applicable Law

In general, international obligations can be found in either treaty law or customary international law. Customary International Law is developed by state practice and *opinio juris*, i.e. the perception of states that a certain behaviour actually reflects a rule of international law. The already mentioned no-harm principle belongs to this category. Treaty Law is the main source of law in international environmental law, containing much more defined rules as well as differentiated obligations regarding implementation control and enforcement – elements that are largely lacking for rules of customary law. The FCCC and Kyoto Protocol, as well as other treaties such as the 1982 UN Convention on the Law of the

¹³ In national legal systems, damage prevention is a duty upon the person responsible for future damage, be it either as an active obligation or only in the form of a duty to bear the costs for damage prevention incurred by the victim or third persons.

Sea (UNCLOS) are relevant sources for this paper. We will not attempt to look at any other treaties, which does not, however, preclude their potential applicability.

II.3.1 The Climate Treaties

We scrutinise the FCCC and the Kyoto Protocol both in terms of existing direct provisions regarding climate change damages and adaptation, and in terms of whether they contain obligations that would give rise to a claim for reparation under the traditional law of state responsibility.

Explicit Provisions regarding state responsibility

The FCCC and Kyoto Protocol provide only a partial answer to the issue of responsibility for damages. While the question of liability and responsibility for climate change damages was addressed several times by Governments and other experts in a political context and during the negotiation of the Convention from 1990 to 1992, the Convention does not address the issue. Rather, during the negotiation process of the FCCC industrialised nations emphasised that they would not accept any treaty provisions hinting at such responsibility (Bodansky, 1993; Ott, 1996; Sands, 1992; Verheyen, 1997). This caused several States, upon signature of the UN FCCC, to make the following declaration, which refers to State responsibility: "(...) *signature of the Convention shall in no way constitute a renunciation of any rights under international law concerning state responsibility for the adverse effects of climate change (...)*".¹⁴ This reservation had been proposed by the Alliance of Small Island States for inclusion in the Convention itself during the negotiations¹⁵ but was not included in the final document. The Kyoto Protocol contains no pertinent provisions either.¹⁶

Explicit provisions on adaptation – direct damage prevention

Both FCCC and Kyoto Protocol contain some unique provisions relating to adaptation and funding for adaptation. Firstly, Article 4.1 (b) FCCC obliges all Parties to "formulate and implement national or regional programmes containing measures to mitigate climate change ... and measures to facilitate adequate adaptation to climate change". Thus, adaptation is not a voluntary undertaking but a substantive obligation on all Parties with a view to reducing future climate change damages. However, there is uncertainty as to what constitute "adequate" adaptation measures and when and exactly how the obligation must be met.

Secondly, by ratifying the Convention, OECD countries (Annex II countries) have accepted a general obligation to assist developing countries in meeting the costs of adaptation under certain circumstances (e.g. Articles 4.3, 4.4, 4.8, 4.9 and 11 FCCC). According to Article 4.3 Annex II countries "shall provide new and additional resources to meet the agreed full incremental costs of implementing measures ... ", which covers "preparing for the adaptation to the impacts of climate change" (Article 4.1 (e) FCCC) as well as the duties under Article 4.1(b) mentioned above. Article 4.4 states that Annex II Parties "shall also assist developing country Parties that are particularly vulnerable to the adverse effects of climate change in meeting costs of adaptation to those adverse effects".¹⁷ Thus, while the obligations are neither

¹⁴ Declarations made by the Governments of Nauru, Tuvalu, Fiji, and Papua New Guinea. See UN Doc. COP1.Inf02, Status of Ratification of the UN FCCC (24/3/1995), available on <http://www.unfccc.int/resource/docs/cop1/inf02.htm>

¹⁵ See submission of Vanatu on behalf of the Alliance of Small Island States (AOSIS), Elements for a Framework Convention on climate change, in: Set of informal papers provided by delegations, related to the preparation of a framework convention on climate change, UN Doc. A/AC.237/Misc.1/Add.3, at 22.

¹⁶ The same holds true for the Intergovernmental Panel on Climate Change (IPCC). Some OECD countries consistently opposed references to responsibility in the IPCC reports, and removed any such references from their summaries for policy makers.

¹⁷ Para. 19 of the preamble to the Convention lists as particularly vulnerable: low lying or small island countries, arid and semi-arid areas or areas liable to floods, drought and desertification, and developing countries with fragile mountainous ecosystems. This is not an authoritative definition as it is only contained in the preamble.

capped nor time restricted, the treaty does not oblige Annex II countries to bear the full costs of adaptation in all developing countries.

Thirdly, the Kyoto Protocol establishes a special adaptation fund that will receive revenues from the operation of the Clean Development Mechanism (CDM 'share of proceeds') and from voluntary commitments by Parties. These were addressed in the recent Bonn Agreement reached by the resumed sixth Conference of the Parties to the FCCC (COP6bis)¹⁸, where some Parties pledged substantial increases in climate change funding for developing nations, including for adaptation purposes.¹⁹

Summing up, the wording of the treaty only foresees partial funding of adaptation measures by Annex II countries. The general legal framework of responsibility as well as burden sharing issues are not addressed. Funding pledges made are not directly connected to any concrete assessment of the actual aggregate adaptation needs of developing countries. Even though the funding provisions of the FCCC are mandatory, thus far, funding is made available on a political basis without attaching it to legal responsibilities, even though the "polluter pays principle" was suggested by countries as the basis for determining respective countries' shares during the COP6bis negotiations.²⁰

Thus, the FCCC and Kyoto Protocol do not resolve issues of state responsibility for adaptation and residual damages. We now proceed to look at specific law rules and treaty provisions which could serve as the basis for showing that a state has "done wrong" or acted negligent, an important element of a state responsibility claim.

Breach of obligations leading to state responsibility

The FCCC formulates the objective of preventing "dangerous anthropogenic interference with the climate system" (Article 2) but does not contain a rule that prohibits greenhouse gas emissions per se. The much discussed Article 4.2 FCCC which contains the "aim" of returning Annex I countries' emissions of greenhouse gases to 1990 levels by the year 2000 is not an enforceable duty under international law due to its ambiguous wording, and would in particular not attach any responsibility to historic emissions before the year 1992 (adoption of the FCCC). Thus, even though many Annex I countries have not met the year 2000-target, there are no direct legal consequences attached.

The Kyoto Protocol is not in force, but does set legally enforceable targets for countries (although the accounting of emissions is still ambiguous). Once it is in force, a country that does meet its target at the end of the 1st commitment period (2012) has breached an international law obligation. However, primarily, the special compliance and enforcement mechanism of the Protocol would be triggered and might even preclude the application of general law on state responsibility, depending on the will of the parties to the Protocol. As envisaged in the Bonn Agreement,²¹ a state that does not meet its targets will be subject to, *inter alia*, a "penalty" rate for excess emissions, i.e. will have to reduce 1.3 times as much in the next commitment period to make good for the non-compliance. The agreement does not however tackle the issue of damages and does not formally preclude damage claims to be based on the infringement of the treaty obligation.

¹⁸ Contained in FCCC/CP/2001/L.7, Decision 5/CP.6, Implementation of the Buenos Aires Plan of Action, downloadable at <http://unfccc.int>

¹⁹ US\$410 million per year by 2005, to be revised in 2008 were committed by the EU, Canada, New Zealand, Switzerland and Iceland. See also "Joint EU Presidency and European Commission statement on the successful conclusion of the Bonn climate change negotiations", DN: MEMO/01/276, 23.07.2001.

²⁰ The President's paper "New Proposals by the President of COP6" of 9th April 2001 paper in preparation for COP6bis contains the phrase that "contribution targets should be based on Annex I Parties' relative share of CO₂ emissions in 1990."(p4) This clearly is a kind of polluter pays approach, even though it only relates to CO₂ and adaptation funding unrelated to the actual needs for damage prevention.

²¹ See note 18.

The Kyoto obligations are *erga omnes* obligations, i.e. obligations that can be invoked by one State on behalf of all (see section II.1) and it is conceivable that even non-Parties could challenge non-compliant Kyoto Parties. There would be no need to show negligent behaviour of the respective state, rather the breach of obligation would in itself constitute the required "wrongdoing" to trigger the right to reparation, i.e. compensation for damages in as much as they are attributable to the State exceeding its Kyoto target. However, such a claim could only encompass the excess emissions over and above the target as agreed by the respective country. We illustrate this scenario and resulting compensation claims taking the average 5% reduction by 2012 compared to 1990 emissions as our guidance (see Sections IV and V).

II.3.2 The UN Convention on the Law of the Sea (UNCLOS)

The IPCC predicts a 9 to 88 cm sea level rise during the 21st century as well as regionally varying increases of ocean temperatures. Sea level rise, coral bleaching and fish migration due to water temperature changes are only some examples of potentially disastrous effects of global warming on oceans and coastal states. UNCLOS both regulates rights and duties of states with regard to the specific jurisdictional regimes of maritime zones and the protection of the maritime environment.

Article 194.2 UNCLOS implicitly prohibits unlimited emissions of greenhouse gases by obliging States to "(..) ensure that activities under their jurisdiction and control are so conducted as to not cause damage by pollution to other States and their environment (...)". Furthermore, Article 235 UNCLOS stresses that state responsibility is triggered if States do not fulfil their environmental duties under UNCLOS: "States are responsible for the fulfilment of their international obligations concerning the protection and preservation of the marine environment. They shall be liable in accordance with international law."

We first turn to the disappearance of territory and impact on maritime zones under UNCLOS due to sea level rise and secondly discuss how the impacts of climate change on the maritime environment itself are covered by UNCLOS. It should be noted that the Convention is not universally applicable as for example the US has not ratified it. However, many of its provisions qualify as customary international law (Brownlie, 1998).

Maritime Zones

UNCLOS defines different maritime zones, including the territorial waters (up to ~22 km off the coastline or 'baseline'), the exclusive economic zone, EEZ (~370 km) and the continental shelf area. In the EEZ, the coastal state has sovereign rights for the purposes of exploring and exploiting, conserving and managing the natural resources. These rights are invaluable for many coastal states. For example revenues from fishery concessions and permits for the exploration of minerals represent a substantive element in many state budgets. Beyond these maritime areas defined by UNCLOS, on the high seas all states have equal rights ("freedom of the high seas").²²

The maritime zones are generally determined by drawing a line around land territories (the baseline) according to a special methodology, and it is likely that sea level rise would affect the positioning and/or scale of State's maritime zones (Soons, 1990; Freestone, 1991). If for example an (inhabited or inhabitable) island²³ disappears, it can no longer serve for baseline determination and the potential loss of maritime zones is quite substantial in some instances. And if a country/island state disappears altogether, it will lose its maritime zones and

²² Treaties such as the UN Straddling Stock Agreement of 1996 and regional fisheries agreements seek to restrict unlimited fishing rights also in the high seas to prevent overfishing and unsustainable management of stocks.

²³ Article 121 UNCLOS provides that rocks "which cannot sustain human habitation or economic life" have no EEZ or continental shelf.

accordingly all sovereign rights while maintaining legal personality.²⁴ The alteration of a coastline due to sea level rise will otherwise lead to a shift of the EEZ while most likely leaving unaffected the continental shelf zone. The overall size of a country's EEZ would remain the same, but it would shift landwards. Since many fish stocks are dependent on the topography of the seabed rather than the distance to the coast, this could lead to fish stocks becoming high seas stocks that formerly were located in or straddled the EEZ of a given country. Since coastal states would lose their (restricted) sovereign rights over these stocks, such shift of EEZ could also be defined as a damage.

If such damage would occur due to anthropogenic climate change, Article 194.2 would apply as a general prohibition against such damages "by pollution" to other states. We will examine conditions for invoking this provision more closely in the next section.

Maritime Environment

A much more likely effect of climate change on coastal states and fishing rights are the predicted temperature changes in the ocean. Already minor changes can cause the migration of stocks and thus affect coastal states' fishing economies severely. Rising water temperatures are also identified as cause for coral bleaching which has severe impacts on coastal ecosystems, the development of fish stocks and tourism in island and coastal states. Both the migration of fish stocks to areas outside a country's EEZ and coral bleaching and other detrimental impacts on the marine environment could qualify as transboundary environmental damages and give rise to compensation claims.

According to Article 193 UNLCOS States have the "obligation to protect and preserve the maritime environment". This is supplemented by Article 207 ff. UNCLOS which contain more detailed duties regarding all sources of pollution to prevent harm and to protect the marine environment, for example: "States shall adopt law and regulations to prevent, reduce and control pollution of the marine environment from land-based sources taking into account internationally agreed rules, standards and recommended practices and procedures" (Article 207.1) .

First, rising water temperatures would have to qualify as maritime pollution, as greenhouse gases obviously do not directly affect the marine environment, other than increasing the amount of CO₂ available for uptake. UNLCOS defines pollution broadly. While this could be subject to a debate, in our view, indirect polluting activities such as emitting greenhouse gases are covered, since this activity, over time "results or is likely to result in such deleterious effects as harm to the living resources and marine life, hazards to human health, hindrance to marine activities, including fishing and other legitimate use of the sea, (...)" (Article 1.1). This is supported by the fact that States explicitly addressed pollution "from or through the atmosphere" (Article 212) and that, during the negotiations, states were aware of the potential threat of climate change to marine life.²⁵

Despite the wording of Article 193 and 194, these obligations in respect of the maritime environment do not represent an absolute prohibition to pollute. Rather, they represent due

²⁴ This is an issue of uncertainty in international law. While the 1933 Montevideo Convention on Rights and Duties of States (165 LNTS 19) lists "a defined territory" as necessary element to qualify as a person of international law, there is also the view that a state which "disappears" must still qualify as a state under international law so as to protect its citizens. They could then be regarded as special (*sui generis*) international persons. The general interest of a state in its survival was recognised in the ICJ Advisory Opinion on Nuclear Weapons, ICJ Rep. 1996, 263 para. 96; see also: Declaration of President Bedjaoui, ICJ Rep. 1996, 273 para. 22. UNCLOS does not protect state territory *per se*, however, this does not preclude claims under customary law.

²⁵ See UN Secretary General "Law of the Sea – Protection and preservation of the marine environment", 18 September 1989, UN Doc A/44/461, para 114.

diligence obligations with the goal to minimize rather than eliminate pollution.²⁶ Thus, to comply with UNCLOS obligations, a state must act with appropriate care.²⁷ There are different methods to determine this crucial standard of care. Firstly, it is necessary to decide what the point of reference is. The fact that climate change is caused by many polluters and over time and its impacts only manifest themselves much later makes this determination more difficult than if we were dealing with, for example, a specific oil spill.

Negligence could be linked to a specific international standard. For example, could Article 4.2 FCCC serve as an indirect point of reference to determine negligence even though it is not phrased as a direct obligation? In that case, all countries that have not met the year-2000 target would be liable for damages under UNCLOS from the year 1994 onward depending on the time of ratification by the state. Another standard could be one of best available techniques, i.e. has a state taken all appropriate measures to prevent further emissions of greenhouse gases by employing best energy efficiency and energy conservation as well as carbon-free technologies. But to date, there exists no such universally standard applicable by an international tribunal.

Foreseeability is also a frequently used concept: a state acts negligent if it could have or has foreseen potential damages. However it remains unclear whether the knowledge of climate change that could result from greenhouse gas emitting activities fulfils this criterion or whether a state must have foreseen (i) the general or (ii) the precise nature of the damages that such changes can cause. The ICJ in the *Corfu Channel* case²⁸ for example asked whether the Albanian authorities had known of mines in the channel which would later damage British ships. It then found that Albania had acted negligent because it failed to warn the British despite having knowledge of the mines. Spinning this further, Albania would in fact have been obliged to remove the mines which represented such a risk from its territorial waters. Thus another question arises, which is linked to the issue of causation (see section II.1): is it a prerequisite that a state could (have) prevent(ed) the damage from occurring? But in our view, in instances of several polluters, the question must be whether States were and are able to take action to significantly reduce emissions of greenhouse gases, which would significantly reduce their contribution to future climate change damages. Otherwise, there would, per definition, not be any legal responsibility in instances where several people/states cause an injury to another. Such a defence is not accepted in national legal systems and is in our view, a general legal principle applicable also in international law.

Another methodology to determine negligence seems to look at the risk involved. If the risk is obvious, states must prove that they have taken all necessary measures to prevent the risk from materialising into actual damage. The quantity or severity of risk thus sets the threshold for the due care duty. This is closely linked with the question of what exactly states would have to be able to foresee. At what point in time could or should a Government have known that its conduct, for example the enforcement of fossil-fuel based energy plans, the licensing of oil exploration or the authorization of fossil fuel based power plants will cause damage to other states in the future? And what are the requirements in terms of scientific certainty – is it enough to establish fault in this context that states knew of the risks or is it only now, that

²⁶ General opinion, see UN Secretary General "Law of the Sea – Protection and preservation of the marine environment", 18 September 1989, UN Doc A/44/461, para 30.

²⁷ Some have argued that UNCLOS contains direct or strict state responsibility in Article 139 which is concerned with sea bed activities. However, a state can exonerate itself if it has taken all "necessary and appropriate measures to ensure effective compliance"(Article 139.2 2nd sentence UNCLOS). This article is not therefore an example for direct state responsibility, but sets rather a special due diligence threshold.

²⁸ 1949 ICJ Reports p.4, *Corfu Channel* (UK v Albania) at 22. Also on the ICJ web pages at <http://www.icj-cij.org/icjwww/idecisions/summaries/lccsummary490409.htm> (merits and assessment of compensation).

scientific certainty has grown to virtual consensus that states are responsible for failing to react to these findings?

The answer to these questions has bearings on when responsibility starts. For example, as early as 1827 the first scientific studies (by Jean Baptiste Fourier) appeared which showed the relationship between concentrations of greenhouse gases, in particular CO₂, and the radiative forcing of the atmosphere. Arrhenius (1896) argued that increasing CO₂ concentrations would lead to warming, calculated the economic impacts of this, and even warned governments that regulation was warranted. In the 1950s, monitoring data from the Antarctica and Hawaii allowed for in-depth research in atmospheric greenhouse gas concentrations and the first studies on possible implications (climate change impacts) appeared. Global warming was a topic of discussion at the first UN Conference on Human Development in Stockholm 1972, and the first world climate conference took place in 1979. Governments and policy makers were publicly alerted to the climate change problem by the Villach Conference in 1985 and in 1990 the IPCC presented its first assessment report, outlining potential climate change scenarios and impacts; estimates of economic impacts of changes in the climatic system were no longer ignorable. Finally, in 1992 an overwhelming majority of the members of the international community adopted the FCCC which explicitly recognises adverse impacts of climate change.

Again, these issues would require much deeper analysis. But we think that at the latest in 1992 with the adoption of the FCCC states knew that their behaviour (or omission to regulate their economies) would contribute to future damages. Thus, if foreseeability is accepted as measure for due diligence, states would be responsible for their respective emissions as of either the beginning of the 19th century, as of the 1950s or as of 1992.

It should be noted that any claims under UNCLOS would only cover damages due to maritime pollution or changes in maritime zones, fishing rights etc. Recoverable damages under UNCLOS would thus not encompass agricultural or health damages, but would encompass all coastal territory and adaptation/protection costs

II.3.3. The no-harm principle

The principle not to cause damage to another state has been mentioned above and is clearly a norm of customary international law. According to the majority view amongst legal scholars, it would be necessary to prove a breach of a due care duty, or negligence. We have already discussed the problems associated with this in the section above. It should be noted, however, that, without discussing damage quantification and coverage in detail, all kinds of climate change damages and direct prevention costs could come under the umbrella of the no-harm principle. We reiterate that, in view of the figures and calculation that we want to present here, we do not attempt to associate a specific damage in a specific country with a polluting activity.

II.4. Other issues

Some final issues should be noted. Firstly, especially if state responsibility is established on the grounds of foreseeability, not only OECD countries might be liable for future damages. While it seems that negative impacts will only occur in developing country, it is theoretically possible that OECD countries will try to recover damage costs from a developing country for its contribution to climate change. Again, this could be subject to much legal discussion but may be prevented by the principle of common but differentiated responsibility, Article 3.1 FCCC which represents a modification of the formal equality of States and which is an emerging principle of customary international law.

Furthermore, regarding burden sharing between developed countries we point to Article 39 of the ILC Draft Articles on State Responsibility which stipulates that in determining reparation,

account shall be taken of the contribution of the state to the injury. This means, essentially, a burden sharing according to emissions.

Moreover, even though we have not discussed various problems associated with actually bringing a claim for compensation before an international tribunal or court, one remark is appropriate. It has been said that States wishing to make a claim (at a minimum before the ICJ) would have to bring claims against all possible defendants, i.e. all OECD countries together since those countries would be jointly liable for the damage caused (joint and several liability). However, in the 1992 *Nauru* case²⁹ the International Court of Justice allowed Nauru to bring a claim against Australia despite the fact that Nauru could have challenged two other nations, New Zealand and the UK. The court argued that, as long as the interests of a state not party to a dispute before the court will not be affected by the judgement, for example by finding illegal behaviour of this third party as a prerequisite for the claim in question, the plaintiff is not required to challenge every possible defendant.³⁰ In the case of greenhouse gas emissions contributing to climate change and thus causing damage to States and individuals of those states, each State's independent behaviour can be judged, even though in practice, the sum of greenhouse gas emissions leading to increased concentrations of greenhouse gases in the atmosphere are causing the climate system to change. This case law has now also been incorporated in Article 47 of the ILC Draft Articles on State Responsibility.

II.5. Preliminary Conclusion

This section has argued that general state responsibility for climate change damages can be established. The general causal link between emissions of greenhouse gases and climate change impacts is closed to a sufficient extent to make a legal case. Therefore, a claim is much less difficult to envisage than only 10 years ago. However, further research into issues such as specific causation, foreseeability as a legal standard for due diligence is needed. Moreover, the analysis has not touched upon the problems of jurisdiction of international courts and tribunals, and enforcement of awards and judgements.

III. The impacts of climate change

There are various reasons why one may worry about climate change. Some people argue it is a problem because it could cause unacceptable hardship for particularly vulnerable populations (e.g. those living on small island states). Others are concerned about the potential threat to certain unique and valuable systems (such as coral reefs). Still others worry that climate change will increase the probability of large-scale climate instabilities (e.g., a shutdown of the Gulf Stream), and will have costly impacts on economies through floods and storms. A fourth group wonders about the total (or aggregate) impacts of climate change on well-being and development (cf. Smith *et al.*, forthcoming).

A key challenge when assessing the impacts of climate change is synthesis, i.e., the need to reduce the complex pattern of local and individual impacts to a more tractable set of indicators. The challenge is to identify indicators that can summarize and make comparable the impacts in different regions, sectors or systems in a meaningful way. If the aim is to integrate the impacts of climate change with standard national accounts, or to compare the benefits of avoided climate change with the costs of emission reduction, or to pay compensation, it is necessary to express the costs climate change in the same metric, that is

²⁹ Certain Phosphate Lands in Nauru (*Nauru v Australia*), 1992 ICJ Reports p240.

³⁰ In the *Nicaragua* case the ICJ expressed as a general rule that the ICJ would "decline ... to exercise the jurisdiction conferred upon it where the legal interest of a State not party to the proceedings would not only be affected by a decision, but would form the very subject-matter of the decision". " (1954 ICJ Reports, p32.)

money (for estimates, see Ayres and Walter, 1991; Cline, 1992; Downing *et al.*, 1995, 1996; Hohmeyer and Gaertner, 1992; Fankhauser, 1995; Nordhaus, 1991, 1994; Mendelsohn and Neumann, 1999; Titus, 1992; Tol, 1995).

Money is a particularly well-suited metric to measure market impacts, that is impacts that are linked to market transactions and directly affect GDP. The costs of sea level rise can be expressed as the capital cost of protection plus the economic value of land and structures at loss or at risk; and agricultural impact can be expressed as costs or benefits to producers and consumers. Using a monetary metric to express non-market impacts, such as effects on ecosystems or human health, is more difficult. There is a broad and established literature on valuation theory and its application, including studies (mostly in a non-climate change context) on the monetary value of lower mortality risk, ecosystems, quality of life, etc (e.g., Freeman, 1993). But economic valuation can be controversial, and requires sophisticated analysis that is still mostly lacking in a climate change context (e.g., Pearce *et al.*, 1996).

Global warming damages are often estimated for the impacts of a doubling of the concentration of greenhouse gases in the atmosphere on the present economy. Most of the research on the assessment of these impacts is carried out in and for the United States, but a handful of studies have estimated the total impact of climate change (disaggregated across sectors) in different regions of the world. Table 1 shows aggregate, monetized impact estimates for a doubling of atmospheric carbon dioxide on the current economy and population from three recent studies and summarises the 'first generation' of studies (Pearce *et al.*, 1996). The numerical results remain speculative, but they can provide insights on signs, orders of magnitude, and patterns of vulnerability. Results are difficult to compare because different studies assume different climate scenarios, make different assumptions about adaptation, use different regional disaggregation and include different impacts. The Nordhaus and Boyer (1999) estimates, for example, are more negative than others, partly because they factor in the possibility of catastrophic impact. The Mendelsohn *et al.* (2000) and Tol (forthcoming) estimates, on the other hand, are driven by optimistic assumptions about adaptive capacity and baseline development trends, which results in mostly beneficial impacts.

Table 1. Estimates of the regional impacts of climate change.^a

	'First Generation'	Mendelsohn et al.		Nordhaus / Boyer	Tol ^b
	2.5°C	1.5°C	2.5°C	2.5°C	1.0°C
North America	-1.5				3.4(1.2)
USA	-1.0 to -1.5		0.3	-0.5	
OECD Europe	-1.3				3.7 (2.2)
EU	-1.4			-2.8	
OECD Pacific	-1.4 to -2.8				1.0 (1.1)
Japan			-0.1	-0.5	
Eastern Europe & fUSSR	0.3				2.0 (3.8)
Eastern Europe				-0.7	
fUSSR	-0.7				
Russia			11.1	0.7	
Middle East	-4.1			-2.0 ^c	1.1 (2.2)
Latin America	-4.3				-0.1 (0.6)
Brazil			-1.4		
South & Southeast Asia	-8.6				-1.7 (1.1)
India			-2.0	-4.9	
China	-4.7 to -5.2		1.8	-0.2	2.1 (5.0) ^d
Africa	-8.7			-3.9	-4.1 (2.2)

DCs		0.12	0.03		
LDCs		0.05	-0.17		
World					
output weighed ^e	-1.5 to -2.0		0.1	-1.5	2.3 (1.0)
population weighed ^f				-1.9	
at world average prices ^g					-2.7 (0.8)
equity weighed ^h					0.2 (1.3)

^a Figures are expressed as impacts on a society with today's economic structure, population, laws etc. Mendelsohn *et al.*'s estimates denote impact on a future economy. Estimates are expressed as per cent of Gross Domestic Product. Positive numbers denote benefits, negative numbers denote costs.

^b Figures in brackets denote standard deviations. They denote a lower bound to the real uncertainty

^c high-income OPEC

^d China, Laos, North Korea, Vietnam

^e Regional monetary impact estimates are aggregated to world impacts without weighing.

^f Regional monetary impact estimates are aggregated to world impacts using weights that reflect differences in population sizes.

^g Regional impacts are evaluated at world average values and then aggregated, without weighing, to world impacts.

^h Regional monetary impact estimates are aggregated to world impacts using "equity weights" that equal the ratio of global average per capita income to region average per capita income.

Source: Pearce et al. (1996); Mendelsohn *et al.* (1996); Nordhaus and Boyer (2000); Tol (forthcoming).

Standard deviations are rarely reported, but likely amount to several times the 'best guess'. They are larger for developing countries, where results are generally derived through extrapolation rather than direct estimation. This is illustrated by the standard deviations estimated by Tol (forthcoming), reproduced in Table 1. These estimates probably underestimate the true uncertainty, because they exclude omitted impacts and severe climate change scenarios.

Overall, the current generation of aggregate estimates may understate the true cost of climate change because they tend to ignore extreme weather events; underestimate the compounding effect of multiple stresses; and ignore the costs of transition and learning. However, studies may also have overlooked positive impacts of climate change and not adequately accounted for how development could reduce impacts of climate change. Our current understanding of (future) adaptive capacity, particularly in developing countries, is too limited, and the inclusion of adaptation in current studies too varied to allow a firm conclusion about the direction of the estimation bias.

Market-impacts are low, and may be positive in some countries and sectors – at least in developed regions. This is largely due to adaptation. Efficient adaptation reduces the net costs of climate change because the cost of such measures is lower than the concomitant reduction in impacts. However, impact uncertainty and lack of capacity may make efficient and error-free adaptation difficult. Even so, market impacts could be significant in some conditions, such as a rapid increase in extreme events, which might lead to large losses and/or costly over-adaptation (if random fluctuations are mistaken for a trend) (see Downing *et al.*, 1998).

Developing countries are more vulnerable to climate change than developed countries because their economies rely more heavily on climate-sensitive activities (in particular agriculture), and many already operate close to environmental and climatic tolerance levels (e.g., with respect to coastal and water resources). Developing countries are poorly prepared to deal with the climate variability and natural hazards they already face today (World Bank 2000). If current development trends continue, few of them will have the financial, technical, and institutional capacity and knowledge base to deal with the additional stress of climate change.

Estimates of global impact are sensitive to the way figures are aggregated. Because the most severe impacts are expected in developing countries, the more weight is assigned to developing countries, the more severe are aggregate impacts. Using a simple adding of impacts, some studies estimate small net positive impacts at a few degrees of warming, while others estimate small net negative impacts.

Net aggregate benefits do not preclude the possibility of a majority of people being negatively affected, and some population groups severely so. This is due to the fact that developed economies, many of which could have positive impacts, contribute the majority of global production but account for a smaller fraction of world population. However, there are no studies so far that have consistently estimated the total number of people that could be negatively affected by climate change.

The value judgments underlying regional aggregation are discussed and made explicit in Azar (1999), Azar and Sterner (1996) and Fankhauser *et al.* (1997, 1998). We underline the importance of aggregation by using four alternative ways of computing world total impacts from regional impact estimates in Table 1.

The impact estimates of Table 1 are very uncertain, and the studies upon which they are based suffer from many shortcomings. We list the most important. A major difficulty in impact assessment is our still incomplete understanding of climate change itself, in particular the regional details of climate change (Mahlman, 1997). Impacts are local, and impacts are related to weather variability and extremes. Current climate change scenarios and current climate change impact studies use crude spatial and temporal resolutions, too crude to capture a number of essential details that determine the impacts.

Knowledge gaps continue at the level of impact analysis. Despite a growing number of country-level case studies (e.g., U.S. Country Studies Program, 1999), our knowledge of local impacts is still too uneven and incomplete for a careful, detailed comparison across regions. Furthermore, differences in assumptions often make it difficult to compare case studies across countries. Only a few studies try to provide a coherent global picture, based on a uniform set of assumptions. The basis of many such global impact assessments tend to be case studies with a more limited scope, often undertaken in the United States, which are then extrapolated to other regions. Such extrapolation is difficult and will be successful only if regional circumstances are carefully taken into account, including differences in geography, level of development, value systems and adaptive capacity. Not all analyses are equally careful in undertaking this task. While our understanding of the vulnerability of developed countries is improving – at least with respect to market impacts – good information about developing countries remains scarce.

Non-market damages, indirect effects (e.g., the effect of changed agricultural output on the food processing industry), horizontal interlinkages (e.g., the interplay between water supply and agriculture; or how the loss of ecosystem functions will affect GDP), and the socio-political implications of change are also still poorly understood. Uncertainty, transient effects (the impact of a changing rather than a changed and static climate), and the influence of change in climate variability are other factors deserving more attention.

Another key problem is adaptation. Adaptation will entail complex behavioural, technological and institutional adjustments at all levels of society, and not all population groups will be equally adept at adapting. Adaptation is treated differently in different studies, but all approaches either underestimate or overestimate its effectiveness and costs. Impact studies are largely confined to autonomous adaptation, that is, adaptations that occur without explicit policy intervention from the government. But in many cases governments too will embark on adaptation policies to avoid certain impacts of climate change, and may start those policies well before critical climatic change occurs – for example, by linking climate change

adaptation to other development and global change actions, such as on drought and desertification or biodiversity.

The analysis is further complicated by the strong link between adaptation and other socio-economic trends. The world will substantially change in the future, and this will affect vulnerability to climate change. For example, a successful effort to roll back malaria could reduce a climate change induced spread of malaria risks. A less successful effort could introduce antibiotic-resistant parasites or pesticide-resistant mosquitoes, increasing vulnerability to climate change. The growing pressure on natural resources from unsustainable economic development is likely to exacerbate the impacts of climate change. However, if this pressure leads to improved management (e.g., water markets), vulnerability might decrease. Even without explicit adaptation, impact assessments therefore vary depending on the 'type' of socio-economic development expected in the future. The sensitivity of estimates to such baseline trends can in some cases be strong enough to reverse the sign, i.e., a potentially negative impact can become positive under a suitable development path or vice versa (Mendelsohn and Neumann, 1999).

Global warming damages under the 2xCO₂ scenario are hypothetical damages on the *present* society. The real damages of global warming will occur in the future, and society will have changed in terms of population numbers, economic size and structure, technology and in terms of socio-cultural and political factors. These changes may affect the vulnerability of society to global warming. If we are interested in the absolute size of damages (for example per ton of CO₂ emissions) it is necessary to establish the future size of the population and stock at risk. The timeframe of global warming damages is too long, however, to predict such future developments with any measure of precision. Hence, scenarios are used that describe possible futures but do not claim to describe the most likely future.

One of the main challenges of impact assessments is to move from this static analysis to a dynamic representation of impacts as a function of shifting climate characteristics, adaptation measures and exogenous trends like economic and population growth. Our understanding of the time path aggregate impacts will follow under different warming and development scenarios, is still extremely limited. Among the few explicitly dynamic analyses are Sohngen and Mendelsohn (1999), Tol and Dowlatabadi (forthcoming) and Yohe *et al.* (1996). These studies are highly speculative, as the underlying models only provide a very rough reflection of real-world complexities. Figure 1 shows examples from three studies. While some analysts still work with relatively smooth impact functions (e.g. Nordhaus and Boyer 2000), there is growing recognition (e.g., Tol, 1996, forthcoming; Mendelsohn and Schlesinger 1999) that the climate impact dynamics – the conjunction of climate change, societal change, impact, and adaptation – is certainly not linear, and might be quite complex.

Impacts in different sectors may unfold along fundamentally different paths. Coastal impacts, for example, are expected to grow continuously over time, more or less in proportion to the rise in sea level. The prospects for agriculture, in contrast, are more diverse. While some models predict aggregate damages already for moderate warming, many studies suggest that under some (but not all) scenarios the impact curve might be hump-shaped, with short-term (aggregate) benefits under modest climate change turning into losses under more substantial change (e.g., Mendelsohn and Schlesinger, 1999).

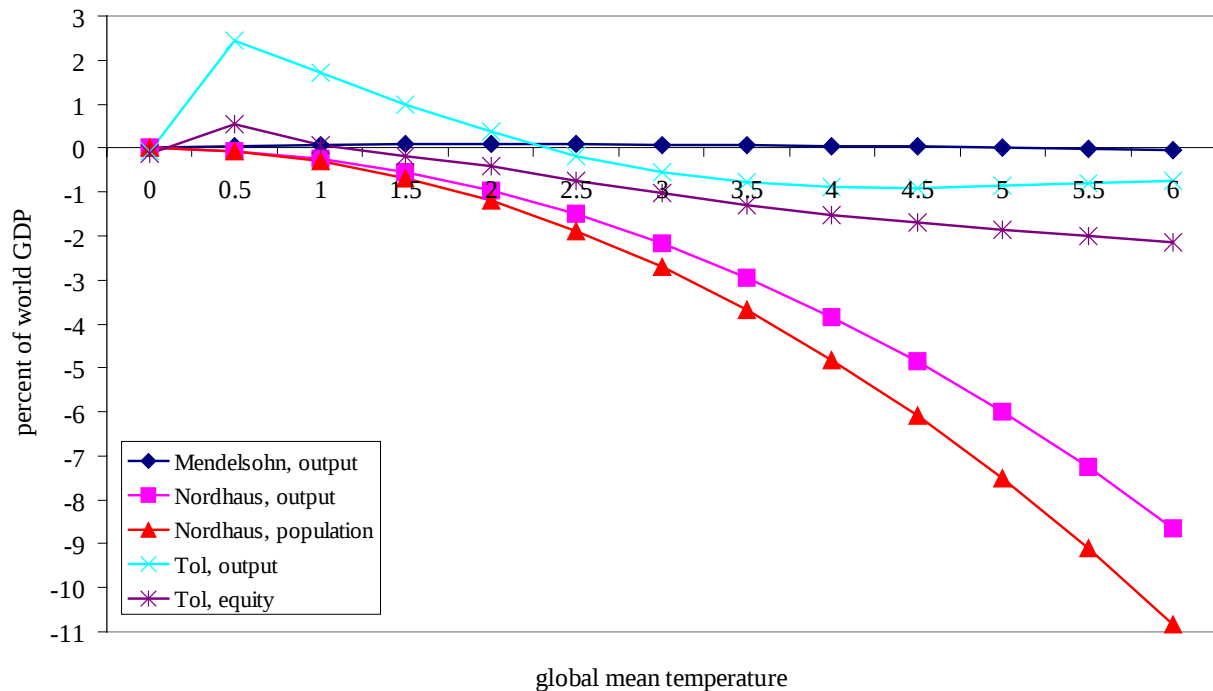


Figure 1. The impact of climate change as a function of the global mean temperature, according to Mendelsohn *et al.* (1996), Nordhaus and Boyer (2000), and Tol (forthcoming). Mendelsohn *et al.* aggregate impacts across different regions weighted by regional output. Nordhaus and Boyer aggregate either weighted by regional output or weighted by regional population. Tol aggregates either by regional output or by equity, that is, by the ratio of world per capita income to regional per capita income.

The hypothetical compensation paid in the calculations below is based on the output-weighted estimates of Tol (forthcoming), as calculated with the FUND 2.0 model (Tol, 1997, 1999a-e, 2001). The scenario used is IS92a (Leggett *et al.*, 1992). Because of the uncertainties, we also present results for seven alternative damage estimates. First, we use the output-weighted impact estimates of Nordhaus and Yang (1996). The other five alternatives are based on Tol (forthcoming). We include the IS92d and IS92f scenarios as alternatives to IS92a. We also look at equity-weighted impact estimates (Fankhauser *et al.*, 1997, 1998), which reflect *utility* rather than *income* losses. We look at market impacts only, excluding the hard-to-measure non-market impacts. We look at negative impacts only, excluding impacts on those sectors that are positively affected by climate change. Finally, we consider the case that *willingness to accept compensation* (WTAC) rather than *willingness to pay* (WTP) is the appropriate way of valuing non-market impacts, assuming that WTAC is 4 times higher than WTP (Pearce and Turner, 1990). Figure 2 displays the eight alternative impact estimates. We consider total impacts in less developed countries, as measured in percentage of GDP.

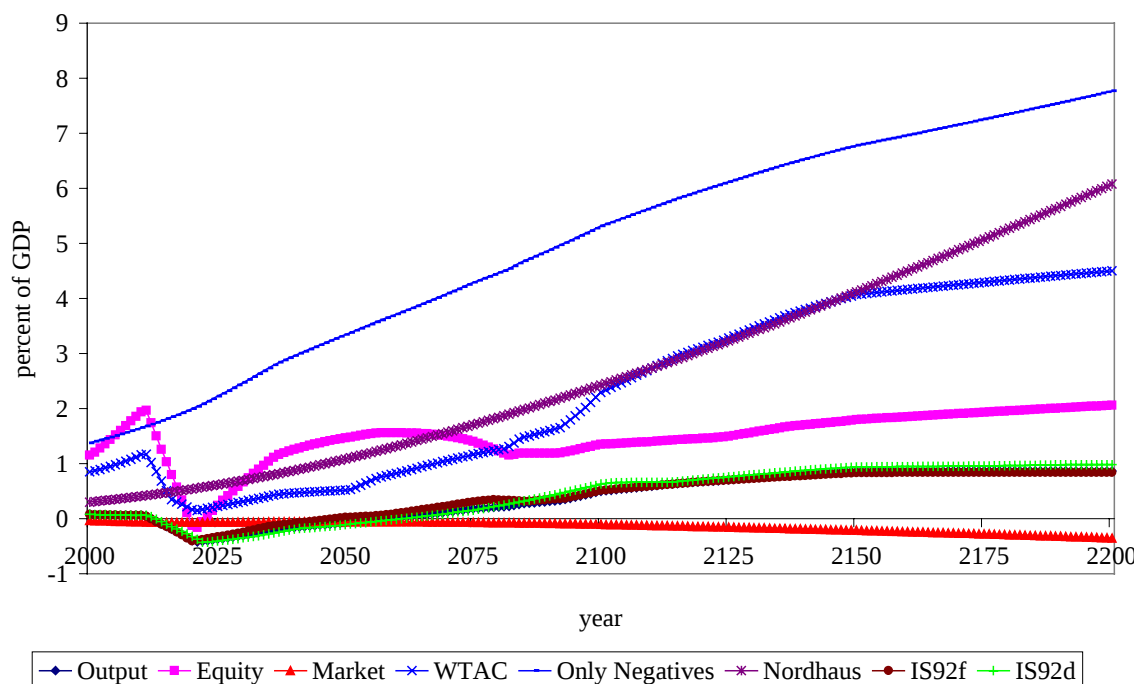


Figure 2. Eight alternative estimates of the impact in less developed countries as a percentage of their GDP. The Nordhaus estimate is due to Nordhaus and Yang (1996), the other estimates are due to Tol (forthcoming). The Equity estimate weights the regional impact estimates by the ratio of world average income and regional average income, the other estimates add up dollars without weighting. The IS92f and IS92d estimates are based on the scenarios of the same name, the other estimates are based on IS92a. The Market estimates excludes non-market impacts, the WTAC estimates multiplies non-market impacts by 4, the other estimates include non-market impacts without weighting. The Only Negatives estimate excludes impacts on those sectors that, on average, benefit from climate change, the other estimates aggregate positive and negative impacts. The Output estimate is the base case.

The base case estimate of LDC climate change impact has slightly positive impacts of climate change up to the year 2050, primarily due to CO₂ fertilization of agriculture. After 2050, impacts become negative, rising up to some 1% of GDP. Impact estimates are hardly sensitive to the scenario used. Aggregate market impacts are positive throughout the period. The negative impacts of climate change run up to some 8% of GDP. The equity-weighted and WTAC impact estimate emphasize the strongly non-linear nature of the non-market impacts, leading to rather speculative total impact estimates. Nordhaus' impact estimates are considerable more pessimistic than those of Tol (forthcoming).

IV. Responsibilities

We use cumulative emissions as our measure of responsibility for impacts of climate change. Emissions are the established metric in international climate policy. Although harder to measure than atmospheric concentrations, emissions are more easily attributable to countries. We ignore greenhouse gases other than carbon dioxide, and also exclude CO₂ from land use change. Carbon dioxide emissions from industry, households and transport are easily and verifiably measure, and constitute about 75% of the problem.

As our base case, we consider only emissions after 2000, the year in which governments can be expected to know about climate change and have had the time to start emission abatement programmes. The first OECD commitments to reduce emissions (part of the UN FCCC) were for the year 2000. We do this for the IS92a scenario as well as for IS92d and IS92f. As an

alternative, we only consider excessive emissions, that is, those emissions above a reasonable emission reduction policy. We assume that a 5% emission reduction policy (from 1990 levels) is reasonable; 5% is approximately what was agreed in the Kyoto Protocol. As a second alternative, we look at cumulative emissions since 1800, the starting point of emissions data. In all cases, cumulative emissions in the OECD are compared to world cumulative emissions since 1800. Figure 3 displays the resulting “responsibility” of the OECD.

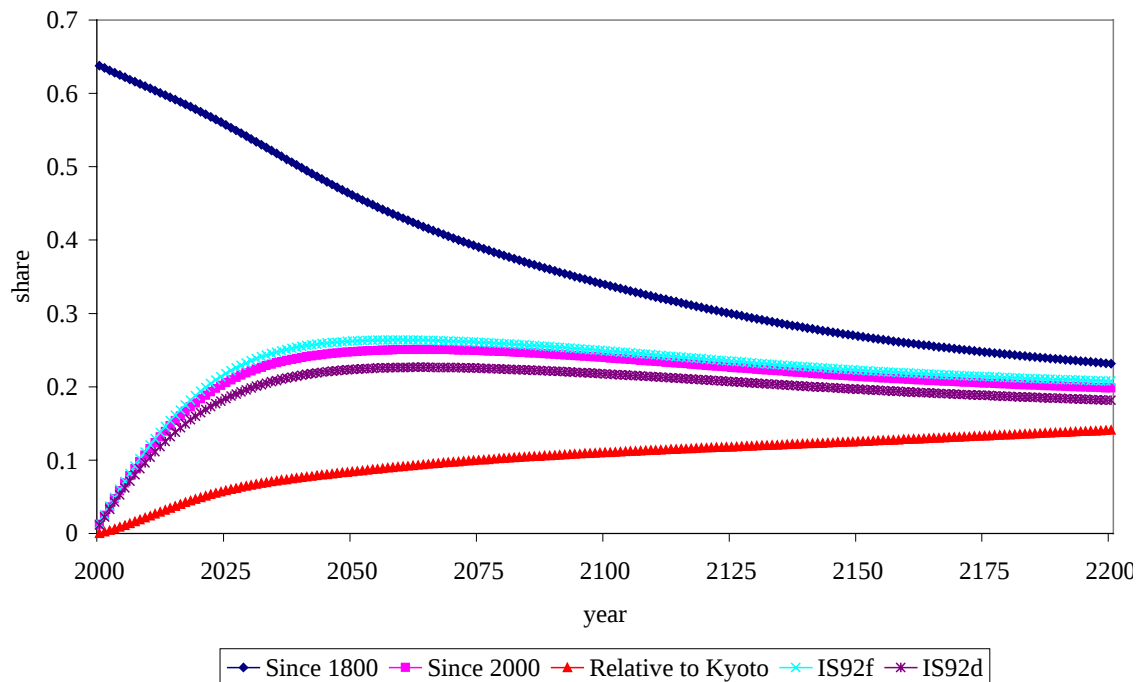


Figure 3. The share of cumulative OECD emissions of industrial carbon dioxide in cumulative world emissions since 1800. Cumulative OECD emissions are measured since 2000 for IS92a, IS92d and IS92f. Cumulative OECD emissions are also measured since 1800, and in deviation from a reasonable emission reduction policy (“relative to Kyoto”).

If cumulative emissions are measured since 2000, the OECD is responsible for 20-25% of climate change from 2025 onwards. These numbers hold for IS92a as well as for IS92d and IS92f. If only emissions in excess of the “Kyoto” emission reduction policy are counted, the OECD’s contribution to climate change slopes up to about 15% in 2200. If cumulative emissions since 1800 are counted, the OECD starts with a contribution of about 65% falling to 25% by 2200.

Section III argues that there alternative dates to our choice of 1800 and 2000, particularly 1827, 1896, 1950, 1972, 1985, 1990 and 1992. This would lead to assigned responsibilities that are somewhere in between the extremes presented in Figure 3. We omit those intermediate cases for ease of exposition.

An alternative to emissions in excess of “Kyoto” would be emissions in excess of some per capita emissions allotment. If we again start counting at the year 2000, the result would a graph very similar to the “Since 2000” graph in Figure 3, albeit lower. The reason is that the “Since 2000” scenario counts all emissions, or phrased differently, all emissions in excess of a zero allotment; any positive allotment would count less emissions, and shift the graph downwards. For the same reason, if we start counting at the year 1800, the result would have a shape very similar to the “since 1800” graph in Figure 3, but lower.

V. Compensations

In Section 3, we present alternative estimates of the impact of climate change on developing countries. In Section 4, we present alternative estimates of the contribution of the OECD to global warming. The compensation, hypothetically paid by the OECD to developing countries,³¹ follows from multiplying the estimated damage with the estimated contribution of cumulative OECD emissions to cumulative world emissions.

Figure 4 displays the results for one view on responsibility (cumulative emissions since 2000) and six alternative damage estimates. Compensations vary between zero – if only market impacts are compensated (as market impacts are positive) – and 4% of the GDP of the OECD – if only negative impacts count – towards the end of the 22nd century. Using the output-weighted estimates of Tol, compensation is small in the 21st century but amounts to 0.5% GDP in the 22nd century. For equity-weighted damages, compensation is more than twice as high in the later years, while also substantial compensation is paid in the earlier years. Compensation is also paid in the earlier year if WTAC rather than WTP is used as the basis for non-market valuation. In the later years, compensations increase to about 2% of GDP.

Figure 5 displays compensations according to one impact estimate (output-weighted Tol) and three alternative views on responsibility. If OECD responsibility is measured as cumulative OECD emissions since 2000 relative to cumulative world emissions since 1800, compensation amounts to an annual .4% of GDP in the long run. This number goes up to .5% of GDP if emissions since 1800 matter, and down to .3% if emissions in excess of “Kyoto” matter.

Figure 6 displays the results for three alternative development scenarios. Note that the scenarios differ both in their impact estimates (output-weighted Tol) and in their responsibilities (cumulative emissions since 2000). Compensation is about a .4% of GDP per year in the long term for the IS92a scenario. This number increases to .5% for IS92f, and falls to .3% for IS92d.

Figure 7 shows the compensation split out over the OECD, using the output-weighted Tol estimates, IS92a, and cumulative emissions since 2000. The USA and Canada (OECD-America) would pay up to .6% of their GDP, Western Europe (OECD-Europe) up to .5% of GDP, and Japan, Australia and New Zealand (OECD-Pacific) up to .2% of GDP.

³¹ In reality, compensation would be paid by one country to another, or even at a lower level of aggregation (e.g., company to individual). The model’s regional resolution does not allow an analysis of that. Besides, an *ex ante* analysis in that detail makes little sense.

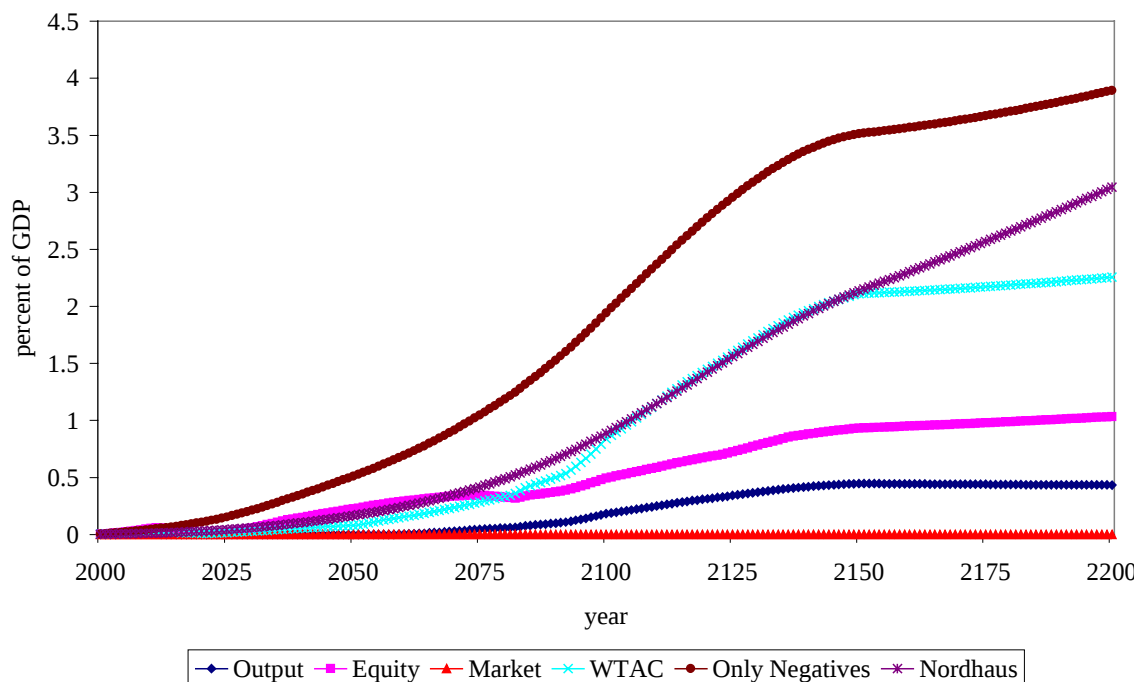


Figure 4. The compensation paid by the OECD to less developed countries as a percentage of the GDP of the OECD. The scenario is IS92a, the compensation is paid on the basis of cumulative emissions since 2000. Six alternative impact estimates are used, as in Figure 2.

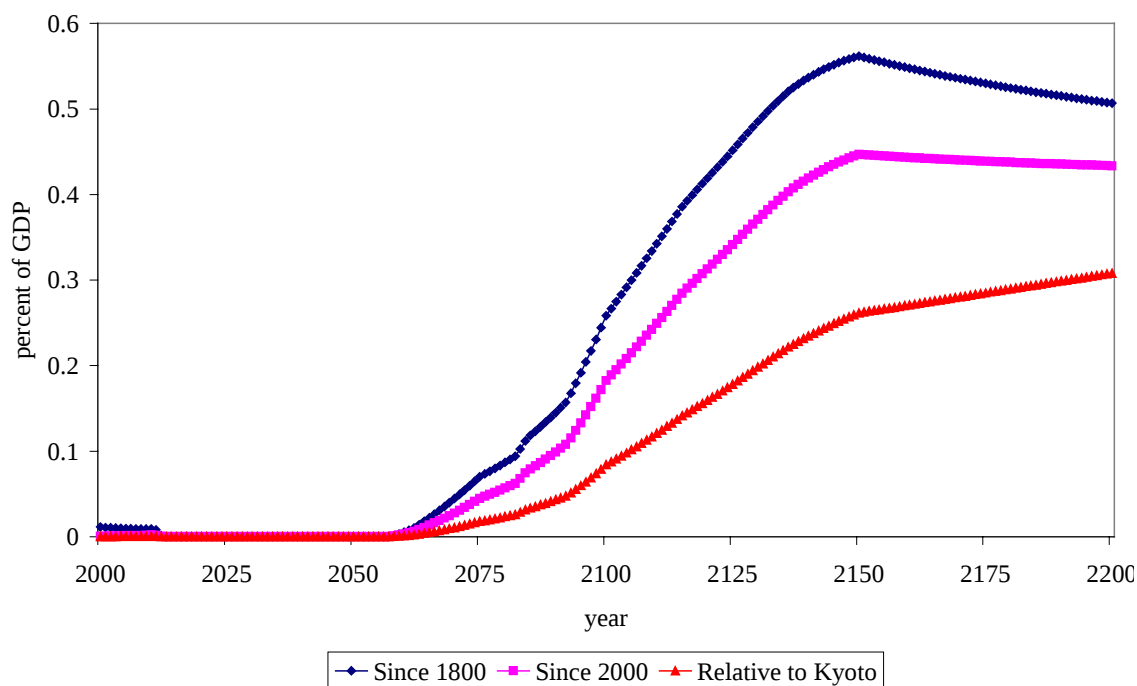


Figure 5. The compensation paid by the OECD to less developed countries as a percentage of the GDP of the OECD. The scenario is IS92a, the damages are the output-weighted impact estimates of Tol. Compensation is paid on the basis of three alternative views on responsibility, as in Figure 3.

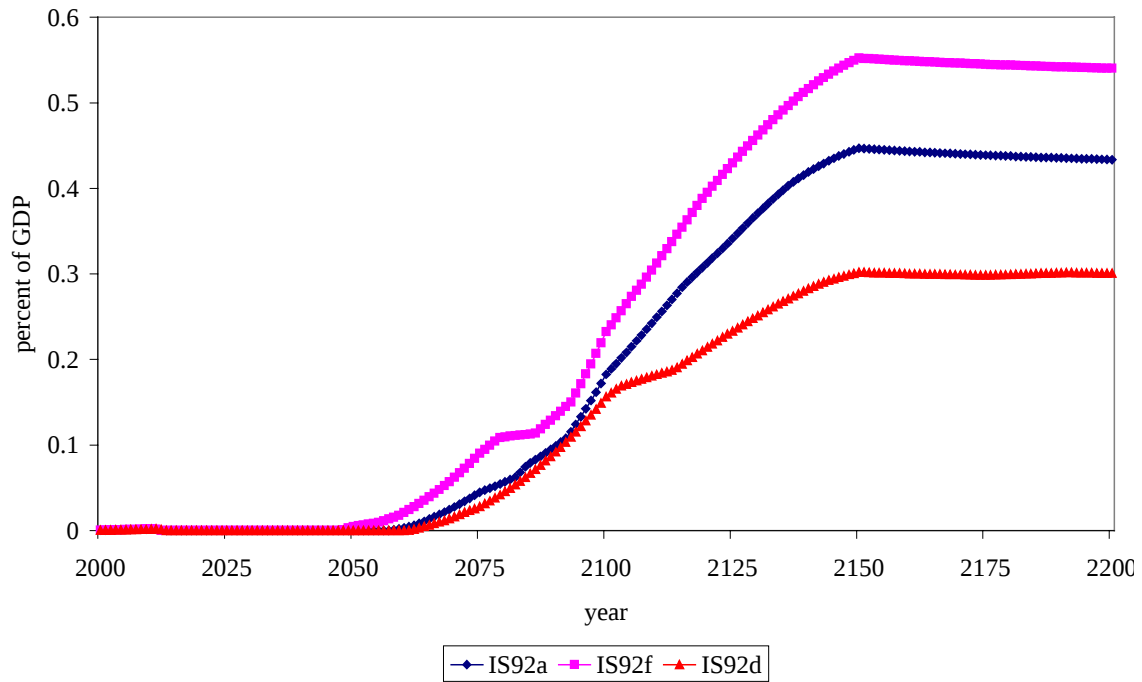


Figure 6. The compensation paid by the OECD to less developed countries as a percentage of the GDP of the OECD. The damages are the output-weighted impact estimates of Tol, the compensation is paid on the basis of cumulative emissions since 2000. Three alternative development scenarios are used, as in Figures 2 and 3.

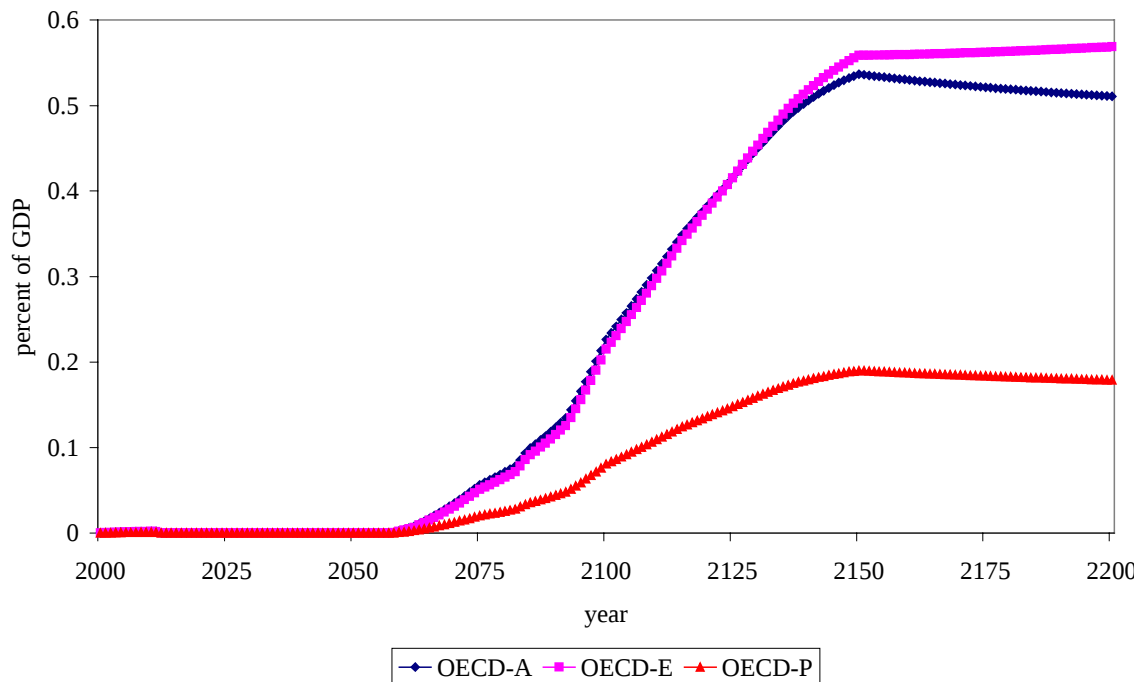


Figure 7. The compensation paid by the various OECD regions to less developed countries as a percentage of the GDP of the OECD. The damages are the output-weighted impact estimates of Tol, the compensation is paid on the basis of cumulative emissions since 2000, and the scenario is IS92a.

VI. Discussion and conclusion

International law does provide some basis for liability for climate change impacts, while also many gaps remain. The crucial issue is whether countries are responsible for all greenhouse

gas emissions and the resulting damages, or only for emissions in excess of a reasonable emission abatement target. In the latter case, the OECD carries only limited responsibility for climate change, as in the past emissions were unregulated and in the future non-OECD emissions are much larger. This case is, legally, more likely. If, however, countries are responsible for all emissions, then it matters when one starts counting. If one counts all emissions from the time governments could have known about climate change, OECD responsibility is large. If one starts counting at the time climate change was officially recognised as a policy problem, OECD responsibility is much smaller.

These questions have a much greater influence on OECD responsibility than do the uncertainties about future emissions.

Assuming that the OECD will be held accountable and will compensate developing countries for damages incurred, the question is for what and how much. This question cannot be answered with any accuracy, as estimates of the impacts of climate change are very uncertain, as are future law suits. Important issues are the magnitude of climate change impacts; whether non-market impacts on health and ecosystems are also compensated; whether compensation is paid for adaptation costs and residual damages only, or whether compensation also includes reparation for imposed damage; and whether positive impacts offset negative ones or not. These issues make billions of dollars of difference in the actual compensation paid. Legally, it seems likely that only "obviously measurable" damages will be compensated, that reparation let alone punitive damages will not be paid, and that positive impacts will be ignored.

The compensation by the OECD to developing countries would imply a transfer of up to 0.25% of GDP in the short run and up to 4% of GDP in the long run. This compares to 0.2% currently paid in development aid, the 0.7% UN goal for official development aid and 0.8% percent annually in foreign direct investments. Potential compensation paid could also be much higher than the climate change impacts on the OECD.

This means that, should liability for climate change impacts be taken seriously, it would substantially affect not only the climate change bill footed by the OECD, but also North-South investment and trade patterns. The wider implications of this require considerable further analysis. On the policy level, states might wish to start developing global solutions to tackle the issue of future climate change damages (see Whitmore, 2000; AOSIS 1991) as legally, ignoring the problem will not exonerate polluters in the future.

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