I.2 The precautionary principle and climate change

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Abstract
The chapter aims to summarize the current knowledge and highlight further research directions on the role that the precautionary principle (PP) is likely to play in climate change. Though there is no shortage of books and articles on the legal status of the PP, legal scholarship is thin with regard to its relationship with climate change (CC). Against this background, it attempts to shed light on the UN Framework Convention on Climate Change (UNFCCC) definition of precautionary measures. In particular, it reviews different thresholds that are likely to limit the scope of such measures: the minimal level of knowledge, the significance of the damages, and the cost-effectiveness of the measures.

Keywords
Uncertainty, false positive and negative errors, seriousness and irreversibility of environmental damages, risk assessment and risk management, cost-effectiveness

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I.2.1 Introduction

Even though the UNFCCC provides its own definition of the PP, it seems appropriate to recall succinctly its core elements and to distinguish it from a preventive approach. According to the latter, the intervention of the decision-maker is conditional upon tangible threats for the environment. On the other hand, the PP requires that authorities address risks that are uncertain in so far as there is no definitive proof of a causal link between the suspected activity and the environmental harm or the likelihood of any materialization of this risk. In other words, the absence of scientific certainty or, conversely, the scientific uncertainty as to the existence or the extent of a risk should not delay the adoption of preventive measures intended to protect the environment. The principle thus expresses a philosophy of anticipated action, not requiring that the entire *corpus* of scientific proof be collated in order for an authority to act preventively.

The statute of the PP in international law is still dogged by controversies, although there is an ongoing trend to recognize the PP as a customary international rule.[1] As far as the practice of Western European states is concerned, the author takes the view that the PP fulfils the criteria regarding the creation of a customary international law as laid down by the International Court of Justice (ICJ) in the *North Sea continental shelf* case.[2] Whether such a recognition is likely to have practical impacts on EU Member States' policies remains to be seen.

I.2.2 The specificity of climate change risks

The risks stemming from CC are fundamentally different from earlier industrial types of risks for four reasons.

First, CC risks have much wider and diffuse impacts. The impacts of CC are global and not merely local.

Secondly, the changes are unprecedented since the end of the last ice age. Its pace is rapid compared with ordinary historical rates of CC, as well as rapid with the adjustment of ecosystems.[3] In contrast to industrial risks, we cannot learn from past experience. Given the novelty of this phenomenon, it seems relevant for decision-makers to reckon upon the PP, which applies precisely to hypotheses where clear experience is lacking.

Thirdly, given its dimension and its novelty, being undoubtedly the crucial difference, CC is permeated by uncertainty. It is impossible to determine the regularity and probability of the damage CC may provoke, in terms of

- time of latency between the increase of temperatures and the actual impact of damage (gradual or abrupt),
- speed (acceleration or deceleration),
- frequency of natural events (e.g. floods),
- duration (persistent, reversible, slowly reversible, irreversible, multigenerational),
- extent (cumulative or synergistic, serious or insignificant),
- localization (e.g. change in the regional distribution of precipitation),
- impacts (e.g. human health, biodiversity loss and agricultural yields), and
- scale (global, continental or regional).

Uncertainty pervades these issues. Indeed, uncertainty affects the calculation of the speed of the phenomenon as well as the nature and scope of the damages it may entail. In approaching such questions, scientists put forward hypotheses rather than assertions. Some uncertainties have decreased over time whereas others are still lingering due to

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1 See Foster (2011) 21; *Request for an examination of the situation in accordance with the Court's judgment in the Nuclear test case (New Zealand v France)* [1995] ICJ Rep 288, dissenting opinion of Judge Palmer, [1995] ICJ Rep 142; *Tătar v Romania* App no 67021/01 (ECtHR, 27 January 2009); Advisory Opinion of the Seabed Disputes Chamber of ITLOS on 'Responsibilities and Obligations of States Sponsoring Persons and Entities With Respect To Activities in the Area'. In that opinion, the Chamber considered the PP as an integral part of the due diligence of sponsoring states which is applicable even outside the scope of the regulations at issue. Most significantly, the Chamber recognized a trend towards making this approach part of customary international law. See also McIntyre and Mosedale (1997) 221.

2 *North Sea continental shelf case* [1969] ICJ Rep 3, paras 41–43.

3 Holdren (2009) 5.

irreducible ignorance or disagreement between what is known and unknowable. Let it be noted that the PP invites the decision-maker to take account of considerably extended timescales, as uncertainty largely resides in the period between a cause and the subsequent manifestation of a harmful effect.

Moreover, this 'cascade of uncertainties'[4] is likely to be compounded by

- natural factors (resilience of ecosystems,[5] reversibility or irreversibility of the damages), and
- anthropogenic factors (e.g. consumption policy choices, demographic trends, increase in trade and GDP growth, technological innovation).

It is in this context important to stress that according to the Intergovernmental Panel on Climate Change (IPCC) 'aspects of uncertainty are associated with each link of the causal chain of climate change, beginning with GHG emissions, covering damage caused by climate change, followed by a set of mitigation and adaptation measures. In particular, damage-function estimates are prone to low confidence as they involve uncertainty in both natural and socioeconomic systems.'[6] It thus comes as no surprise that the intermingling between these natural and socio-political factors prevent clear-cut answers on many questions of particular importance for decision-makers.[7]

Last but not least, whereas the costs of damages caused by industrial pollution can be calculated somewhat accurately, CC risks may give rise to damage outside the realm of commerce and thus be impossible to evaluate. Moreover, for a risk to be insurable, it must be as objective as possible. Given the dearth of statistical data concerning the frequency or intensity of heavy precipitation events, droughts and floods, and their average costs, it is difficult to insure the risks stemming from CC. Furthermore, given that many damages will not be easily translated into monetary terms, the benefits of CC policies are difficult to estimate accurately.

I.2.3 Anticipatory approach v business as usual

In a context of incomplete knowledge and in the course of the 1980s, the international community had to deal with the question of whether public authorities should act under conditions of uncertainty to parry a threat of CC that was merely suspected.[8] Or should they first have to reduce the margin of uncertainty (avoiding thus false positive errors), even if it meant delaying action?

Several Western states pushed in favour of the adoption of a precautionary strategy by limiting the emission of GHGs.[9] The potentially serious consequences of CC justified

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[4] Haritz (2011) 16.

[5] Despite the efforts of the scientific community, there is still no hope of fully understanding the complexities of the interactions of the atmosphere, the oceans and greenhouse gas (GHG) in stabilizing the climate.

[6] IPCC, 2014: *Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects, Contribution of Working Group III*, 10.4.2.2 Precautionary Considerations.

[7] Grassl and Metz (2013) 309.

[8] Iverson and Perrings (2011) 11.

[9] Grassl and Metz (2013) 320–21.

preventive action in spite of lingering uncertainties. What is more, 'it may be less costly to spread the costs of averting CC by beginning mitigation efforts early, rather than to wait several decades and take actions after the problem has already advanced much further'.[10]

However, other states wanted to delay the adoption of a regulatory approach until the CC hypothesis had been validated. The proponents of this 'business as usual' strategy took the view that embracing an anticipatory approach would sacrifice economic welfare for the sake of avoiding an event that was not likely to occur (false positive errors). They gave priority to further research in order to assess, first, the existence of a cause-and-effect relationship between the release of GHGs since the Industrial Revolution and CC, and, secondly, the probability of adverse effects and the extent of the ensuing damage. By avoiding hasty and precipitate costly regulatory measures (false positive), their delayed stance appeared to be more proportionate to the suspected risk.

I.2.4 Recognition of the right to enact precautionary measures under the UNFCCC

I.2.4.1 Genesis

The UNFCCC provides for the following obligation

> [T]he Parties should take precautionary measures to anticipate, prevent or minimize the causes of climate change and mitigate its adverse effects. Where there are threats of serious or irreversible damage, lack of full scientific certainty should not be used as a reason for postponing such measures, taking into account that policies and measures to deal with climate change should be cost-effective so as to ensure global benefits at the lowest possible cost. (Article 3(3)).

Moreover, the Preamble to the Convention calls upon parties to prevent damage even if there are 'many uncertainties in predictions of climate change, particularly with regard to the timing, magnitude and regional patterns thereof'. Given the lingering uncertainties in 1992, the proclamation of the PP in the UNFCCC was a touchstone issue.[11]

Though the 1997 Kyoto Protocol does not mention the PP, political precautionary action was nonetheless strengthened at a time when scientific knowledge was still giving rise to conflicting opinions.[12]

It should be noted that Article 3(3) is worded in such a way that its statutory language is less forceful than in other multilateral environmental agreements (MEAs). First, precaution has been coined here neither as a *principle* nor as an *approach*. In order to avoid such a debate – while an approach is rather vague from a legal point of view, a principle entails legal effects – the authors of the Convention refer to 'precautionary measures'. Secondly, given that the parties 'should' and not 'shall' enact these measures, Article 3(3) is far less prescriptive than other treaty obligations. Thirdly, Article 3(3) encapsulates a right to take preventive measures and not an obligation to act. Fourthly, unlike other MEAs, the precautionary measures do not coexist with other environmental principles, such as the polluter-pays prin-

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[10] IPCC, 2014: *Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects, Contribution of Working Group III on mitigation*, 1.2.4 The Role of Uncertainty.

[11] Grassl and Metz (2013) 338.

[12] ibid 326.

ciple. In sharp contrast, under EU treaty law, the PP takes its place – without definition – beside the principles of prevention, rectification at source and the polluter-pays principle (Article 191(2) Treaty on the Functioning of the European Union (TFEU)). All these principles are deemed to contribute to achieving the objectives of the EU environmental policy laid down under Article 192 TFEU, among which the fight against CC. Moreover, the EU Treaties require both the EU institutions and the 28 Member States to achieve a high level of environmental protection (Articles 3(3) Treaty on European Union (TEU) and 191(2) TFEU). That said, in spite of its place in treaty law, the PP has not been proclaimed in the different EU directives and regulations addressing CC issues. Nor has it been applied by the Court of Justice of the EU in adjudicating CC cases, perhaps on account of the fact that none of these cases dealt with a context of scientific uncertainty.

I.2.4.2 Scope of application of the precautionary measures pursuant to Article 3(3) UNFCCC

Regarding the material scope of the precautionary measures, the activities likely to be subject to precautionary CC measures are extremely broad. Paragraph 3 calls for preventive and mitigation measures which are not predetermined, and these can take the form of *inter alia* bans, requirements of best available technologies, cap and trade, carbon taxes, removing fuel subsidies, etc. Given that the PP does not command any specific measure, the Parties are endowed with much leeway and each measure has to be determined on a case-by-case basis taking into consideration the different 'socio-economic' contexts. Needless to say, they have to be consistent with World Trade Organization (WTO) law.[13]

With respect to their temporal scope, Article 3(3) does not provide for any temporal limit and could accordingly apply to damages which occurred generations after the release of GHG.

Last, these measures either 'anticipate' or mitigate' CC risks. This two-pronged aim is somewhat paradoxical on account of the fact that the PP is reckoning upon an *a priori* and not an *a posteriori* approach.

I.2.4.3 Critical analysis of the risk thresholds set out in Article 3(3) UNFCCC

So far all the provisions in different legal orders expressly embodying the PP share a number of common features (type of damages to be averted, CBA requirement, proportionality, etc.) with Article 3(3) UNFCCC.[14] By defining the risk to be averted ('lack of full scientific certainty') and specifying the damage likely to occur (which should be 'serious or irreversible'), Article 3(3) UNFCCC is setting out two thresholds aiming to limit the adoption of precautionary measures. Once these thresholds have been crossed, a precautionary measure may be taken to avert the anticipated CC risk, but it should be 'cost-effective so as to ensure global benefits at the lowest possible cost'. All in all, these three thresholds assume that the earth can assimilate a certain level of change of the climate and ensuing damages that are not too serious or irreversible.

These thresholds are critical because of the context of uncertainty which justifies the

13 Voigt (2008).
14 de Sadeleer (2005) 155–201.

use of precaution. However, state authorities are not precluded from embracing a more environment-friendly interpretation of the PP. Below, the difficult interpretation of the requirements will be discussed.

I.2.4.3.1 First requirement: 'lack of full scientific certainty' This requirement of the UNFCCC is in line with other MEAs. Hence, the application of the precautionary measures depends on minimal evidence of the probability of a risk; they must be linked to a minimum of knowledge, that is to say, to scientific grounds with a demonstrated degree of consistency. The fact of referring to a 'lack of full scientific certainty' allows public authorities to reckon their action upon reasonable scientific uncertainty, even if this evidence does not enjoy unanimous scientific support. In other words, knowledge of the more or less predictable nature of the CC risks does not have to be entirely validated. Given that there is a 'lack of full scientific certainty', further information is requested either as to cause-and-effect relationships or as to the extent of damages that are likely to occur.

Uncertainty has been taking centre stage in the IPCC reports. Explicit assignment of the author's confidence in the underlying science backs up each conclusion.[15] The type, the amount, the quality and the consistency of the evidence determines the level of certainty. Evidence is thus expressed either qualitatively or quantitatively. Hence, the degree of certainty is expressed as a qualitative level of confidence (from very low to very high), and, when possible, probabilistically with a quantified likelihood (from exceptionally unlikely to virtually certain).[16] Moreover, modelling varies from simple to comprehensive.[17]

Though evidence that CC has a man-made origin has strengthened continuously since the 1995 IPCC report (with 'very high confidence' in AR4 to 'extremely likely' in AR5),[18] 'the connections between emissions of GHGs and climate change are not yet fully understood'.[19] The speed with which oceans and land ecosystems will continue to act as 'sinks' or will become saturated cannot be clearly established. The cooling and warming effects of aerosols are dogged by uncertainty. Uncertainty in aerosol radiative forcing complicates the assessment of climate sensitivity.[20]

On the one hand, the scientific community is now convinced that CC entails significant damages. On the other hand, despite the consensus among scientists regarding the man-made origin of CC, they have not yet reached full agreement on the scope, the rapidity of the phenomenon and the ensuing damages. In particular, the interaction between natural and anthropogenic factors is impossible to assess with accuracy: oceans and forests can

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15 IPCC Cross-Working Group Meeting on Consistent Treatment of Uncertainties, *Guidance Note for Lead Authors of the IPCC Fifth Assessment Report on Consistent Treatment of Uncertainties* (2010).

16 IPCC, 2014: 'Summary for Policymakers' in *Climate Change 2014*, 4.

17 ibid 19.

18 ibid 17.

19 IPCC, 2014: *Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects, Contribution of Working Group III on mitigation*, 1.2.4 The Role of Uncertainty.

20 Mastrandrea and Schneider (2009) 17–19.

undoubtedly re-absorb some portion of GHG emissions. However, increased evaporation of water from the ocean into the atmosphere is likely to result in more warming.[21] To make matters worse, natural catastrophes such as fires, likely to become more frequent, in turn are giving rise to further emissions that have not been hitherto adequately accounted for in climate models. If warming accelerates evaporation, resulting in the formation of clouds, the latter could in turn strongly amplify the warming phenomenon (by trapping infrared radiation) rather than serving to stabilize it (by reflecting solar rays).

Limited understanding of the physical mechanisms involved as well as the lack of observational data implies large uncertainty about the likelihood of CC events that have potentially very damaging consequence for the world.[22] The IPCC working group on mitigation has been stressing that 'evaluation of uncertainty and the necessary precaution is plagued with complex pitfalls'. These include 'the global scale, long time lags between forcing and response, the impossibility to test experimentally before the facts arise, and the low frequency variability with the periods involved being longer than the length of most records'.[23] What is more, imprecise, unreliable and inconclusive evidence, as well as irreducible ignorance, are additional hurdles.

Thus, a time element comes into play. A number of instances of ecological damage may show up belatedly. It is still impossible accurately to determine the extent of the ensuing disturbances and the speed with which they will occur. By way of illustration, most recent IPCC estimates indicate that global mean sea level could rise due to a few degrees' increase between 0.26 to 0.98 metres.[24]

The uncertainty surrounding this swathe of phenomena is still likely to evolve in a completely unforeseen manner (large-scale discontinuities). Even greater uncertainties affect the regional impact of CC. Some regions of the world will experience unusually heavy rainfall; others will be affected by drought. Such changes will be exacerbated by the continuing severity of extreme weather events such as droughts, floods and heat waves, which characterize the phenomenon of CC. It is not possible to determine with accuracy the probability and the magnitude of each impact at regional or local level.[25]

It comes as no surprise that regarding long-term damage, the IPCC can provide forecasts encumbered with uncertainty.

Critics of the PP often set precaution and scientific knowledge against one another. The principle might somehow be seen *a priori* as being antithetical to the principles of scientific rigour in the regulation of risk (systematic methodology, scepticism, transparency, emphasis on learning, etc.). Within such a perspective, implementation of the PP essentially becomes a politically determined compromise which has nothing to do with 'sound science'.[26] These views are misleading. Obviously, the PP is not running against

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[21] ibid 21.

[22] EEA (2010) 22.

[23] IPCC, 2014: *Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects, Contribution of Working Group III on mitigation*, 10.4.2.2 Precautionary Considerations.

[24] IPCC, 2014: 'Summary for Policymakers' in *Climate Change 2014*, 25.

[25] van der Sluijs and Turkenburg (2006) 245.

[26] Bergkamp and Kogan (2013) 493.

science.[27] To the contrary, the PP promotes scientific research with a view to justifying the soundness of anticipatory measures. Faced with the growing complexity and globality of the CC phenomenon, complete scientific certainty is the exception, rather than the norm. Strictly speaking, one cannot expect CC experts to express their scenarios in a definitive manner. A paradigm of uncertainty has taken the place of certainty. The fact that the IPCC takes into consideration this context of uncertainty explains why climate science is evolving continuously.

As a matter of course, the intrusion of uncertainty seriously disturbs the relations with the political authorities that scientific circles have patiently built up over time. The decision-maker always seeks reassurance through certainty; he therefore expects scientists to provide simple and categorical answers from which he can deduce political decisions. To the contrary, the IPCC reports assign different confidence levels, and express doubts and even ignorance. As stated by the IPCC, 'some of these uncertainty aspects may be irreducible in principle, and hence decision-makers will have to continue to take action under significant uncertainty, so the problem of climate change evolves as a subject of risk management in which strategies are formulated as new knowledge arises'.[28] Hence, the IPCC has to work to overcome the aversion of the political class to everything that is imprecise, improbable or uncertain. From the perspective of precaution, the focus is placed upon strengthening the duty of care to overcome the lingering uncertainties. The PP invites experts to anticipate what they do not yet know, to take into account the most far-fetched forecasts and even to tackle ignorance, though it cannot gear the response to such possibilities as such.

I.2.4.3.2 Second requirement: 'serious or irreversible' damages With this requirement, the authors of the UNFCCC took the view that a threshold had to be set in order to avoid an over-use of these measures.[29] As a result, states are obliged to restrict the application of their precautionary measures to certain categories of damages. Does that condition make sense?

Let's contemplate first the condition of 'seriousness', a highly subjective concept which is perceived quite differently depending on location, period in time, and persons affected. Against which background would it be possible to assess whether the precautionary measure aims at eschewing a 'serious' risk? Article 3(3) should be read in conjunction with Article 2, which sets forth the objective of the Convention, which is to 'stabilize greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system'. In order to flesh out that goal, the Copenhagen Accord included the long-term goal of limiting the maximum global average temperature increase to no more than 2 degrees Celsius above pre-industrial levels, subject to a review in 2015. It also included a reference to considering limiting the temperature increase to below 1.5 degrees on the basis of new scientific insights. As a matter of course, this is far from

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27 EEA (2001); de Sadeleer (2005) 192–95.

28 IPCC, 2014: *Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects, Contribution of Working Group III*, 10.4.2.2 Precautionary Considerations.

29 In so doing, Article 3(3) copied and pasted thresholds that were already set out in other MEAs. See the 1976 Barcelona Convention for the Protection of the Mediterranean Sea against Pollution (as amended in 1995) and 1992 Rio Declarations.

being a zero risk approach, given that an increase of 2 degrees Celsius amounts to serious consequences.[30] The Paris Agreement from 12 December 2016 has now codified the goal of holding the increase in the global average temperature to well below 2 degrees Celsius and pursuing efforts to limit the temperature increase to 1.5 degrees Celsius, thereby recognizing that this would significantly reduce the risks and impacts of climate change.

The Paris Agreement illustrates that there is no serious doubt that the CC issue is one where humankind confronts a threat of serious damage. As discussed above, CC is likely to entail a swathe of short-term as well as long-term impacts ranging from the collapse of marine-based sectors of the Antarctic ice sheet to the weakening of the Atlantic Meridional Overturning Circulation. The rise in temperatures has already had serious impacts at global level (sea level rise, melting of glaciers, increase in acidification in all ocean surface waters, increased risk of wildlife extinction, etc.). Moreover, several examples of the damage contemplated in the IPCC reports are catastrophic in nature. From a global perspective, poor nations and communities are more at risk on account of the fact that they have a low capacity to adapt.[31] To conclude, given that according to two of the four scenarios (RCP8.0 and RCP8.5) global temperature increase is likely to exceed the 2 degrees Celsius above pre-industrial levels by the end of this century,[32] CC precautionary measures do address a serious, let alone a significant risk.

We turn now to the risk of irreversible damage. Since irreversibility may be scientifically, objectively determined, this condition might appear easier to determine than the risk of serious damage. Under a reversible scenario, the system affected by CC can be returned to its original state. In contrast, an irreversible situation is irrevocable: it is impossible to return to the point of departure. Accordingly, we should ask ourselves if it is correct to equate the concepts of seriousness and irreversibility: for while irreversible damage is always serious, the opposite is not necessarily the case. Whereas the risk of irreversible impacts (also called tipping elements) was considered to be low in the early 2000s, they are nowadays considered with ever decreasing uncertainty to be moderate for the same increases in temperatures. By way of illustration, forest die-off provoked by CC will increase wildfires and lead to more warming. As a result, the shrinkage of carbon sinks will form a positive feedback compounding the impacts of CC.[33] Given that small shifts in the climate system can trigger large-scale and often irreversible damage,[34] this second condition is fulfilled.

I.2.4.3.3 Third requirement: cost-effectiveness of the precautionary measure The proclamation of the PP in various legal orders was aimed at reintroducing more political common sense into decision-making. Accordingly, where risks are deemed unacceptable, they must be prevented absolutely. To the contrary, Article 3(3) UNFCCC requires that precautionary measures must 'be cost-effective so as to ensure global benefits at the lowest possible cost'. Such requirement raises more questions than answers. Voigt takes the view that the cost-effectiveness requirement does not encompass a CBA approach:

30 Grassl and Metz (2013) 327.
31 EEA (2010) 5, 22.
32 IPCC, 2014: 'Summary for Policymakers' in *Climate Change 2014*, 20.
33 Fearnside (2009) 104.
34 EEA (2010) 23.

there can be no question of mitigation or adaptation on the grounds that Article 3(3) places emphasis upon mitigation.[35]

Does such obligation require the public authorities to carry out a classical CBA to assess whether the precautionary measure is cost-effective enough before taking any action? Such an obligation does not address the issue of defining what 'costs' are 'economically acceptable' and for whom, how to determine the 'global benefits', how to balance the economic losses incurred by CC and the potential economic benefits of preventive action, and how to take into consideration non-quantifiable values, etc. Is some kind of proportionality test implied? In effect, this requirement poses more questions than it solves.

The majority of environmental economists nowadays take the view that examining costs and benefits entails comparing the overall cost to the community of action and lack of action, in both the short and long term. However, the economic methodology to be used can be flawed as long as economic analysis remains incapable of correctly internalizing all externalities in a context of uncertainty. In effect, the uncertainty inherent in precaution increases the possibility that ecological interests could systematically be compromised compared to competing interests since, as recalled above, the gravity of suspected damage can only be known in an approximate manner. This raises the chicken-and-egg question of whether it is better to anticipate severe risks whatever the costs of immediate action or to delay action so long as the risks are not occurring. The latter option can give rise to irreversible and costly damage which could be averted by timely action. Account must be taken of the *2007 Stern review on the economics of CC* stating that the costs of aggressive preventive action are substantially lower than the costs of climate impacts and adaptation measures.[36]

Last but not least, in a case brought by a Dutch NGO regarding the duty of the Netherlands to limit annual GHG emissions, the Hague District Court reviewed the onerousness of taking precautionary measures. This judgment provides some insights into the understanding of the cost-effectiveness requirement. The Court held that:

> Various aspects can be discerned in this. For instance, it is important to know whether the measures to be taken are costly. Moreover, it may also be important to establish whether the precautionary measures are costly in relation to the possible damage. The effectiveness of the measures can also be relevant. Finally, significance should be attached to the availability of the (technical) possibilities to take the required measures.[37]

The Court concluded that 'in view of the latest scientific and technical knowledge it is the most efficient to mitigate and it is more cost-effective to take adequate action than to postpone measures in order to prevent hazardous climate change'.[38] Accordingly, it ordered the Dutch state to limit annual GHG emissions from the country to 25 per cent below 1990 levels by 2020.

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35 Voigt (2008) 107.
36 See also OECD (2012) 73.
37 The Hague District Court, 24 June 2015, *Urgenda Foundation v The Netherlands*, §4.67.
38 §4.73.

I.2.5 Conclusions

The scope of application of the precautionary measures as stated in the UNFCCC is connected to a number of thresholds. Many critics contended in 1992 that too bold an interpretation of the PP generates false positive errors leading to over-regulation at the expense of welfare considerations. By and large, given the sheer extent and the speed of CC 23 years later all these thresholds are exceeded.

Though observed warming is unequivocal, for long-term damages scientists are still facing a high level of uncertainty compounded by socio-economic impacts. Future emissions abatement policies can strongly influence the first source of uncertainty: the level of impacts. However, scientists are unable to assign precisely what the severity of impacts will be for a specific trajectory for future emissions.[39] If the PP makes it difficult to delay adopting measures to prevent environmental degradation on the grounds that scientific certainty has not been established, scientific certainty or 'sound science' can no longer, *a contrario*, be considered as the absolute reference criterion for long-term decision-making. From a legal perspective, as stressed by Haritz,[40] preventive action is needed given that liability claims are likely to be confronted by major hurdles (causal connection, diffuse damages, retroactivity, etc.).[41]

Despite more accurate and reliable evidence as to the actual and potential impacts of CC, the international community is still falling short of adopting a robust GHG abatement strategy.[42] Therein lies the paradox. How much science is needed to trigger preventive action? As stressed in the IPCC 5th ACR, when the overwhelming evidence is so compelling and the costs are mounting, 'substantial and sustained reductions of GHGs emissions' are required to limit further CC.[43] The author is of the view that the PP should lead to more vigorous action.

It should be pointed out that the PP does not play any role in deciding the allocation of the costs of the preventive and mitigation measures. This issue must be resolved in the light of the polluter-pays principle and the principle of common but differentiated responsibility.

Given that precautionary considerations appear today to have a modest effect on climate policy action,[44] there have so far been few attempts in legal circles to assess the consistency of CC measures with the PP. Uncertainty remains a matter of debate among scientists. Against this background, new directions of cutting-edge research are needed regarding the merits and weaknesses of different precautionary measures, the ways in which liability regimes could integrate uncertainty, the interaction between CC risk assessment and risk management, etc. What is a dangerous interference with the climate system is also likely to become a touchstone issue.

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39 Mastrandrea and Schneider (2009) 26.
40 Haritz (2011) 15.
41 de Sadeleer (2005) 211–21.
42 Grassl and Metz (2013) 336.
43 IPCC, 2014: 'Summary for Policymakers' in *Climate Change 2014*, 19.
44 Grassl and Metz (2013) 338.

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