Jean Monnet Working Paper Series

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Environment and Internal Market

Vol. 2016/1

Climate Change, Uncertainties and the Precautionary principle

by

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Published on http://www.desadeleer.eu

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1. Introduction

Arising in the mid-1980s from the German *Vorsorgeprinzip*, the precautionary principle (PP) has throughout these last two decades been widely invoked within international legal circles and legitimated in a swathe of international treaties. In addition, it has come to occupy an uncontested position in EU environmental and food safety law as well as in different national legal orders in Europe, to the point where it overshadows a number of other principles such as the principle of prevention or the polluter pays principle.

Even though the UNFCC 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 which 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 materialisation 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. In spite of these controversies, there is an on going dynamic of tending to recognise the PP as a customary international rule.[1] As far as the practice of Western European States is concerned, we are

[1] See CE Foster, *Science and the precautionary principle in international courts and tribunals. Expert evidence, burden of proof and finality* (CUP, Cambridge 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; 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

taking the view that the PP fulfils the criteria regarding the creation of a customary international law as laid down by the ICJ in the *North Sea continental shelf* case [2].

The chapter aims to summarize the current knowledge on the role that the precautionary principle could play in climate change (CC) policies. Though there is no shortage of books and articles on the legal status of the PP, legal scholarship is rather thin with regard to its relationship with CC.

2. The specificity of CC risks

Environmental law at the outset focused on industrial risks. Accordingly, the policy principles underpinning this legal branch were related to these risks (e.g. prevention, rectification at source, self-sufficiency regarding waste management, etc.). The risks stemming from CC are fundamentally different from earlier industrial types of risks for four reasons.

Firstly, while the industrial risk preventive policies assumed by environmental agencies concerned either individuals (consumers, workers) or specific groups (neighbourhood, local communities), CC risks that have much wider and diffuse impacts. In fact, it is more a question of accumulation of greenhouse gases (GHG) in the atmosphere due to mass production, globalisation and free trade, intensive agriculture, increase of transportation by road and by air than of emissions from a limited number of industrial plants. As a result, the impacts of CC are global and not merely local (e.g. pollution of the Great Lakes or the North Sea). The expected CC winners and losers are unequally distributed across time and the world,[3] an issue giving rise to difficult questions of intergenerational equity.

Secondly, the changes are unprecedented since the end of the last ice age. Its pace is rapid compared with ordinary historic rates of CC, as well as rapid with the adjustment of ecosystems.[4] 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 that applies precisely to hypotheses where clear experience is lacking. Moreover,

Thirdly, given its dimension and its novelty, and this is 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 (storms, floods, droughts, wildfires, erosion),
- duration (persistent, reversible, slowly reversible, irreversible, multigenerational),
- extent (cumulative or synergistic, serious or insignificant),
- localisation (e.g., change in the regional distribution of precipitation, Artic region warming more rapidly than the normal mean, warming over land larger than over the ocean, increase concentration of ozone),

also O. McIntyre and T. Mosedale, 'The Precautionary Principle as a Norm of Customary International Law', (1997) 9 *Journal of Environmental Law* 221.

[2] *North Sea continental shelf case* [1969] ICJ Rep 3, paras 41-43.
[3] Grassl and Metz (2013) 309.

[4] J.P. Holdren, 'Introduction', in S Schneider and al. *Climate Change Science and Policy* (Island Press, 2009)5.

- impacts (human health, vulnerable countries, biodiversity loss, agricultural yields, tourism),
- and scale (global, continental, or regional).

Uncertainty is touching all 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 irreducible ignorance or disagreement between what is known and unknowable. Let 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'[5]is likely to be compound by

- natural factors (resilience of ecosystems,[6] reversibility or irreversibility of the damages),
- and anthropogenic factors (consumption and energy policy choices, demographic trends, increase in trade and GDP growth, land use changes, technological innovation, etc.).

It is in this context important to stress that according to the 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.'[7] 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.[8]

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, floods, and their average costs, it is difficult to insure the risks stemming from CC. Furthermore, given that many damages won't be easily translated into monetary terms, the benefits of CC policies are difficult to estimate.

3. Anticipatory Approach v Business as Usual

In a context of incomplete knowledge regarding CC speed and impacts in the course of the 80s, the international community was confronted to the following dilemma.[9] Should public

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[5] Haritz (2013) 16.

[6] 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 GHG in stabilising the climate.

[7] Working group III, 10.4.2.2 Precautionary Considerations.

[8] Grassl and Metz (2013) 309.

[9] T. Iverson and C. Perrings, 'The Precautionary Principle and Global Environmental Change, Ecosystem Services Economics', Working Paper Series (2011) 11.

authorities act under conditions of uncertainty to parry a threat of CC that was merely suspected? Or should they first had 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, limiting the emission of GHGs in response to the threat they posed to the stability of the climate.[10] The potentially serious consequences of CC justified preventive action in spite of lingering uncertainties. The stakes were too high to postpone key international decisions. Failing to act in due time would involve false negative errors. What is more, 'it may be less costly to spread the costs of averting climate change by beginning mitigation efforts early, rather than to wait several decades and take actions after the problem has already advanced much further'.[11]

Other States, on the other hand, wanted to delay the adoption of a regulatory approach until the CC hypothesis had been validated (Business as Usual Strategy). The proponents of that latter 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 researches in order to assess, firstly, of the existence of 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 ("let's wait and see what the experts propose"). By avoiding hasty and precipitate costly regulatory measures (false positive), their delayed stance appeared to be more proportionate to the suspected risk. Needless to say, such strategy meant delaying decisions.

4. Recognition of the right to enact precautionary measures under the UNFCCC

4.1. Genesis

The PP was accorded universal recognition at the UN Conference on Environment and Development in course of which the non-binding 1992 Declaration on Environment and Development proclaims: 'In order to protect the environment, the precautionary approach shall be widely applied by States according to their capabilities. Where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation.' (Principle 15)

Against this background, the 1992 Framework Convention on Climate Change (UNFCCC) provides for a rather similar obligation: 'the Parties should take precautionary measures to anticipate, prevent or minimise 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, he Preamble of the Convention calls upon Parties to prevent damages 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.[12]

[10] Grassl and Metz (2013) 320-321.
[11] See IPCC, Working group III on mitigation, 1.2.4 The Role of Uncertainty.
[12] Grassl and Metz (2013) 338.

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.[13]

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). Firstly, 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 don't coexist with other environmental principles, such as the polluter pays principle. 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 (Article 191(2) TFEU). All these principles are deemed to contribute to achieve the objectives of the EU environmental policy laid down under Article 192 TFEU, among which the fight against climate change. 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) 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 climate change cases, perhaps on the account that none of these cases dealt with a context of scientific uncertainty.

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

The aim of this section is to explore some key questions arising in discussion of the scope of ambit of that paragraph.

Regarding the material scope of the precautionary measures, the Convention acknowledges the right of States to enact measures deemed to be precautionary in order **'**to anticipate, prevent or minimise the causes of climate change and mitigate its adverse effects.' In contrast to MEAs whose scope of ambit is limited to hazardous substances,[14] the activities likely to be subject to precautionary CC measures are extremely broad. They may range from listed installations to aviation. Paragraph 3 calls for preventive and mitigation measures which are not predetermined. These can take the form of *inter alia* bans, restrictions, authorisations, emissions abatement, notifications, surveillance, requirements of best available technologies, cap and trade, carbon taxes, fees, removing fuel subsidies, etc. Accordingly, the Parties are endowed with much leeway in enacting their regulatory measures. Given that the PP does not command any specific measure, 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 WTO law.[15]

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[13] Grassl and Metz (2013) 326.
[14] Only hazardous substances are covered by the precautionary measures in the 1992 United Nations Economic Commission for Europe (UNECE) Convention on the Protection and Use of Transboundary Watercourses and International Lakes.
[15] C. Voigt (2008).

Regarding their personal scope, Article 3(3) applies to State Parties, though operators of undertakings emitting GHGs are likely to be subject to precautionary measures as well.

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 the account that the PP is reckoning upon an a priori and not an a posteriori approach. Obviously, authorities mitigate environmental damage when it's too late to prevent its occurrence.

4.3. Critical Analysis of the risk thresholds set out in Article 3(3) UNFCCC

Although the PP has been enshrined somewhat differently in the different legal orders, so far all the provisions embodying expressly the PP share a number of common features (type of damages to be averted, CBA requirement, proportionality, etc.) with Article 3(3) UNFCCC.[16] 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. What is more, 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 use of precaution. That being said, State authorities are not precluded to embrace a more environment-friendly interpretation of the PP. In the following subsections, we will examine the difficulties of interpretation raised by the level of scientific certainty required to trigger precautionary action (1st requirement), the type of damages (2nd requirement) as well as the cost-effectiveness of the precautionary measures (3rd requirement).

1st Requirement: 'Lack of full scientific certainty'

Introductory remarks

In requiring that only 'lack of full scientific certainty' triggers precautionary action, the UNFCC 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. Failing this, scientific uncertainty – which serves to advance knowledge – would be transformed into a sterile debate and would eventually serve to discredit research. A further observation must be made: 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 do 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.

[16] N. de Sadeleer (2005) 155-201.

Uncertainty has been taking centre stage in the IPCC Reports. Explicit assignment of the author's confidence in the underlying science is backing up each conclusion.[17] 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 law to very highly), and, when possible, probabistically with a quantified likelihood (from exceptionally unlikely to virtually certain). [18] Moreover, modelling varies from simple to comprehensive.[19]

The effect of uncertainty on cause-and-effect relationships

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)[20], 'the connections between emissions of GHGs and climate change are not yet fully understood'.[21] The speed with which oceans and land ecosystems will continue to act as "sinks" or will become saturated cannot be well-established. The cooling and warming effects of aerosols is dogged by uncertainty. Uncertainty in aerosol radiative forcing complicates the assessment of climate sensitivity. [22]

The effect of uncertainty on damage

On the one hand, the scientific community is now convinced that CC entails significant damages. For instance, sea levels will continue to rise, droughts and floods are likely to become more severe, etc. if nothing is done to reduce emissions of GHG into the atmosphere.

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 undoubtedly reabsorb some portion of GHG emissions. However, increased evaporation of water from the ocean into the atmosphere is likely to result in more warming.[23] To make matters worse, natural catastrophes such as volcano eruptions or fires likely to become more frequent, in turn are giving rise to further emissions. 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 stabilise 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.[24] 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

[17] 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).
[18] IPCC, SPM Summary for policymakers (2014) 4.
[19] Ibid., 19.
[20] Ibid., 17.
[21] IPCC, Working group III on mitigation, 1.2.4 The Role of Uncertainty.
[22] M. Mastrandrea and S Schneider, 'Climate Change Science Overview, in S Schneider and al. *Climate Change Science and Policy* (Island Press, 2009) 17-19.
[23] Mastrandrea and Schneider (2009) 21.
[24] EEA, *The European Environment State and Outlook 2010. Understanding Climate Change* (Copenhague, 2010) 22.

low frequency variability with the periods involved being longer than the length of most records'.[25] 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 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 (melting of the ice sheet, dwindling of estuarian environments, flooding of coastal plains, droughts, etc.). By way of illustration, most recent IPCC estimates indicate that global mean sea level could rise due to a few degrees' increase between O, 26 m to 0,98 metre.[26]

Our only certainty at present is precisely the uncertainty surrounding this swathe of phenomena, which are still likely to evolve in a completely unforeseen manner (large scale discontinuities). Even greater uncertainties affect the regional impact of climate change. 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 characterise 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.[27]

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

The PP calls for more research

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,...). Within such a perspective, implementation of the PP essentially becomes a politically determined compromise which has nothing to do with 'sound science'. These views are misleading. Obviously, the PP is not running against science.[28] 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

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[25] IPCC, Working group III on mitigation, 10.4.2.2 Precautionary Considerations.
[26] IPCC, SPM Summary for policymakers (2014) 25.
[27] van der Sluijs and Turkenburg (2006) 245.
[28] EEA, *Late Lessons from Early Warnings: the Precautionary Principle 1896-2000* (EEA, Copenhague, 2001) ; N de Sadeleer (2005) 192-195.

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'.[29] 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.

2nd Requirement: 'Serious or irreversible' damages

In considering that the precautionary measures should only apply to eschew risks entailing 'serious or irreversible' damage, the authors of the UNFCC took the view that a threshold had be set in order to avoid an over-use of these measures.[30] 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 consider 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 being a zero risk approach, given that an increase of 2°C amounts to serious consequences.[31]

In 2015, no one seriously doubts that the CC issue is one where humankind confronts a threat of serious damage. The fundamental importance of climatic conditions to maintaining life on earth leads people to take the prospect of global warming seriously. 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. Some damages, such as the loss of ecosystems, will appear somewhat insignificant in some countries whereas they will be taken seriously in other countries (desertification and reduced yields from agriculture in Africa; inland flash floods and increased erosion, glacial retreat in mountaineous areas in Europe). The rise in temperatures has already 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 damages contemplated in the IPCC reports are catastrophic in nature. As far as Europe is concerned, the threats are tangible (shrinking of artic ice, melting of Alpine glacier, potential deglaciation of the Greenland ice sheet). From a global perspective, poor nations and communities are more at risk on the account that they have a low capacity to

[29] Working group III, 10.4.2.2 Precautionary Considerations.
[30] 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.
[31] Grassl and Metz (2013) 327.

adapt.[32] To conclude with, given that according to 2 of the 4 scenario (RCP8.0 and RCP8.5) global temperature increase is likely to exceed for the end of this century the 2° C above pre-industrial levels,[33] 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) were considered to be low in the early 2000, they are nowadays considered with ever decreasing uncertainty to be moderate for the same increases in temperatures. By way of illustration, forest died-off provoked by CC will increase wildfires and would lead to more warming. As a result, the shrinkage of carbon sinks will form a positive feedback compounding the impacts of CC.[34] Given that small shifts in the climate system can trigger large-scale and often irreversible damage,[35] this second condition is fulfilled.

3rd Requirement: Cost-effectiveness of the precautionary measure

The proclamation of the PP in various legal orders was aiming at reintroducing more political common sense into decision-making. Accordingly, where risks are deemed unacceptable, they must be prevented absolutely and must not be subject to a cumbersome scientific risk assessment as well as a drudgery cost-benefit analysis (CBA). 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 is taking the view that cost-effectiveness requirement does not encompass a CBA approach: there can be no question of mitigation or adaptation on the grounds that Article 3(3) places emphasis upon mitigation.[36]

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, how to take into consideration non-quantifiable values, etc.

The majority of environmental economists are nowadays taking 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 internalising all externalities in a context of uncertainty. In effect, the uncertainty inherent in precaution increases the possibility that ecological interests could systematically be compromised

[32] EEA (2010) 5, 22.
[33] IPCC, SPM Summary for policymakers Summary for policymakers (2014) 20.
[34]P.M. Fearnside, 'Tropical Forests of Amazonia', in S Schneider and al. *Climate Change Science and Policy* (Island Press, 2009) 104.
[35] EEA (2010) 23.
[36] Voigt (2009) 107.

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.[37]

5. Conclusions

To conclude, it is worth observing that the scope of application of the precautionary measures as stated in the UNFCCC had to be rendered limited by a number of thresholds, such as the irreversibility and the seriousness of the damages, and the cost-effectiveness of the measures. Under multiple conditions of this sort, the recourse to precautionary measures under the UNFCCC was subject to excessive precaution. Indeed, many critics were contending 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, long-term damages, scientists are still facing a high level of uncertainty compound 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.[38] 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. Indeed, as it has been acknowledged by the IPCC, uncertainty is not an argument for delaying action. From a legal perspective, as stressed by Harwitz, preventive action is needed given that liability claims are likely to be confronted by major hurdles (causal connection, diffuse damages, retroactivity, etc.).

Whereas research scientific community has been gathering more accurate and reliable evidence as to the actual and potential impacts of CC, the international community is still falling short of adapting a robust GHG abatement strategy. Political decisions don't and perhaps won't in a near future match the emissions ceilings proposed to achieve the UNFCCC goal.[39] Therein lies the paradox. That begs the following question: how much science is needed to trigger preventive action? As discussed above, scientific evidence is required to enact precautionary action. Though there is an increasing amount of overwhelming evidence regarding the impacts of CC, action is still belated. As stressed in the IPCC 5th ACR, when the overwhelming evidence is so compelling and the costs are mounting, 'substantial and

[37] See also *OECD Environmental Outlook to 2050. The Consequences of Inaction* (OECD Publishing, 2012) 73.
[38] Mastrandrea and Schneider (2009) 26.
[39] Grassl and B. Metz (2013) 336.

sustained reductions of GHGs emissions' are required to limit further climate change.[40] We are of the view that the PP should lead to more vigorous action.

Given that precautionary considerations appear today to have modest effect on climate policy action[41], there has been so far 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 is 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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[41] Grassl and B. Metz (2013) 338.