LEUPHANA UNIVERSITÄT LÜNEBURG

Christian-Albrechts-Universität zu Kiel

Workshop

# Conceptualizing Sustainability under Uncertainty

**October 2–5, 2008 | Camp Reinsehlen, Germany**

*Sustainability Economics Group*, *University of Lüneburg, Germany*
*Research Group for Fishery Economics*, *University of Kiel*, Germany

## Background

The imperative of *sustainability* requires sustaining nature, and its functioning and services for humans, over a long time into the future. There is an ongoing, broad and diverse discussion about how exactly to define, operationalize and measure sustainability, reflecting the breadth and diversity of ideas about (i) what exactly is the normative content of sustainability and (ii) how exactly can the structure and functioning of economy-environment systems be described.

As *uncertainty* is one of the essential challenges of the long run, and sustainability is – by any definition – about the long run, the question arises of how to conceptualize sustainability under uncertainty.

Uncertainty prevails about both the needs of future generations and the exact functional relationships that govern economy-environment interactions and the provision of ecosystem services from different types of natural capital. Relevant types of uncertainties comprise *risk*, where the possible future development paths and their probabilities are known, Knightian uncertainty or *ambiguity*, and even fundamental *ignorance*. Different approaches exist to conceptualize sustainability under different types of uncertainty:

- In economics, sustainability under risk is generally identified with *non-declining expected welfare*, in analogy with the expected utility approach in individual decision theory.

- In ecological and natural resource economics sustainability (under conditions of certainty) has often been conceptualized as non-declining stocks of natural capital. Such a conceptualization has been termed 'strong sustainability', as opposed to 'weak sustainability' which requires that the aggregate capital basis does not decline. Under conditions of risk, the *viability* of ecosystem stocks and services may be a suitable measure of strong sustainability.

- Inspired by a more ecological perspective, the *resilience* of ecological or coupled ecological-economic systems has been suggested as an essential prerequisite of sustainability.

- As a guiding principle for taking action, the *precautionary principle* has been invoked as an expression of responsibility towards future generations. Different operational approaches to precautionary decision-making have already been formulated.

## Aims and Scope of the Workshop

The aims of the workshop are twofold: (1) Taking stock of the current state of the discussion about how to conceptualize sustainability under uncertainty. (2) Exploring the potential of emerging concepts such as *viability*, *resilience* or the *precautionary principle* to provide operational criteria of sustainability under uncertainty. In particular, the relationship of these concepts to the conceptualization of sustainability as non-declining expected welfare will be discussed, and the most promising strands for future research will be identified.

The workshop brings together a small and focused group of approximately 25 participants, including eight invited speakers, in a stimulating environment for an intensive and fruitful discussion.

## Speakers

*Geir B. Asheim*, University of Oslo

*Wolfgang Buchholz*, University of Regensburg

*Luc Doyen*, Muséum National d'Histoire Naturelle, Paris

*Richard B. Howarth*, Dartmouth College

*Frank Krysiak*, University of Basel

*Charles Perrings*, Arizona State University

*Per Sandin*, Royal Institute of Technology, Stockholm

*Hans-Peter Weikard*, Wageningen University

## Venue


The workshop will take place at the conference guest house Camp Reinsehlen in the heart of the Lüneburg Heath, just 30 minutes from Hamburg. The quietness and colorful vastness of its traditionally conserved landscape provides a peaceful atmosphere and recreational environment which should build the basis to stimulate fruitful discussions and productive research. The guest house's philosophy to live in harmony with nature and among each other, which serves the topic of the event, is furthered by the cheerful atmosphere and the celebration of the deliberate and exquisite slow food concept. Last not least, the heathlands are a nice example for a strongly coupled ecological–economical system.

More information at http://www.campreinsehlen.de


## Program

Thursday, October 2, 2008,

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| till 6:00 pm | arrival and check-in |
| 6:00 pm | welcome reception |
| 7:00 pm | dinner |

Friday, October 3, 2008

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| full day | scientific program |

Saturday, October 4, 2008

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| morning | scientific program |
| 12:15 pm | end of scientific program |
| afternoon | hike in the Lüneburg Heath |

Sunday, October 5, 2009

till 11:00 am check out

## Hosts

The workshop is organized jointly by the *Sustainability Economics Group* of the *University of Lüneburg* (head: Stefan Baumgärtner) and the *Research Group for Fishery Economics* of the *University of Kiel* (head: Martin F. Quaas).

More information at http://www.leuphana.de/seg/
http://www.ozean-der-zukunft.de

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## Travel Information

*By plane:*

The closest airport is Hamburg (HAM). There will be a shuttle transfer from/to the airport for workshop participants.

*By train:*

The most convenient railway station is Schneverdingen (Bahnhof). The conference venue can be reached from the station by taxi.

Detailed travel information will be provided later.

## Acknowledgement

The workshop is funded mainly through a grant from the German Federal Ministry of Education and Research.

Bundesministerium
für Bildung
und Forschung

**Saturday, 4 October 2008**

**Chair:** Johannes Schiller (Helmholtz Center for Environmental Research Leipzig)

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|---|---|
| 8:45–9:45 | **Frank C. Krysiak** (University of Basel): *Sustainability, risk, and responsibility* |
| 9:45–10:45 | **Richard B. Howarth** (Dartmouth College): *Sustainability, uncertainty, and duties to posterity* |
| 10:45 | Coffee break |

**Chair:** Martin F. Quaas (University of Kiel)

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| 11:15–12:15 | Final discussion |
| 12:15 | Closing of scientific program |
| 12:30 | Lunch |
| 14:00 | Hike in the Lüneburg Heath<br>Meeting point: Hotel Lobby |
| 19:30 | Dinner |

**Sunday, 5 October 2008**

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| Before 11:00 | Check-out |

LEUPHANA UNIVERSITÄT LÜNEBURG

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Workshop

# Conceptualizing Sustainability under Uncertainty

**October 2–5, 2008 | Camp Reinsehlen, Germany**

## Program

**Locations:**
All meals are served in the "Gasthaus".
All scientific sessions take place in the room "Weiße Halle".
Other locations or meeting points are specified in this program.

**Thursday, 2 October 2008**

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| Before 18:00 | Arrival and check-in |
| 18:30 | Welcome reception<br>Location: Hotel Lobby |
| 19:30 | Dinner |

**Friday, 3 October 2008**

8:45–9:30 **Stefan Baumgärtner** (Leuphana University of Lüneburg) and Martin F. Quaas (University of Kiel):
*Introduction: Conceptualizing sustainability under uncertainty*

**Chair:** Andreas Lange (University of Maryland)

9:30–10:30 **Geir B. Asheim** (University of Oslo):
*Discounting the future under sustainable preferences and productivity risk*

10:30 Coffee break

11:00–12:00 **Wolfgang Buchholz** and Jan Schumacher (University of Regensburg):
*EU-theory and intergenerational ethics: Match or mismatch?*

12:15 Lunch

**Chair:** Andreas Lange (University of Maryland)

14:00–15:00 **Luc Doyen** (Muséum National d'Histoire Naturelle, Paris):
*Viable control under uncertainty: Conservation, precaution or intergenerational equity?*

15:00–16:00 **Per Sandin** (Royal Institute of Technology – KTH, Stockholm):
*Sustainability – stewardship, states and processes*

16:00 Coffee break

**Chair:** Johannes Schiller (Helmholtz Center for Environmental Research Leipzig)

16:30–17:30 Silke Gabbert and **Hans-Peter Weikard** (Wageningen University):
*Precautionary chemicals policies: Implications for the sequencing of testing*

17:30–18:30 **Charles Perrings** (Arizona State University):
*Uncertainty and irreversibility*

19:30 Workshop dinner

Workshop

# Conceptualizing Sustainability under Uncertainty

**October 2–5, 2008 | Camp Reinsehlen, Germany**

# Book of Abstracts

## Contents

# Discounting the future under sustainable preferences and productivity risk*

Geir B. Asheim

Department of Economics, University of Oslo

Both in the theory of economic growth and in the practical evaluation of economic policy with long-term effects (e.g., climate policies), it is common to apply *discounted utilitarianism (DU)* as criterion. DU means that one infinite stream of consumption is deemed better than another if and only if it generates a higher sum of utilities discounted by a constant per period discount factor δ, where δ is positive and smaller than one.

In spite of its prevalence, DU is controversial, both due to the conditions through which it is justified and due to its consequences for choice in economically relevant situations. As a matter of principle, DU gives less weight to the utility of future generations and therefore treats generations in an unequal manner. If one abstracts from the probability that the world will be coming to an end, thereby assuming that any generation will appear with certainty, it is natural to question whether it is fair to value the utility of future generations less than that of the present one. Moreover, when applied some models of economic growth—like the model of capital accumulation and resource depletion first analyzed by Dasgupta and Heal (1974) and Solow (1974) (the DHS *model*)—DU leads to seemingly unappealing consequences.

This motivates Asheim and Mitra (2008), where we show the existence an alternative criterion of intergenerational justice satisfying the following desiderata:

(1) The criterion incorporates an equity condition respecting the interests of future generations.

(2) The criterion resolves intergenerational conflicts by leading to consequences with ethical appeal, in particular when applied to the DHS model, as well as to the usual one-sector model of economic growth (the *Ramsey model*).

The resulting criterion—which we refer to as *sustainable discounted utilitarianism* (SDU)—departs from DU by requiring that social evaluation not be sensitive to the interests of the present generation if the present is better off than the future.

* This presentation builds joint work with Tapan Mitra and Bertil Tungodden.

An SDU social welfare function (SWF) is a special case of a *sustainable recursive SWF*, a concept which has been proposed and axiomatized by Asheim, Mitra and Tungodden (2008). In both our papers we adopt a framework, used by Koopmans (1960) to axiomatize the class of recursive SWFs (as well as DU under additional axioms), where criteria are required (a) to be representable by a numerical SWF, (b) to satisfy Koopmans' (1960) stationarity condition, and (c) to retain some sensitivity to the interest of the present generation.

Since an SDU SWF is recursive, it can be applied for the evaluation of policies under uncertainty, using stochastic programming techniques.

Motivated by the uncertainty caused by global climate change, my presentation will consider a Ramsey model with two outcomes: Either a business-as-usual (BAU) growth path with growing consumption will be realized throughout, or—at a given time—the economy's net productivity will be reduced to a fraction of its BAU level. It will be assumed that if such a catastrophe occurs, then the optimal path under DU will lead to decreasing consumption. The behavior under SDU (cf. Asheim and Mitra, 2008, Theorem 1) coincides with DU under BAU, but leads to an efficient and egalitarian path if the catastrophe has occurred.

*What is the economy willing to pay in order to decrease the probability for the catastrophe occurring?* I will pose this question under two alternative assumption:

(1) Actual future behavior will be SDU optimal, and SDU is also used for normative analysis.

(2) Actual future behavior will be DU optimal, while SDU is used for normative analysis.

In both cases, the willingness to pay for catastrophe avoidance will be compared to what it would have been with DU optimal future behavior, and with DU as the normative criterion. I will show that, compared with this reference case, the willingness to pay for a decrease in the catastrophe probability will be larger under both cases considered, and in particular under case (2).

The analysis supports the following intuition: Concern for sustainability enhances our willingness to pay for climate policies decreasing the probability that the productivity of human activity is undermined by future climate conditions.

### Keywords

intergenerational equity, sustainability, uncertainty, discounted utilitarianism

### References

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# EU-Theory and Intergenerational Ethics: Match or Mismatch?

Wolfgang Buchholz & Jan Schumacher

University of Regensburg

Since Vickrey and Harsanyi in the 1940s and 1950s expected utility (EU) theory is not only applied at an individual level but also to ethical decisions at a collective level. Ethical decisions under risk, e.g., have to be made in environmental policy when, as in the context of greenhouse gas abatement, consequences in the very long run arise and thus future generations are a_ected. Hence, it is no surprise that the Stern Review on the Economics of Climate Change referred to EU theory when exposing the ethical foundations of its cost-benefit-analysis.

In our presentation we want to provide some general discussion on the applicability of EU theory to ethical questions in the intergenerational context. First of all, we reconsider the Harsanyi approach and show that, based on a set of four axioms for rational decision making, EU theory gives a unified and exible framework to treat problems of distribution between generations from an ethical perspective. As is already known from classical utilitarianism the ensuing decision criteria crucially depend on speci_c properties of the underlying von Neumann-Morgenstern (vNM) utility function on which in the usual presentations of Harsanyi's approach only scant and accidental remarks can be found. Here our own analysis sets in as we want to ask in a more systematic way which ethically important implications additional assumptions on the vNM utility function may have in the intergenerational context and whether it is possible to reect, by an adequate choice of the utility function, relevant ethical values that correspond to ethical intuition. In this way we partly apply some basic ideas of the work by Asheim (that dealt with the inequality of intergenerational distribution) and Asheim & Buchholz (that specifically dealt with the ethical justification of sustainability) to some novel situations e.g. to such with income risk in the future. Our results on the applicability of EU theory to ethical questions will turn out to be ambivalent, since we can observe a match between EU theory and ethical objectives on the one hand but a mismatch on the other.

We distinguish two scenarios which both assume a model with two periods/generations. In the first one, just as in Harsanyi's seminal work and also in Rawls' theory of justice, ethical decisions are made behind a veil of ignorance where the decision maker does not know the actual position she will have later on but there is, apart from this basic uncertainty, no risk between the two periods. Then it is well possible to incorporate the desires for a more equal distribution of consumption between generations and for protection of the least well-off generation by use of EU theory, i.e. by using a vNM utility function that has more risk aversion in the sense of Arrow & Pratt. Moreover, by only adopting a concave utility function, i.e. by assuming risk aversion, both the principles of need and of ability to pay are observed by the savings decision of the earlier generation. So in this first quite familiar scenario a far{reaching match between EU theory and ethics exists.

In the second – with respect to ethical questions less standard – scenario in which there is an income risk in the second period things partly take a turn for the worse. Even though also in this case risk aversion entails compliance with specific forms of the principles of need and ability to pay, more specific assumptions in the vNM utility function are required if one wants to take other versions of the need principle into account. In this context, we will in particular present an alternative, but ethically relevant motivation for the prudence property of risk preferences, which is Kimball's naming for a utility function with concave marginal utility. More seriously, however, some not quite trivial mismatches between EU theory and ethics can be identified in our second scenario. So it is not ensured, that the transition to a more risk averse utility function gives more protection for the weakest. Rather, there are always situations in which the income of the later generation 2 in the bad state is further decreased when a more risk averse utility function is applied. This result reflects the general conflict between the first and the second generation in its bad state, which, e.g., has been observed by Dasgupta in his discussion of the Stern Review. Furthermore, it cannot be excluded by an adequate choice of the utility function that generation 1 has to make more investment in favor of generation 2 even though (by change of exogenous income of generation 2) the welfare position of generation 2 is considerably improved. This clearly violates another type of the need principle. Finally, some other mismatches are shortly discussed, so in particular the inability of EU theory to cope in a sensible way with high catastrophic losses that occur with very small probability, as it is likely to be the case with climate change.

# Viable control under uncertainty: conservation, precaution or intergenerational equity?

Luc Doyen

CNRS, Muséum National d'Histoire Naturelle, Paris

A basic issue for a sustainable management of natural resources is the reconciliation of ecological and economic requirements with an intergenerational equity perspective. Such a goal is made more complex by the presence of numerous uncertainties in the systems at stake including climatic, habitat, demographic or market disturbances. Stochastic or robust viability and more generally viable control under uncertainty is here proposed as a relevant modeling framework to deal with such issues (DeLara & Doyen, 2008). Such approach does not strive to determine optimal or steady-state paths and decisions for the joint dynamics of resources and exploitations, but rather aims at maintaining the trajectories of systems within satisfying normative bounds and constraints that mix ecological, economic and social requirements (Béné et al., 2001; Eisenack et al, 2006). Hence the approach offers a multi-criteria perspective which allows to easily accomodate monetary values and non monetary criteria and to combine commodities and services derived from biodiversity. The approach also provides ways to analyze and control (if possible) the risks and vulnerability of ecological-economic systems dynamics. Hence conceptual links to Population Viability Analysis (Tichit et al, 2007), precautionary approaches (Delara et al, 2007; Doyen & Pereau, 2008) and conservation biology are strong. Moreover it is is closely related to the maximin or rawlsian approach (Martinet & Doyen, 2007) which provides important insights regarding intergenerational equity. Connections with resilience concept (Martin, 2004) or recovery problems ( Martinet et al, 2007) are also strong. From the methodological viewpoint, it can be proved how a dynamic programming method applies for stochastic or robust viable control.

Examples related to the management of renewable resources or biodiversity illustrate the general ideas. In particular, a diversification result is given. Other case studies dealing with agriculture or fisheries are also briefly exposed involving more or less complex and uncertain dynamics. Some perspectives are discussed.

### Keywords

viability, control, stochastic, robust, renewable resource, biodiversity.

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# Sustainability, Uncertainty, and Duties to Posterity

Richard B. Howarth

Environmental Studies Program, Dartmouth College, Hanover, New Hampshire

In the economics literature, the concept of sustainability has been interpreted in at least three distinct ways: (a) defining the resource rights of future generations and pursuing Pareto-improving reallocations over intergenerational timescales (Howarth and Norgaard, 1990); (b) maintaining the utility of a typical member of society (Pezzey, 1989); and (c) maintaining the total value of the diverse capital stocks that support economic activity and human flourishing (Pearce *et al.*, 1989). These three approaches have different underpinnings and implications. The nondeclining utility and nondecreasing capital criteria, for example, are equivalent only in economies characterized by constant population, technology, and terms of trade (Brekke, 1997).

In popular discourse, the term "sustainability" is used to refer to a three-part normative framework involving commitments to environmental conservation, distributive justice, and the improvement of the quality of life over time. This is tied to the famous definition of "sustainable development" embraced by the Brundtland Commission (WCED, 1987). In recent years, the emerging field of sustainability science has sought to interpret and apply this three-part approach (Kates *et al*., 2001).

Issues of risk and uncertainty have deep implications for the definition and application of sustainability criteria. With some exceptions, the literatures on the nondeclining utility and nondecreasing capital criteria have been based on models involving perfect foresight. Applying these models, however, requires analysts to make empirical assumptions about processes and phenomena that are poorly understood in scientific terms. This raises epistemological issues related to the objective validity of subjective expert judgments (Funtowicz and Ravetz, 1990).

In contrast, the resource rights framework is well-suited to addressing decision problems involving scientific uncertainty. Conserving resource stocks is a secure way to safeguard the life opportunities and welfare of future generations in settings where the social costs of resource depletion cannot be gauged with confidence (Bromley, 1989; Howarth, 2007).

Sustainability is a normative concept involving principles of intra- and intergenerational fairness. Accordingly, discussions of sustainability must begin through appeals to principles derived from moral philosophy and political theory. This presentation will argue that duties to future generations flow logically from a commitment to ensure equality of opportunity between members of society. Drawing on Sen's (1999) concept of "development as freedom," it will argue that securing the life opportunties of future generations requires the maintenance or enhancement of a variety of primary goods that necessarily include natural resources and environmental quality (Sneddon *et al.*, 2006). This need not, however, rule out a concern for achieving efficient resource allocation over time.

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# Sustainability, Risk, and Responsibility


Frank C. Krysiak

Department of Business and Economics, University of Basel


Sustainability needs to be analyzed under conditions of uncertainty, because the influence of present actions on future conditions and future welfare cannot be accurately predicted. Several concepts of sustainability have been advanced that can be applied in the context of uncertainty, such as non-declining expected welfare (Asheim and Brekke, 2002) or fairness-based concepts, as in Woodward (2000), Krysiak and Krysiak (2006), or Krysiak (forthcoming). However, if the availability of information about future conditions and future preferences decreases with temporal distance, these concepts imply that the active constraint for present actions will often result from the action's impact on the most distant generation. Thus decisions are based on those conditions and preferences about which the least information is available.

This is unsatisfying for two reasons. First, it may induce substantial welfare losses. Projects that have a high likelihood of benefiting all generations might not be pursued, so that there is a trade-off between sustainability and ex-post efficiency (Krysiak, forthcoming). In extreme cases of uncertainty, for example, if the variance of future welfare becomes unlimited for an infinite time horizon, no action with persistent consequences might be sustainable, eradicating the prospects for growth. Second, the uncertainty is sometimes not caused or increased by present actions but simply an unavoidable lack of knowledge. Thus it is ethically questionable to demand a compensation for this uncertainty from the present generation, as is done by the above sustainability concepts.

In the framework of intertemporal welfare maximization, these points are taken as major reasons for discounting future welfare. But such discounting is problematic in the context of sustainability, because it violates even weak conditions of intergenerational equity (Asheim et al., 2001) and because some present actions may expose future generations to additional risks and this actively induced uncertainty should be treated differently than a lack of knowledge.

In this paper, I introduce a concept of responsibility into the context of sustainability. The idea is to use responsibility to differentiate between the impacts of present actions on close and distant future generations and to account for the difference between "natural" and "induced" uncertainty. In this context, responsibility is understood in the descriptive sense of an "ability to influence" rather than in a normative sense of "moral responsibility," see (Baumgärtner et al., 2006, Ch. 11). This concept of responsibility is based on the influence present actions have on the probability distribution of a future generation's welfare. Thus it is related to the concept of partial responsibility advanced in Vallentyne (2008).

I investigate the inclusion of this concept in the axiomatic approach to sustainability used in Asheim et al. (2001) as well as in the fairness-based approach of Krysiak and Krysiak (2006). I show that this concept results in placing more emphasis on the welfare of close generations and thus on less uncertain outcomes than the above-mentioned sustainability concepts. However, there is an important difference to discounting in that the measure of responsibility depends on the action in question. Actions with persistent outcomes or actions that increase the susceptibility of future conditions to random shocks result in a high responsibility even for distant generations.

I use a resource economic example to highlight the implications of accounting for responsibility in sustainability and show that this approach has implications that differ substantially from those of conventional sustainability concepts. Especially, it is more constraining with regard to actions that alter the influence that random shocks to the resource stocks have on future welfare. In this sense, it puts a higher value on the resilience of ecological-economic systems than conventional sustainability concepts and is thus related to the viability framework of Baumgärtner and Quaas (2008).

## Keywords

Sustainability, Uncertainty, Responsibility, Resource Management, Resilience, Intergenerational Justice, Viability

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# Uncertainty and irreversibility

Charles Perrings

Arizona State University

The economic importance of irreversible ecosystem changes has been an intermittent interest of economists since the mid 1970s. This paper reviews the arguments for the importance of irreversibility in both analysis and policy since that time. It considers, in particular, the implications of irreversibility for option value under different ecological-economic structures. Irreversibility is qualitatively similar to hysteresis in its implications for policy, and is similarly sensitive to the social rate of time preference. The close relationship between irreversibility and uncertainty is investigated, along with the relation to learning and precaution.

# Sustainability: stewardship, states and processes

Per Sandin

Royal Institute of Technology – KTH, Stockholm

In a puzzling and oft-cited passage in *Utilitarianism* (1863), John Stuart Mill writes:

> The only proof capable of being given that an object is visible, is that people actually see it. The only proof that a sound is audible, is that people hear it: and so of the other sources of our experience. In the like manner, I apprehend, the sole evidence it is possible to produce that anything is desirable, is that people do actually desire it.

Mill has been criticised (e.g. by G.E. Moore) for confusing the normative and the factual, and fort illegitimately trying to derive a normative conclusion from purely factual premises. In this presentation, I will argue that similar problems apply to sustainability. I will therefore explore the conceptual relationship between normative and factual aspects of sustainability, and a fundamental question is: What evidence can be produced that something is sustainable, given different types of definition of sustainability and the fact that uncertainty prevails? Does it make a difference whether we think of, for instance, sustainable *development*, sustainable *activities* such as sustainable forestry or agriculture, or sustainable *processes* such as sustainable population growth? The focus is thus on sustainability in general, not on the narrower conception of sustainable (economic) development. If time allows, I will also take issue with the question of whether the concept of progress has a place in the discussion of sustainability, the term 'progress' often having been replaced with the more neutral-sounding 'development'. Building on a critical discussion of G.H von Wright's essay 'The Myth of Progress' (1993), I argue that we should not be afraid of bringing progress back in.

# Precautionary chemicals policies: implications for the sequencing of testing

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Under the European Community Regulation “REACH” on chemicals and their safe use (EC Regulation 1907/2006) several tenth of thousands of chemicals are to be tested. REACH deals with the **R**egistration, **E**valuation, **A**uthorisation and Restriction of **Ch**emical substances. The REACH regulation adopts the Precautionary Principle as a guiding general principle (CEC 2006, Article 9, 69, and Title I, Article 1.3), but does not offer a definition and does not specify how it applies. Moreover, in the broader literature on the precautionary principle there is no consensus concerning the meaning of “precaution”; see O’Riordan and Jordan (1995) and Sandin (2004) for surveys.

We hold the view that an important aspect of precaution –whatever its full definition may be– is that it requires respecting future individuals’ rights. Our starting point is that every individual has a right to life an health, see Gabbert and Weikard (2008). We argue that a notion of precaution should be built around the fact that future individuals have the same basic individual rights as current individuals. Given that the use of chemicals can have important impacts on future individuals’ life and health, we explore how chemical testing should be organised to satisfy our notion of precaution. The testing of a large number of chemical substances under REACH requires time and resources and forces a prioritisation of testing. This involves to determine the sequence in which chemicals should be tested when they differ with respect to toxicity and persistence and when human exposure and testing costs differs across chemicals. This is the first aim of our study.

However, under current legislation it is left to the firms how they schedule the testing of the substances they produce, use and market. Hence, our second aim is to determine how profit maximising firms would organise the testing. We compare our findings for profit maximising firms to a precautionary sequencing of chemicals’ testing. Finally, we conclude with implications for a precautionary chemicals policy.

**Keywords**

Precautionary Principle, responsibilities for future generations, chemicals’ testing, European chemicals policy

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