Individual and collective responsibility for nanotechnology

First Annual Report on Ethical and Social Aspects of Nanotechnology

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Abstract
The question of responsibility in the interaction between science, technology and society is one of the most pressing issues. This report starts by surveying the state of the art of the concept of responsibility in ethics and social studies of science literature. This is followed by a short overview of codes of conduct and other attempts at shaping responsible development of nanotechnology in a situation of uncertain risks. Subsequently, current trends in nanotechnology development in ten technology domains are reviewed, identified in technological and economic trend reports produced in the ObservatoryNano project. Apparent responsibility issues are highlighted. These issues are analysed with the following questions:

- Who can be and who is held responsible for the nano-scientific and technological development? (Nanoscientists; Industrialists (large companies and SMEs); Government; Parliaments; Trade Unions; Consumer Associations; Environmental NGOs; Patient Associations; Churches; Media; General Public; Others)
- How can each stakeholder group take its responsibility?
1. Introduction

ObservatoryNano aims to support European decision-makers with information and analysis on developments in nanoscience and nanotechnology (N&N). One of the activities is assessment of ethical and societal aspects of nanotechnology, in annual reports, quarterly interviews and by development and testing of an ethics toolkit. The annual reports are intended to bring together recent insights from relevant ethical and social science literature and results from stakeholder dialogue and public engagement activities. These insights and results are presented to European policy makers and other interested parties and intended to support governance of nanotechnology. Each report focuses on one of four key themes in nanoethics and society:

1) Responsibility;
2) Nanobioethics;
3) Nanoelectronics, privacy and security and
4) Communication.

The present report is the first annual report on ethical and societal issues published by ObservatoryNano. It focuses on “Individual and Collective Responsibility for Nanotechnology”. Chapter 2 reviews nanoethics and social studies of science literature on some key concepts in responsible nanotechnology development. Subsequently, chapter 3 summarises the current debate on the European Commission and other codes of conduct for nanotechnology. Chapter 4 includes an overview of ethical and societal issues identified in the draft reports on technical and economic trends in nanotechnology produced by other partners in ObservatoryNano. Chapter 5 analyses the highlighted issues in these reports which are relevant to responsible nanotechnology development. Finally, chapter 6 gives conclusions. The references include weblinks enabling further study of particular issues.
2. The concept of responsibility in ethics and social studies of science and technology

During the 20th century, it became increasingly clear that ethical theories of individual responsibility cannot fully capture contemporary ethical and social challenges of scientific, technological and organizational developments. Traditionally, ethical thinking was based on the idea of attributing responsibility to an autonomous individual based on evaluations of the intentional actions of this individual. Today, however, individuals very often take on responsibility for actions which are framed in terms of professional responsibilities in highly organized settings. Moreover, due to the ever-increasing social and technoscientific complexity, very often it is virtually impossible to assess the full range of actions involved in particular circumstances, less alone predict possible risks and outcomes. How we deal with unintended consequences of science and technology seems to be more important today than ever.

In a paper addressing urgent ethical and social problems in relation to science and technology Réne von Schomberg (2007) argues that in increasing number of instances it is impossible, even in hierarchically structured technical professional systems, to assign any one person responsibility for producing or solving some particular problem. Who was responsible for the production and utilization of asbestos in buildings, making many people ill with asbestoses? Who bears responsibility for technological disasters such as Chernobyl and Challenger? And what about more mundane technical problems such as the spread of computer viruses or the break-down of one’s car?

Such complex, socio-technical questions cannot be answered if we base our conception of responsibility on the idea of autonomous individuals and simple, well-defined social situations. More generally, we would say that the attribution of responsibility is a means of reducing complexity in social action (Lenk & Maring, 2000). Taking on or placing responsibilities, then, are ways of making explicit ethical and social implications of science and technology in professional settings and on a broad societal level. Responsibility has consequences for the scientific and engineering professions but also for the way in society incorporates technology.

Many different actors have made a call for responsible nanoscience and nanotechnology. The 2004 communication of the European Commission aiming towards a European strategy for nanotechnology declared: “Nanotechnology must be developed in a safe and responsible manner” (p. 3). In chapter 3 we review different stakeholder positions on responsibility. In this chapter, we address questions concerning nanotechnology and responsibility on more general levels. First, we take a look at some philosophical points regarding professional role responsibility of scientists and engineers and collective responsibility with respect to technological innovation. Then, we survey work on sustainability, precaution, and governance with a particular emphasis on nanotechnology.

2.1 Philosophical debate on responsibility and technology

We first need to clarify that primarily we are dealing with ethical responsibility rather than legal, regulatory, or financial responsibilities. Although these issues cannot be fully separated, in particular when it comes to defining responsibilities for future developments, the latter forms of responsibility usually entail more or less institutionalized modes of accountability. In
contrast, we think about – and assume – moral responsibility because we claim that, in some way, we need to respond to current developments and answer for our actions in other, less formalized ways. Arguably, this may seem like a more vague way of inferring responsibilities. Nevertheless, we usually accept that we are morally responsible for actions which are not covered by the more formal systems of responsibility and accountability.

In 1979, the German philosopher Hans Jonas raised the issue of moral responsibility in a technologically shaped world (Jonas, 1979). He argued that rapid progress in 20th century science and technology had for the first time given humankind the powers to influence and damage the biosphere on earth. Therefore, an ethical principle of responsibility, rather than a codified ethics of responsibility, had become necessary. This principle would not only entail ethical prescriptions of responsible individual behaviour such the Kantian imperative whereby all one’s actions should aspire to become some kind of universal law. In effect, Jonas formulated a new, collective imperative of responsibility: “Act so that the effects of your actions are compatible with the permanence of genuine human life.”

Hans Jonas placed great emphasis on the need for foresight and future scenarios. Negative scenarios should in his view be given greater credibility and have more consequences for policy measures than positive scenarios. Jonas also suggested prohibiting all activities which, intentionally or unintentionally, could lead to the extinction of the human race, as a kind of generalised version of the commandment in Jewish and Christian religion: “You shall not kill.” He has been criticised for his pessimistic vision, and the critique has made it clear that while Jonas’ approach was a way of raising awareness of technological risks, it also produced a “heuristic of fear” inadequate for deciding about responsible technology (Grunwald, 2008; Jonas, 1980).

The call for responsible technology also reverberated with philosophers and organization sociologists who took an interest in the role responsibility of scientists and engineers. Establishing a difference between free moral agents and individuals acting in professional roles, philosophers Albert Flores and Deborah G. Johnson (1983) argued that “the fact that behaviour is role-governed does not insulate a collective’s member from the responsibility that the collective bears” (p. 543). Along the same lines, Daryl Chubin (1985) argued that scientific and engineering bodies had to adopt frameworks of role responsibility for scientists and engineers, i.e., ethical norms, codes of conduct, etc. To Chubin, enacting such norms simply meant replacing implicit with explicit role responsibility ethics. Somewhat later, John Braxton (1994) picked up on this idea, envisioning a “trans-scientific community” based on role responsibility.

The notion of professional role responsibility and the need to enact explicit norms have been translated to the question concerning responsible nanotechnology. Robert Lee and P.D. Jose (2008) identified a potential conflict of role responsibilities for corporate managers dealing with nanotechnology. On the one hand, managers need to consider the competitiveness and profitability of the company; on the other hand, taking into account long-term interests, they also need to behave in a socially and environmentally responsible way. The tension between the self-interest of corporations in bringing innovative technologies to the market and the self-restraint in promoting responsible and socially robust technologies can be dealt with in certain ways:

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1 We recognize that Hans Jonas was not the first to talk about responsibility in this way. His ideas serve as a convenient starting point for our purposes. We also note that we are primarily dealing with secular perceptions of responsibility.
1. Creating internal ethical and best practice standards consistent with external stakeholders demands
2. Investing in strategic risk research
3. Monitoring warning signals and forecasting trends
4. Creating codes of conduct with external partners, especially in cases where the ability of firms to respond in an individual capacity is limited due to cost or complexity considerations.

Reviewing the literature on professional role responsibility, Carl Mitcham (2003) concludes that it may be useful to think in terms of a kind of distributed, process-oriented “co-responsibility” (see also below). He argues that the very concept of professional role responsibility may be too limited for the dynamic nature of technological innovation and risk assessments. Instead, we need to implement collective responsibility for professional as well as non-professional groupings, all the while taking into account feedbacks and new developments in the technology.

Many philosophers have dealt with the notion of collective responsibility. Philosophers such as David Copp (1980), Margaret Gilbert (2000), and Russel Hardin (1988) have argued the need to consider collectives as independent moral agents, while Seumas Miller (2001) conceived of collective responsibility as joint responsibility of individual human persons. Larry May speaks about the “web of commitments” in which all individuals find themselves embedded (May, 1996). The collective approach has profound implications for professionals. Whereas, traditionally, the professional was an occupational self-governing, high status person, most professionals, today, are employed in, or affiliated with, organizations that are influenced and governed by complex external and internal interests. No one is free from multiple, perhaps even conflicting, commitments, nor from the challenges of differing professional and personal identities and even incompatible epistemic cultures and moral priorities (Abbott, 1988; Knorr-Cetina, 1999).

According to May (1996), acknowledging the consequences of living in a “web of commitments” makes it necessary to understand professional responsibilities as “legitimate negotiated compromises”. However, this does not imply loss of responsibility. On the contrary, professionals as well as their organizations should strive to identify and communicate possible conflicts in the “web of commitments” in order to reach temporary consensus on responsibilities.

The collective, process-oriented view on responsibility is shared by René von Schomberg who in 2007 published a working document on ethics of knowledge policy. He criticised contemporary ethical theories for not adequately capturing the ethical and social challenges of scientific and technological development. The unintended consequences of science and technology as well as the implications of collective actions can not be addressed adequately by these existing theories which deal with individual responsibility for intentional actions. Four developments illustrate these shortcomings:

1) Division of labour has increased the number of different roles of individuals involved in technology development;
2) The area for which each individual can be held responsible is narrowed;
3) Each individual can play many different roles in society;
4) The institutional spheres in which role differentiation takes place have become more distinct and separated. Regulation of each sphere is the responsibility of the professionals who are active inside it.

Von Schomberg argued that due to these shortcomings it is necessary to shift to an ethics of forward-looking, collective co-responsibility involving the whole of society. This new ethics has four dimensions: Public debate; Technology Assessment; Constitutional Change; Foresight and Knowledge Assessment. As we later explain, these dimensions are already being implicated in the development of nanosciences and nanotechnologies. The idea of future-oriented, collective co-responsibility is also very much present in the following discussion about precaution, sustainability, and governance of nanotechnologies.

2.2 Precaution

The Rio Declaration on Environment and Development adopted by the United Nations Conference, 3-14 June 1992, codified for the first time on the global level the precautionary approach:

> 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 (United Nations Environment Programme, 1992, p. Principle 15)

In the EU, the concept of the precautionary principle was set out in a Commission communication adopted in February 2000. The report concluded that the precautionary principle was widely applicable to specific cases where scientific evidence is insufficient, inconclusive or uncertain, and where a preliminary scientific evaluation shows that potentially dangerous effects for the environment and human, animal or plant health can reasonably be feared (European Commission 2000).

The precautionary principle is a rationale for precautionary action. Precautionary measures are always provisional and have to be updated and modified as long as new scientific evidence becomes available (Schomberg, 2006). We need to avoid the common misunderstandings, on the one hand, that the precautionary principle is a one-sided argument for the elimination of all adverse effect on health and environment, or, on the other hand, that the precautionary principle is a threat to the foundation of technological progress (Harremoës, 2005).

Certain criteria can be applied to the kinds of actions and revisions deemed necessary in order to accommodate precautionary approaches. The European Commission (2000) provides the following list (p. 4):

- Proportional to the chosen level of protection,
- Non-discriminatory in their application,
- Consistent with similar measures already taken,
- Based on an examination of the potential benefits and costs of action or lack of action (including, where appropriate and feasible, an economic cost/benefit analysis),
- Subject to review, in the light of new scientific data, and
- Capable of assigning responsibility for producing the scientific evidence necessary for a more comprehensive risk assessment.
The Health Council of the Netherlands (2008) recently published an advice to the Dutch government on prudent implementation of the precautionary principle. They distinguish weak and strong forms of the precautionary principle. In strong interpretations such as by Hans Jonas, potential negative consequences should be given more weight than potential positive consequences in situations of uncertainty. Experts on decision making have formulated the maximin-rule. Decision makers must only let themselves be guided by potential negative consequences of options for actions, and choose the one with the least negative expected impact. The committee of the Health Council responsible for the advice does not favour this or any other general rule for deciding under uncertainty. They believe that potential negative consequences must not by definition weigh heavier than potential positive consequences, because choosing not to strive for potential benefits may lead to other risks. They consider the precautionary principle to be a transparent way to weigh pros and cons of the variety of available options for actions.

There are three distinct but interrelated cases where policy makers are confronted with special challenges: ambiguity, uncertainty and complexity. Ambiguity means there are diverging value judgments. Normative and interpretative ambiguity is distinguished. Normative ambiguity implies differences in ethical acceptance; interpretative ambiguity implies differences in evaluation of research results. Uncertainty can exist on hazard properties, exposure, type and size of potential damage and chance of occurrence. Sources of uncertainty include variability of phenomena and lack of knowledge. Complexity implies difficulties to form a qualitatively and quantitatively good picture of the impacts of a variety of potential causes and effects, given available information.

The three cases require different policy approaches. Ambiguity requires discussion and debate for identifying common values; foster understanding; and look for options that enable people to practice their own vision. Uncertainty asks for implementation of the precautionary principle, if it is a serious obstacle for decision making. Complexity requires a multidisciplinary discourse among scientific and experience experts to form as good a picture as possible of the issues at stake.

The precautionary principle must therefore be applied in cases of uncertainty with plausible risks. The plausibility of risks must be determined by experts, who are open for critical questions and remarks of non-experts and communicate openly on what is uncertain. The decision whether or not to act and the appropriate response in a give situation, however, remain a political issue dependent on the risk level that is acceptable to the society on which the risks are being imposed.

The Health Council of the Netherlands (2008) advises a judgment and decision making process for risk governance consisting of several steps:

- Specification
- Collection & Analysis
- Characterisation
- Decision & Evaluation
- Communication
- Management
The process includes different cycles which can be run through depending on the problem at stake. Communication plays a central role.

The precautionary principle has been proposed for application to nanotechnology. In 2003 the Canada-based ETC Group (2003) used the precautionary principle to recommend a moratorium on the commercial production of new nanomaterials. The Group also called for an international process evaluating the socio-economic, health and environmental implications of nanotechnology (p. 74). More recently, the European Trade Union Confederation (2008) adopted a resolution demanding that the precautionary approach be taken with respect to nanotechnologies and nanomaterials.

Within the framework of medicine and health, the Swiss Reinsurance Company (2004) has advocated applying the precautionary principle to nanotechnology. Among other things, the company suggested the following activities designed to shift the burden of proof to the proponents of nanotechnology:

1. The handling of nanotechnologically manufactured substances should be carefully assessed and accompanied by appropriate protective measures.
2. No reasonable expense should be spared in clarifying the current uncertainties associated with nanotechnological risks (p. 47).

Also on a limited scale of application, the Royal Society and the Royal Academy of Engineering (2004) recommended precautionary measures with respect to nanoparticles (see also: Grunwald, 2008). All factories and laboratories should treat manufactured nanoparticles and nanotubes as if they were hazardous and reduce them from waste streams. Moreover, the use of free nanoparticles in environmental applications such as remediation of groundwater should be prohibited (p. 9).

In the same vein, Andre Del a pioneer in nanomedicine at the University of California, Los Angeles, said:

While it is likely that most nanomaterials will be safe from a biological perspective, we need to demonstrate this is the case as a matter of precautionary principle. As a rational approach to the problem, we should establish predictable paradigms of toxicity that can help to classify these materials into those that are likely to be safe and those that could be hazardous (Stoddart, 2006).

Reviewing transnational, legislative models for regulation of nanotechnology, Gary E. Marchant and Douglas J. Sylvester (2006) took a sceptical stance towards the application of the precautionary principle to nanotechnology for three reasons:

1. Since there are no standard or globally accepted versions of the precautionary principle, it does not provide a robust or reliable foundation for transnational regulation.
2. Every version of the precautionary principle is ambiguous with respect central risk management decisions. Thus, there is a great deal of interpretative flexibility in enacting the precautionary principle(s).
3. Applied in the stronger version, the precautionary principle would prevent nanotechnology from moving forward. Because of novelty and scale, all emerging
nanotechnologies entail some level of risk and could never satisfy the precautionary principle (p. 721).

They conclude that a range of less formal alternatives may be more likely to succeed in the shorter term:

- Transnational dialogue and information sharing forums
- “Civil-society-based-monitoring”
- Codes of conduct
- Enlisting a group of expert to issue periodic reviews
- International consensus standards
- Export controls
- Confidence building measures

In theory, such measures could be seen as a way of distributing responsibility for formulating each of the four dimensions of the precautionary principle described above. To some extent, the effectiveness of such measures is contingent upon agreement between the actors involved which may be one of the greatest hindrances to adopting precautionary measures within nanotechnology.

Based on qualitative interviews with four groups of stakeholders in Norway, Throne-Holst and Sto (2008) found substantially different interpretations of the precautionary principle. Norway has a strong tradition for promoting the precautionary principle. As early as 1997, the Norwegian Parliament adopted the strong version of the precautionary principle in relation to cloning. Despite the strong political affiliation with the precautionary principle in Norway, the majority of stakeholders interviewed by Throne-Holst and Sto were reluctant to relegate responsibility to the political level. Although agreeing that, in principle, the responsibility for adopting the precautionary principle had to be distributed, they still felt that more information and scientific evidence was needed before politicians, NGOs, and others could understand relevance of choices. This was even the opinion of some politicians.

When scientific data is scarce and/or uncertain, a range of risk management options are available to decision-makers (Tyshenko & Krewski, 2008). Other principles besides the precautionary principle include ALARA (as low as reasonably achievable) and BACT (best available control technology). Monitoring programs, regulations and standards, and voluntary guidelines may also be useful measures in adopting a precautionary strategy towards nanotechnology.

In their survey of 40 Swiss and German companies producing nanoparticulate materials, Aasgeir Helland, Hans Kastenholz, and Michael Siegrist (2008) found disagreement with respect to placing responsibility for precaution. Among the respondents, there was no majority opinion regarding whether the burden of proof should be on the company or not. A vast majority accepted the ALARA principle. Also, there was widespread acceptance that measures should be taken if specific criteria of potential irreversibility are fulfilled. For the respondents, however, adopting the strong version of the precautionary principle in industry was not seen as the right way to move ahead. This result supports the Norwegian study cited above as well as an earlier study of European industry showing that most industries find regulatory interventions regarding nanoparticulate materials useful if they are voluntary and evidence-based (Helland, Kastenholz, Thidell, Arnfalk, & Deppert, 2006).
Thomas Faunce and colleagues (2008) have analysed how the Australian authorities have and should have applied the precautionary principle in their decision to allow sunscreens with nanoparticles on the market. Jennifer Kuzma and John Besley (2008) have argued that risk assessment should not only take into account traditional utilitarian aspects such as health, environmental and economic impacts, but also the value choices of actors taking into account principles such as integrity, justice, non-maleficence and autonomy.

2.3 Sustainability

Like precaution, the concept of sustainable development has a long history with many dimensions and ambiguities (Mitcham, 1995). Sustainability has been reflected in regard to energy, research and innovation policies, business practices, product development, and consumption. The most widely used definition of sustainable development has been proposed by the Brundtland Commission: “Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs” (Brundtland Commission, 1987).

Taking sustainability into account, the development of nanotechnologies has to include not only considerations of the probability and extent of possible damages (and goods), but also criteria of acceptable levels of uncertainty, intra- and inter-generational justice, reversibility and delay effects, and potential of discursive mobilization and participation of many different actor groups (Helland & Kastenholz, 2008).

Responsible development of nanotechnology is often considered to be also sustainable development. However, it is important to recognize that technological innovation is embedded within a wide constellation of societal activities and actors. Who gets to define “the needs of the present” as well as the needs of “future generations” is always an open question. Therefore, questions pertaining to the sustainability of nanotechnology also relate closely to the mobilization and enrolment of stakeholders and other involved parties into decision-making processes (Helland & Kastenholz, 2008; Meaney, 2006).

There seems to be some agreement that sustainable development of nanotechnology requires technology assessment and life cycle analyses. In order to assess the sustainability of nanotechnology, Torsten Fleischer and Armin Grunwald (2008) stress the need to distinguish between various levels of nanotechnology. They identify four levels of interdependences in the complex and heterogeneous set of nanotechnologies applied to or using systems at the nanoscale:

1. Nanomaterials: The “small” set of original nanotechnology products such as nanoparticles for medical applications.
2. Enabling technology for other key technologies: Nanotechnology applied in the “macro” fields of energy technologies, water technologies, life sciences, and/or ICTs.
3. Enabling technology for other complex technological systems: Nanotechnology as part of converging technologies (NBIC), pervasive computing, and/or biochemical analyses.
4. Nanotechnology in the wider societal framework.

Fleischer and Grunwald (2008) argue that the question concerning sustainability differs from level to level. In particular, they emphasise the need to take into account not only environmental sustainability, but also economic and social sustainability effects. Technology
assessment, i.e., the provision of knowledge and orientation for future acting and decision-making concerning technology and its implementation in society, is one way of intentionally shaping the different levels of nanotechnology in a sustainable manner. An important part of providing sound anticipatory technology assessments, current eco-assessments procedures such as life cycle analysis offer a range of detailed methods to obtain such knowledge and orientation. However, since many nanotechnologies are still more or less unknown and untested, traditional technology assessment methods have to be replaced with more future- and innovation-oriented techniques that directly feed into the development processes they pertain to describe. Designating the novel approach to nanotechnology assessment, Fleischer and Grunwald use the term “reflexive sustainability assessment of nanotechnology” (p. 896).

This view finds some support (Sengul, Theis, & Ghosh, 2008; Sweet & Strohm, 2006; Wardak & Gorman, 2006). Arnim von Gleich, Michael Steinfeldt, and Ulrich Petschow (2008) agree on the need to develop a three-tiered approach to prospective nanotechnology assessment:

1. Technology characterisation: Prospective assessment of nanotechnologies with respect to opportunities and hazards
2. Eco-profiles: Evaluation of eco- and resource-efficiency potentials by application of life cycle assessments
3. Orientation through “Leitbilder”: Influencing the development of technologies, processes, and products through discursive explication of vision statements that integrate aspects of health, safety, and environment (p. 900).

C. Bauer et al. (2008) develop a framework for life cycle analysis of nanotechnologies in the face of uncertain knowledge about future applications and implications. Importantly, moving beyond the described life cycle analysis methodology in ISO 14040, they argue that economic and social as well as environmental aspects need to be taken into account. Based on their proposed model, they perform two case studies of surface coating using physical vapour deposition and of the use of carbon nanotubes in electronics, respectively. The first study concerns nanotechnology quite close to the producer of nano-based products. This study suggests that the release of nanoparticles to the environment is unlikely due to vacuum conditions in the coating plants, but also that redesigning the technology might increase the yield in using target material. The second, and broader, study addresses a large array of issues for a nano-based product that faces market introduction, including decisions about replacement of existing products.

Another case study comparing innovation and sustainability is provided by Fred Steward, Joyce Tsoi, and Anne-Marie Coles (2008). They identify three types of nano-based innovations with application to “print-on-paper”: ink, fiber, and coatings. Their results based on a socio-technical analysis of the emerging network promoting these innovations, indicate that primary role of the nanoparticle innovations is for “commercial printability rather sustainable deinkability” (p. 957). Even though the authors recognize that the lack of nanotechnological innovation relevant to deinkability may be due to technical difficulties, they still find enough evidence to suggest that the aspirations for nanoparticle innovations contributing to sustainability goals are not as yet being translated into practice.

In the case of layered silicate biopolymer nanocomposites, however, it seems that nanoclay production may actually improve the sustainability of common biopolymer products by reducing energy use and greenhouse gas emissions. Still, other parameters seem to point in
the other direction. In comparing nanoclay-biopolymer composites with conventional fiber-biopolymer composites, Satish Joshi (2008) discovers that on a per kilogram basis “the environmental burdens from nanoclays are worse than those from natural fibers in most dimensions except phosphate and nitrate emissions, but nanoclay are better than glass fibers from an energy perspective” (p. 487). As the relative performance depends on the functional unit, Joshi recommends detailed product-specific life cycle analyses.

Analysing the development of the nanotechnology funding strategy in Germany, Axel Zweck, Gerd Bachmann, Wolfgang Luther, and Christiane Ploetz (2008) find that, indeed, sustainability aspects are becoming more widely accepted. In particular, they identify several overlaps between the national sustainability strategy adopted by the German Government in 2001 and the nanotechnology activities funded by the German Ministry for Education and Research between 1995 and 2006. Despite the general image of sustainability and innovation as two separate cultures, the authors conclude that links between sustainability concerns and technological developments evolved over time. They recommend more research and development programs that explicitly aim at contributing to sustainability such as the recent Framework Programme “Research for Sustainability”, enacted by the German Ministry for Education and Research in 2004.

Japanese and Chinese governments have also taken initiatives to investigate social and environmental aspects of nanotechnology aiming at public acceptance of nanotechnologies, but also at evaluation of impacts of nanotechnology on health and environment (Takemura, 2008; Zhao, Zhao, & Wang, 2008). In the case of the UK, Tee Rogers-Hayden and Nick Pidgeon (2008) argue that the road to sustainable nanotechnology necessarily has to lead through more “up-stream” public participation engaging the public as the technology develops. The tendency of articulating sustainability in relation to other aspects is also found in the German case. H. van Lente and J.I. van Til (2008) argue that sustainability might need other discursive “vehicles” in order to become a more prominent concern of governments, stakeholders, and others.

### 2.4 Governance

Sustainability seems to have gained some importance at the level of technology assessments (including life cycle analyses) and even, to a lesser extent, in policy-making. Most research into the sustainability of nanotechnologies indicates that achieving sustainability requires participation of a wide range of societal actors. Thus, it may be useful to think in terms of responsible (if not sustainable) governance of nanotechnologies.

Governance is a broadening of the concept of government. Government is the formal authority in a State, with legislative, policy making and executive powers. Governance encompasses processes of organising a country or other territory involving other stakeholders than just formal government bodies. With regard to nanotechnology, the International Risk Governance Council (IRGC) has proposed and applied a specific concept of Risk Governance aimed at the identification, assessment, management and communication of risks in a broad context (Renn, 2005):

Risk governance includes the totality of actors, rules, conventions, processes and mechanisms concerned with how relevant risk information is collected, analysed and communicated, and how management decisions are taken. Encompassing the combined risk-relevant decisions and actions of both governmental and private actors, risk
governance is of particular importance in, but not restricted to, situations where there is no single authority to take a binding risk management decision but where, instead, the nature of the risk requires the collaboration of, and co-ordination between, a range of different stakeholders. Risk governance however not only includes a multifaceted, multi-actor risk process but also calls for the consideration of contextual factors such as institutional arrangements (e.g. the regulatory and legal framework that determines the relationship, roles and responsibilities of the actors and co-ordination mechanisms such as markets, incentives or self-imposed norms) and political culture, including different perceptions of risk (p. 22).

The IRGC Risk Governance Framework consists of five elements:

- Risk pre-assessment
- Risk appraisal
- Characterisation and evaluation
- Risk Management
- Risk Communication

The relevant knowledge includes not only traditional risk assessment knowledge, but also insight in human concerns associated with risks and communication and dialogue. IRGC has applied this Risk Governance Framework to nanotechnologies (O. Renn & M. Roco, 2006; O. Renn & M. C. Roco, 2006). They distinguish four generations of nanotechnologies:

- Passive (steady function) nanostructures (from 2000)
- Active (evolving function) nanostructures and nanodevices (from 2005)
- Integrated nanosystems (systems of nanosystems) (after 2010)
- Heterogeneous molecular nanosystems (after 2015)

The first generation passive nanotechnologies require another governance framework (Frame One, characterised by traditional risk governance methods) than later generations of active nanotechnologies (Frame Two, characterised more by (public) concern governance).

W.E. Bijker, et al. (2007), who all served on an ad hoc committee on the health significance of nanotechnologies (Health Council of the Netherlands, 2006), criticize the temporal framework provided by the IRGC white paper on nanotechnologies. They argue that there is no, a priori relation between the time of development of a particular kind of nanotechnology and the type of risk issue that pertains to it. If so, only future nanotechnology products would generate uncertain and ambiguous risk issues necessitating more public concern governance. Bijker, et al. (2007) maintain that “it is the purpose and the application rather than the device itself that may create the risk” (p. 1219).

The report by the Health Council of the Netherlands (HCN) (2006) use the five different process levels of the first IRGC white paper on which to base risk governance processes involving nanotechnologies (pre-assessment, appraisals, characterization and evaluation, management, and communication). The report also use the four risk categories provided by the original IRGC white paper to categorize risk problems:

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<th>Risk category</th>
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<td>Simple</td>
<td>Privacy problems</td>
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<td>Self-tests</td>
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Toxicity of readily degradable nanoparticles

Complex

Sustainability

Gap between rich and poor

Uncertain

Toxicity of poorly degradable nanoparticles

Ambiguous

Gap between diagnostic and therapeutic capabilities

Advance home-care technology

Human enhancement

Some military applications of nanotechnologies

| Table 1 | Categorisation of risk problems that arise from or are intensified by nanotechnology applications using the risk categories of the IRGC (Health Council of the Netherlands, 2006, p. 86). |

The IRGC Risk Governance framework has also been criticised for looking too exclusively at nanotechnologies pertaining to medical health and environment, thus overlooking social safety and social risk issues. Based on an analysis of IRGC documents, Wolbring (2007) conclude that “the IRGC discourse (scope and inclusiveness) is less than satisfactory for marginalized groups such as disabled people, indigenous people and marginalized groups from the South as their issues and their views are totally ignored” (p. 19). One such attempt to construct meaningful upstream engagement in nanotechnology of otherwise marginalized groups are the nano-dialogues organized by Demos, Practical Actions, and researchers from the University of Lancaster (Demos, 2007).

Kamilla Kjølberg, Gian Carlo Delgado-Ramos, Fern Wickson, and Roger Strand (2008) identify four dimensions according to which ideas about governance of nanotechnologies may differ. One is the conceptualization of time which so clearly made a difference between the IRGC and the HCN. The three other dimensions are: 1) Uncertainty, 2) Complexity in terms of higher-order effects, and 3) Complexity with respect to values. The authors use these four categories to analyse two visions and recommendations on the development of converging technologies (CT), one American and one European. Conceiving temporal development in terms of technological development, the American report (the result of a conference) emphasized the need for rapid technological development, brushing aside most issues relating to uncertainty about the future, complexity of higher-order effects and values. In stark contrast, the European equivalent (the outcome of a foresight exercise commissioned by the EC Directorate K “Knowledge-based economy and society”) amounts to strong social commitment and involvement in the development of CT. Accordingly, the report stresses radical uncertainties, unexpected and undesirable higher-order effects, including feedbacks between the physical and social/cultural world. Kjølberg, Delgado-Ramos, Wickson, and Strand (2008) conclude that (European) approach translates into the following recommendation of governance: “Consensus, resolution of conflict, and political efficiency should not by governance design override the need for real resistance, conflict and change at the fundamental level of policy” (p. 95).
3 Codes of conduct

This chapter summarises the current debate on the European Commission and other codes of conduct for nanotechnology, and places it in a broader framework of discussions and initiatives relevant to responsible nanotechnology development including defining guiding principles, governance initiatives such as the EC code, and capacity building and participation activities.

The European Commission has published a “Commission Recommendation of 07/02/2008 on a code of conduct for responsible nanosciences and nanotechnologies research” and is stimulating debate on and implementation of this code with governments and stakeholders. The recommendation is addressed to member states of the European Union and includes seven general principles: meaning (comprehensible to the public, respect human rights), sustainability, precaution, inclusiveness (openness, transparency and participation), excellence, innovation and accountability (for social, environment and health impacts). Implementation is monitored; member states are asked to report annually on implementation of the code in their country to the European Commission. (European Commission, 2008)

Parallel to the work on the European Commission Code, another Code of Conduct has been developed, in dialogue with the EC. This Responsible NanoCode has been developed by a Working Group of the Responsible Nano Forum and is supported by four organisations including the Royal Society, Insight Investment, Nanotechnology Industry Association and Nanotechnology Knowledge Transfer Network. The code is addressed to organisations involved in the research, production, retail and disposal of products using nanotechnologies. It includes seven principles: board accountability, stakeholder involvement, worker health & safety, public health, safety & environmental risks, wider social, environmental, health & ethical implications & impacts, engaging with business partners and transparency & disclosure. The Working Group intends to monitor compliance with this code during 2008, 2009 and possibly afterwards. Evidence of the announced launch of the Responsible NanoCode and Benchmarking Framework in October 2008 has not been published on the website. (Responsible NanoCode, 2008) The steering group has chosen Cranfield University to be the organisation to take forward the benchmark and become the permanent home for the code. They are currently putting together a funding programme for this. (Hilary Sutcliffe, personal communication, 15-01-09)

A precursor to the European Commission code, aimed at developing a practical precautionary approach to nanosafety started in 2005, in the form of a private partnership of the NGO Environmental Defence and the company Dupont. These partners have joined forces to develop a NanoRisk framework. This framework for evaluating potential risks of nanoscale materials (2007) is a six step approach:

1) Describe material and application;
2) Profile life cycle(s);
3) Evaluate risks;
4) Assess risk management;
5) Decide, document and act;
6) Review and adapt.

The approach is published on a website (www.nanoriskframework.com), applied to case studies and discussed in meetings. Environmental Defence and Dupont have been criticised for their attempt at sharing responsibility for nanotechnology development.
What is the relationship between these three initiatives?

All three initiatives are attempts at voluntary governance of nanotechnology in a situation characterised by uncertain risks. There are also other relevant initiatives as discussed below. Recently, the International Risk Governance Council has compared these two codes and Nanorisk framework plus the ICCA Global Core Principles of Responsible Care report on “Risk Governance of Nanotechnology Applications in Food and Cosmetics”. The authors have found that the documents overlap in shared core principles, but that each code also includes particular priorities. They conclude that voluntary codes are a useful complement to regulation of nanotechnology in a situation characterised by uncertain risks. Even though it would be ideal to have only one code, such a code would have to reflect national differences and different positions of players like SMEs and large companies. A step by step approach harmonising various parallel codes is recommended. Voluntary codes can play a role in building trust by stakeholders in companies risk management policies, but must include mechanisms for ensuring compliance in order to be credible. (Grobe, Renn & Jaeger, 2008)

International organisations’ activities on responsible nanotechnology development

UNESCO and OECD have created international platforms for discussing responsible nanotechnology at global scale. UNESCO’s World Commission on the Ethics of Scientific Knowledge and Technology (COMEST, 2007) has proposed several actions to be taken by UNESCO and its member states to stimulate an ethical approach to the development of nanotechnology. These proposals include activities for articulating the ethical framework (ethical principles, public accountability and transparency, capacity building on ethical issues, public participation, media outreach, international cooperation and establishing an International Commission for Nanotechnologies and Ethics). They also stress the need for awareness raising and debate on nanotechnologies, including public debate addressing environmental impact and health issues; the need for risk assessment; issues related to nanomedicine; privacy and confidentiality; and intellectual property. In the existing UNESCO Ethics Education Programme (EEP), specific additions should be made to address issues raised by nanotechnology. UNESCO could also develop voluntary compliance guidelines for incorporation in regional education programmes, addressing researchers and governments. Finally, COMEST sees a need for research and development policies including in developing scientific and technical knowledge, social science research to guide policy, ethical research and ethics in connection with legal issues, social science research and innovation in research methodology, promotion of Ethical, Legal and Social Issues (ELSI) research, nanotechnology and development, voluntary guidelines and institutionalisation. It appears that UNESCO favours an approach like the European Commission policies and code of conduct for responsible nanotechnology research. So far, no follow up on the recommendations has been initiated.

The OECD Working Party on Nanotechnology WPN aims for responsible development of nanotechnology through six focus areas including three relevant to ethical and social aspects of nanotechnology rather than more innovation issues:

- Outreach and Public Engagement;
- Policy Dialogue;
- Global Challenges: Water;
- Companies and Business Environments;
- International Research Collaboration;
In the field of “Outreach and Public Engagement,” OECD WPN organized a conference exploring best practices in “how to best engage the general public in nanotechnology,” in Delft, The Netherlands, 30 October 2008. According to keynote speaker Arie Rip (University of Twente), several governments including the Dutch now have to start new public engagement activities for nanotechnology which are more aimed at orchestration of the public debate than at trying to do traditional risk communication. He also warned that traditional public engagement, as a form of direct democracy, may undermine our system of parliamentary, representative democracy. He concluded that it is more important to stimulate good governance of nano than to democratise the debate. Involving stakeholders should get more priority than activities aimed at the general public.

The Dutch government published an action plan for nanotechnology in July 2008. As part of this, it is about to install a temporary “Commission for the social dialogue on nanotechnology” (end of 2008-2011). This commission will draw up a political agenda for nanotechnology priority issues to be discussed, including privacy. The French government is discussing plans for a national debate on nanotechnology, to be organised by the National Committee on Public Debate CNDP. Both are looking for new ways to do this.

In the UK, the government intends to fund social and ethical research into:

- exploring social impacts of geographical clustering of nanotechnology innovation communities (DEFRA will issue a call for proposals shortly);
- (ethics of) nanotechnologies in medical research;
- life cycle effects of nanotechnology products;
- Exploring potential lessons for nanotechnology from GMO crops, asbestos etc.²

The aim of the “Policy Dialogue” is to facilitate dialogue on policy responses to nanotechnology issues through questionnaires, events and other materials. In the field of “Global Challenges: Water”, OECD has organised a workshop in connection with the Nanotech Europe 2008 conference in Copenhagen.³ The aim is to identify nanotechnology opportunities for water purification.

Relevant stakeholder initiatives in Europe and internationally

Not only governments and intergovernmental organisations are active in codes of conduct and other voluntary measures for responsible nanotechnology development. Both NGOs and industry associations have taken relevant initiatives. NGOs tend to focus on defining guiding principles, whereas industry associations are more focused on putting responsible nanotechnology in practice.

In 2007, an international coalition of originally 44 and currently 69 NGOs and research organisations has published “Principles for the Oversight of Nanotechnologies and Nanomaterials”, including eight principles:

I. A Precautionary Foundation;
II. Mandatory Nanospecific Regulations;
III. Health and Safety of the Public and Workers;
IV. Environmental Sustainability;
V. Transparency;
VI. Public Participation;
VII. Inclusion of Broader Impacts;

² A longer report on this conference has been published at www.nanoforum.org > news, 3 November 2008
³ See: http://www.nanotech.net/content/conference/themes/water/state-the-art-research-nanotechnology-enabled-water-purification-tec
VIII. Manufacturer Liability. (Nanoaction, 2007)\textsuperscript{4}

Related to this, in Europe, the Health and Environment Alliance HEAL has published recommendations on a strongly precautionary approach to nanotechnology and health risks on their website after consultation with their member organisations and other NGOs. The recommendations include assessment of nanomaterials as new chemicals, mandatory safety testing, labelling, consideration of broader societal implications and public participation in decision making.\textsuperscript{5} Furthermore, the European Trade Union Confederation (ETUC) executive committee has called for applying the precautionary principle to nanotechnologies, 26 June 2008. The main concern is worker (and consumer) safety. (ETUC, 2008)

In parallel to this, several chemical industrial companies have published company codes of conduct on their website and are participating in stakeholder dialogue organised by governments and the European Commission. In addition, the European Chemical Industry Council CEFIC is organising stakeholder dialogue on enabling responsible innovations of nanotechnologies, in response to a call in October 2007 from Director General Robert Madelin of European Commission DG SANCO (Health and Consumer Protection) for informing public authorities, NGO’s and the general public about functionality, benefits and risk related questions of nanoproducts. CEFIC has identified two topics for dialogue: nano-coatings (with the highest number of consumer-relevant products) and environmental technologies incorporating nanotechnology (with the highest potential for the future to solve challenges like energy efficiency and renewable energies). Cosmetics and food are also considered topics for debate, but other industry associations are in a better position to take the initiative: COLIPA for cosmetics and CIAA for food. In 2009, CEFIC wants to carry out stakeholder participative projects on nanotechnologies stimulating the European Chemical Industry to research, develop and market nano-enabled products in a socially responsible and environmentally sustainable manner. (CEFIC, 2008)

On a global level, the International Council for Chemical Associations (ICCA) has issued Global Core Principles of Responsible Care. Currently, nanotechnology or nanomaterials are not explicitly included, but there are plans to do so according to the IRGC. (Grobe et al, 2008)

What does the general public think about responsible (nanotechnology) research?

In a recent Flash Eurobarometer study on “Young People and Science,” almost 25000 young people aged 15-25 in the EU27 member states were asked to give their opinions on science and technology. The survey included questions relevant to responsible nanotechnology. Most respondents agreed strongly or tended to agree that “Science brings more benefits than harm”, and that “science and technology make our lives healthier, easier and more comfortable”. Opinions were split over the potential of science and technology to eliminate poverty and hunger, and to create more jobs than they eliminate. Most respondents thought that “today, scientific research is influenced too much by profit.”

Eight out of ten respondents agreed that “scientists are devoted people who work for the good of humanity”. But six out of ten thought that “due to their knowledge, scientists have power that can make them dangerous.” This seems to imply young people think scientists have a large responsibility for technological development.

The citizens are most often seen as the group who should have the biggest influence on decisions about where money for research is spent. (26% considered them firstly, 18% secondly). They were followed by the scientific community (20% firstly, 17% secondly) and the government (18% firstly, 20% secondly). Research organisations (16% firstly, 17% secondly).

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\textsuperscript{4} See website: [http://www.nanoaction.org/nanoaction/index.cfm](http://www.nanoaction.org/nanoaction/index.cfm)
\textsuperscript{5} See website: [http://www.env-health.org/a/2892](http://www.env-health.org/a/2892)
secondly) and the European Union (13% firstly, 16% secondly) were mentioned a bit less, and private enterprises (2% firstly and 5% secondly) and the media (2% firstly and 3% secondly) were hardly considered as groups which should be influential.

The young respondents were considerably less aware of nanotechnology than of other innovations. 61% had heard about nanotechnology, and 34% had not heard about it. 34% were interested in nanotechnology and 52% not. They felt much less able to give an opinion on whether nanotechnology presented more risks or more advantages to society compared to other innovations. 27% gave the answer “don’t know” or no answer, which was 2-7% for other innovations. The young people who gave an opinion on nanotechnology were mostly positive. 44% thought nanotechnology presents more advantages than risks to society, 11% thought it presents more risks than advantages and 19% foresaw the same amount of risks and advantages. This was less optimistic than for brain research, mobile phones, computer & video surveillance techniques, and human embryo research; but more optimistic than for nuclear energy and genetically modified foods. (Gallup Organisation, 2008)

Young Europeans in 2008 were more certain about nanotechnology than the general public in 2005, according to the latest Eurobarometer study on biotechnology. Then, 42% of respondents did not know if nanotechnology would have positive or negative impacts on their lives. 40% were positive, 13% expected no change, and 5% believed nanotechnology will deteriorate their life. Only 44% said they had heard of nanotechnology. Nanotechnology was considered morally acceptable, useful and not risky, and most respondents believed it should be encouraged. 55% of respondents supported nanotechnology.

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### 4 Responsibility issues in current nanoscience and nanotechnology

The ObservatoryNano interim reports on technological and market trends in nanotechnology give rise to a number of ethical and societal issues. The issues are listed in Table 4.1.

**Table 4.1: Ethical and societal issues in the technical trend reports**

<table>
<thead>
<tr>
<th>Topic of the report</th>
<th>Identified issues</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Agricultural production</strong></td>
<td>- <strong>Sensor networks</strong> (for crops and livestock): potential ethical issues: privacy, dual use, balance security-freedom (not typical for agricultural applications);</td>
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<td></td>
<td>- Disease and pest control in crop plants: risks of residue and unintended consequences for human health and the environment, <strong>precaution</strong>;</td>
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<td></td>
<td>- <strong>Intellectual property issues</strong> (proprietary technologies and knowledge may hinder innovation in e.g. nano-emulsion technology);</td>
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<tr>
<td></td>
<td>- <strong>Genetic engineering</strong> of crops and livestock is controversial;</td>
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<tr>
<td></td>
<td>- Agriculture as means to produce nanomaterials: competition with food-crops may lead to increased food prices and hunger (cf biodiesel), distributive <strong>justice</strong>;</td>
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<tr>
<td></td>
<td>- Chances for green/sustainable production of (nano)materials offer potential <strong>benefits for society and the environment</strong>.</td>
</tr>
<tr>
<td><strong>Textiles technology and sector</strong></td>
<td>- Chances for greening textiles production offer potential <strong>benefits for society and the environment</strong> (chemicals/materials/energy saving; reduced waste);</td>
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<tr>
<td></td>
<td>- Potential unknown health/safety risks, need for life cycle analysis, <strong>precaution</strong>;</td>
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<tr>
<td></td>
<td>- Antimicrobial applications: offers benefits as well as potential risks for health and the environment. Need for life cycle analysis, <strong>precaution</strong>;</td>
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<td></td>
<td>- Fear of side effects of nano-products (environmental/toxicity/allergy issues) to some extent for Clothing, domestic and medical uses (Cientifica, 2006), <strong>precaution</strong>;</td>
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<tr>
<td></td>
<td>- <strong>Intellectual property issues</strong> (e.g. preference to licence, rather than implement) especially for medical and military uses (Cientifica, 2006);</td>
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<tr>
<td></td>
<td>- Medical e-textiles: preventive healthcare applications change definitions of health, raising ethical issues of enhancement, choices in use of limited healthcare resources and privacy issues (also for sports).</td>
</tr>
<tr>
<td><strong>Regenerative medicine</strong></td>
<td>- General <strong>biomedical ethics</strong> issues apply;</td>
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<tr>
<td></td>
<td>- Possibly <strong>enhancement</strong> issues?</td>
</tr>
<tr>
<td><strong>Construction sector</strong></td>
<td>- <strong>Precaution</strong> (worker safety)?</td>
</tr>
<tr>
<td></td>
<td>- Use of raw materials / commodities markets? (Sustainability, distributive <strong>justice</strong>);</td>
</tr>
<tr>
<td></td>
<td>- <strong>Sustainability</strong> issues, incl. energy saving, emission reduction in manufacturing building materials or in use;</td>
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<tr>
<td></td>
<td>- Cooperation with or impact on socio-economic development of</td>
</tr>
</tbody>
</table>
developing countries, distributive justice

Security
- Focus on terrorism, excluding other security issues including warfare and crime (but includes narcotics);
- Dual use is acknowledged (detection of chemical agents incl. industrial toxins);
- Cf HIDE project discussion of biometrics / Nanoforum report on nanosecurity – elsa issues;
- Terahertz detectors lead to severe privacy and human rights issues if used to see through clothes of people;
- What is the main market for security technologies (small shop-owners wanting to prevent theft?).

Environment
- groundwater remediation
- Potential benefits for sustainable development;
- Life cycle analysis needed to avoid unintended consequences, precaution.

Environment
- chemical and gas sensor
- Privacy issues;
- Other ethical or ELSA issues depend on the application.

Chemistry & materials
- Precaution, risk governance

ICT- Displays
- Ubiquitous computing issues (privacy);
- Human-machine interactions;
- Life cycle analysis, precaution.

No issues were identified for ICT – Power components, Energy (incl. solar cells), Automotive & Aeronautics. The identified issues are related to the themes for the annual reports on ethical and societal aspects of nanotechnology in the first, second and third year: individual and collective responsibility for nanotechnology development (table 4.2); nanobiomedical ethics, ICT, privacy and security (table 4.3). In the present report, the focus is on the first theme. References to relevant literature are included for the other themes, which will be analysed more in depth in future years.

Table 4.2 Individual and collective responsibility for nanotechnology development
- Governance (choices in limited resources, benefits, sustainable, scenario/foresight): agricultural production, textiles, the construction sector and the environment (groundwater remediation);
- Innovation, intellectual property: agricultural production and textiles;
- Precaution, risk, dual use: agricultural production, textiles, the construction sector, security, the environment (groundwater remediation), Chemistry and materials and ICT (Displays);
- Justice, nano and the poor: agricultural production, textiles, regenerative medicine and the construction sector.

Table 4.3 Other issues

<table>
<thead>
<tr>
<th>nanobiomedical ethics</th>
<th>ICT, privacy and security</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Human machine interaction;</td>
<td>- Security;</td>
</tr>
<tr>
<td>- Enhancement;</td>
<td>- Freedom;</td>
</tr>
<tr>
<td>- Anthropology;</td>
<td>- Privacy;</td>
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<tr>
<td>- Human rights;</td>
<td>- Computer ethics;</td>
</tr>
<tr>
<td>- Health or medical ethics;</td>
<td>- Human rights.</td>
</tr>
<tr>
<td>- Bioethics.</td>
<td></td>
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</table>

22
5 Analysis

In this chapter, responsibility issues identified in the technical trend reports and economic reports presented in chapter 4 are being analysed with the following questions:

- Which stakeholder group are and are held responsible for which aspect of nanotechnology development? (Nanoscientists; Industrialists (large companies and SMEs); Government; Parliaments; Trade Unions; Consumer Associations; Environmental NGOs; Patient Associations; Churches; Media; General Public; Others)
- How can each stakeholder group take its responsibility?

5.1 Choosing priorities in nanotechnology research

Choosing priorities in nanotechnology research is an issue in agricultural production, textiles, the construction sector and the environment (groundwater remediation).

Which stakeholder groups are currently responsible for choices in research priorities of nanotechnology?

In the present circumstances, decisions on priorities in research are taken in the “triple helix” of the scientific community, industry and government departments and agencies funding research.

In principle, governments are responsible for choices in research priorities for basic and application oriented research, as they fund most of this research either as basic funding for universities and research centres or as funding for competitive projects. However, in practice governments do not have the expertise in house to decide such priorities by themselves, and rely to a large extent on advice by leading researchers and industry. In some countries like the Netherlands, priority setting is left over to “the field” (research community and industry) on purpose.

The scientific community is responsible for choices of priorities in nanoscience and its applications. Part of the government budget for research is at the discretion of universities, part is distributed via funding councils who determine priorities after expert consultation and in peer review processes, and part comes from external sources including industry. For nanoscientists, internal academic credentials including numbers of publications and citations remain a strong incentive for their work, but they also have to take into account industrial priorities.

Industrialists (large companies and SMEs) are responsible for choices in research priorities in case they participate in public-private research projects, fund research in universities or public research centres as well as for in-house research. It depends on the national (or EU) research policy how much influence they have in practice on priorities in nanoresearch. In the EU framework programmes, large companies and SMEs can participate as partners in EU funded projects. Large companies also play leading roles in European Technology Platforms where long term strategies for European research have been developed. E.g. the ETP
Nanomedicine\(^7\) is chaired by representatives of Philips and Siemens, and the ETP ENIAC\(^8\) on nanoelectronics has a steering committee consisting of representatives of chipmakers, equipment suppliers, users, research organisations, EUREKA, the Commission and public authorities.

**Parliaments** are responsible for regulating nanotechnology, as the legislative power in government. But as elected representatives of the people, **parliamentarians** are also mandated to discuss strategic choices regarding investments of public funds, including in science, technology and innovation.

**Which stakeholder groups are not currently responsible for choosing priorities in nanotechnology research, but would like to be involved?**

**Trade Unions** are responsible for representing workers interests including in occupational health and safety at work. The European Trade Union Confederation (ETUC) represents over 60 million workers, members of 82 trade unions in 36 European countries\(^9\). ETUC and several national trade unions have developed positions on nanotechnology in the EU funded NanoCAP project and published them in 2008\(^10\). They participate in dialogue on priorities in nanotechnology research, and have proposed to invest at least 15% (European level) or even 30% (Dutch FNV) of the budget for nanotechnology research in risk assessment.

**Environmental NGOs** like Greenpeace UK see opportunities for environmental applications of nanotechnology. (Arnall, 2003) The Dutch Animal Rights organisation AVS Proefdiervrij pleads for developing applications of nanotechnology in alternative toxicity tests for animal testing\(^11\).

**Patient Associations** are currently not so visible in the dialogue on nanotechnology priorities, but in the past, Mary Baker of the European Parkinson Disease Association EPDA has participated in discussions on nanomedicine. The Dutch Genetic Alliance VSOP and the Biotechnology and Genetics Forum have expressed interest in stakeholder input in the discussion on nanotechnology (Hanssen et al, 2008). Patients may welcome medical applications of nanotechnology and be concerned about potential health risks.

Some **Church-related organisations** have already published statements or discussion documents on nanotechnology. E.g. an advisory committee of the Evangelical Church in Germany EKD pleads for responsible nanotechnology development, and has analysed anthropological and ethical principles from a protestant Christian perspective. They would like to participate in public dialogue. (Kordecki, Knüppel, Meisinger, 2007) The Church of Scotland’s Society Religion and Technology project has been engaged in debates on ethics of nanomedicine for years\(^12\). COMECE, representing European (Catholic) Bishops Conferences to the European Community, has published an opinion of their Bioethics group (2007) on nanomedicine, also pleading for public dialogue. The World Council of Churches has published a discussion document on converging technologies (Lee & Robra, 2005).

\(^7\) Website: [http://www.etp-nanomedicine.eu/public](http://www.etp-nanomedicine.eu/public)
\(^8\) Website: [http://www.eniac.eu/](http://www.eniac.eu/)
\(^9\) Website: [http://www.etuc.org/](http://www.etuc.org/)
\(^10\) Website: [www.nanocap.eu](http://www.nanocap.eu)
\(^12\) Website: [http://www.srtp.org.uk/srtpage3.shtml](http://www.srtp.org.uk/srtpage3.shtml)
Marginalised populations and poor people of the South are also not currently engaged in decision making on priorities in nanotechnology research, except in some pilot projects, e.g. on nanotechnology for water purification organised by DEMOS (UK) and Meridian Institute (USA). Gregor Wolbring (direct communication) is concerned that they are not seen as a group that should be involved in governance.

Which stakeholder groups are held responsible for choices in research priorities for nanotechnology and which are not?

Young people in Europe think scientists have a large responsibility for societal consequences of their work, and many of them think the scientific community or research organisations should influence choices in science and technology. But scientists are not the only ones expected to decide on priorities in research. A higher percentage of young people think citizens should be most influential and many think governments and the European Union should be most influential. Only a few percent of European young people think industry should have high influence on choices in science and technology (Gallup, 2008, see chapter 3).

Parliaments are often seen merely as part of governments, as the legislative power, and responsibility for choices in research priorities is not commonly attributed to them. Media publish about nanotechnology issues with news value, including large investments in research, scientific breakthroughs and the risk debate. More strategic developments in research policy and priorities in research don’t tend to get a lot of media attention. Only a few percent of young Europeans think the media should be influential in priorities in research. (Gallup, 2008, see chapter 3)

The General Public is not currently engaged in discussions on priorities in nanotechnology research. According to several Eurobarometer surveys, a high percentage of Europeans is not even aware that nanotechnology exists (56% of the general public in 2005, 34% of young people in 2008). Many stakeholders who do participate in the nanodebate plead for larger public engagement. 44% of European young people want the general public to take first or second place in influencing technology development, but more than half of them are not interested in nanotechnology. (Gallup, 2008, see chapter 3) Arie Rip (2008) pointed out that stimulating direct democracy by greater public engagement in nanotechnology governance might undermine the current system of parliamentary democracy in Europe.

How can different stakeholder groups take their responsibility?

Nanoscientists are expected “To use their skill transparently relinquishing the idea of short term personal gain,” and “Governmental and/or strong financed institutions can take responsibility for nanotechnology development by dedicating considerable number of experienced workers with significant amount of money. These institutions should recruit young researcher to work for nanotechnology,” according to respondents to a short questionnaire on responsibility for nanotechnology.

On the other hand, the traditional system of scientific self-governance is challenged by social and human scientists, civil society actors and policy makers, who plead for upstream and midstream public engagement in decision making on choices in limited resources and the development of more robust future scenarios of technology and its societal consequences. Nanotechnology is one of the first areas of research where experiments with these engagement activities have been undertaken in cooperation with the nanoscientific community under pressure of funding bodies, since the beginning of the 21st century.
According to Arie Rip (2008), such engagement may lead to more reflectivity on choices in limited resources and better quality future scenarios.

Some researchers and industry representatives request governments to take more initiative, “orchestrating” a stakeholder engagement process. (e.g. Arie Rip, 2008) E.g. the European Commission has been taking initiatives for governing nanotechnology development including the action plan for nanotechnology (2005-2009) and the recommendation for a code of conduct for nanotechnology research (2008). Other governments in Europe and elsewhere are developing similar initiatives, some citing the EU activities as example to follow or improve. A respondent to a short questionnaire on responsibility for nanotechnology thought politicians were most responsible for nanotechnology development: “In my opinion, a serious burden to the development of a “responsible” nanotechnology is the lack of democracy in the decision-making on science policy. Furthermore, politicians entitled to take decisions are often not very well aware of the problems and complexities and they finish up to take only decisions as a compromise between the reasons of the so-called stakeholders, which are mainly industrialists and (less) different lobbies. Scientists cannot be very much involved in the decision-making. The biggest obstacles regard the entire decision-making process of science-policy.” Not everyone would agree to this view. Another respondent also thought government is most responsible, for “regulation, implementing a system of checks and balances and informing the public.”

Parliaments could take more initiative for decisions on the public budget including research in nanotechnology. E.g. the European Parliamentary Committee on Industry, Research and Energy ITRE is responsible for this. They participate in policy making on nanotechnology, not only through lawmaking, but also by discussing action plans, communications and other documents prepared by the European Commission and by adopting resolutions and asking questions.

5.2 Precaution, risk, dual use

Precaution, risk and dual use aspects are issues in agricultural production, textiles, the construction sector, security, the environment (groundwater remediation), Chemistry and materials and ICT (Displays). Dual use aspects are generally defined as moral or societal issues related to technologies with military as well as civil uses.13

Which stakeholder groups are currently responsible for a precautionary approach to nanotechnology?

The scientific community consists of different disciplines with distinct responsibilities for nanosafety and nanosecurity. Toxicologists and risk assessment specialists are responsible for scientific research to find evidence for potential hazards or exposure scenarios for nanomaterials. Bionanoscientists have to comply with codes of conduct for biosecurity14 and strict government regulations governing dual use aspects of their research. In general, nanoscientists are responsible for implementing Good Laboratory Practices including guidelines for safe handling nanomaterials.

13 According to Gregor Wolbring there are also dual uses that have both social benefits and social risks, not just safety issues. For example how a goal of competitiveness is impacting on governance and S&T direction (see Wolbring (forthcoming, Int. journal of nanotechnology), Wolbring (2008) ).

Industrialists are responsible for occupational health and safety and for the safety of their products. The same or stricter codes and legislation on safety and security for research apply as for scientists.

Governments and Parliaments are responsible for regulating market access of products, also those with made with nanotechnology, and for investing in risk research.

Different civil society groups are responsible for lobbying for a particular interest or issue with governments, parliaments and industry, and for influencing public opinion. Trade Unions should represent worker interests, consumer associations must represent consumer interests, environmental NGOs should plead for avoiding environmental risks of nanotechnology and for stimulating environmentally sustainable development of nanotechnology.

Which stakeholder groups are held responsible for a precautionary approach to nanotechnology?

In the current discussion on a precautionary approach to nanotechnology, there is no consensus on the responsibilities of different stakeholders. Apart from formal (legal) accountability, different stakeholders are calling upon other stakeholders to take their voluntary responsibility for governing uncertain risks. Governments and NGO’s expect industrial companies to cooperate with authorities and submit results of risk assessment of nanomaterials. Members and committees of the European Parliament (EP) demand that the European Commission should take a much more proactive approach to regulation of nanomaterials, risk assessment, labelling, intellectual property issues and ethical guidelines.

How can different stakeholder groups take their responsibility?

Voluntary codes of conduct may function as an instrument for self-regulation of industry. Several companies have published their own company code of conduct for nanosafety, or are participating in stakeholder dialogue organised by the EC, governments or industry sector associations like CEFIC. Some sectors are more open about their use of nanotechnology than other sectors. E.g. the food sector has a reputation of not being open enough about nanomaterials in food.

Currently, governments take responsibility by imposing existing regulations, adapting guidelines for implementing the regulations and through soft law including voluntary codes of conduct such as the EC code discussed in chapter 3. They discuss common standards and risk research programmes in international forums including OECD, the Food and Agricultural Organisation FAO and World Health Organisation WHO.

Parliaments can put risk governance of nanotechnology on their agenda and amend legislative proposals or initiate legislation. E.g. the European Parliament (EP) is currently discussing a motion from the Environment Committee for a European Parliament resolution.

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15 See website www.cefic.org
16 FAO and WHO are organising an expert meeting on food safety implications of nanotechnology in agrifood, 1-5 June 2008, see call for experts: http://www.fao.org/ag/agn/agns/expert_consultations/Nanotech_EC_Call_for_Exp_and_Info.pdf
on regulatory aspects of nanomaterials, which demands that the European Commission should take a much more proactive approach to regulation of nanomaterials, risk assessment, labelling, intellectual property issues and ethical guidelines. (Schlyter, 2009) Earlier, the EP Environment Committee had expressed its concern “about the lack of specific legal provisions to ensure the safety of consumer products containing nanoparticles and the relaxed attitude of the Commission with regard to the need to review the regulatory framework for the use of nanoparticles in consumer products in light of the increasing number of consumer products containing nanoparticles being put on the market.” (European Parliament, 2008) In July 2008, the EP has also amended a proposed food additives regulation in second reading, making it obligatory to test food additives already allowed on the market under that regulation again after a significant change in particle size including the use of nanotechnology.

**Trade Unions** can lobby industry and governments asking for application of the precautionary principle. They can also lobby governments asking for regulation and law enforcement; and inform workers about best practices in nanosafety. E.g. the executive board of the European Trade Union Confederation ETUC adopted a resolution on nanotechnology in June 2008\(^\text{17}\).

**Consumer Associations** can make statements aimed at influencing government and industrial policies. E.g. several consumer associations are pleading for labelling of consumer products with nano inside, to enable freedom of choice. They also want to be able to trust that unsafe products are not allowed on the market. Michael Hansen of the US Consumers Union (2008) listed consumer requirements for information and risk governance.\(^\text{18}\) The European association of consumer associations BEUC and European Environment Bureau EEB propose to exclude products which contain manufactured nanomaterials and nanostructures which could be released into the environment from their proposed ecolabel. (EEB & BEUC, 2008) In BEUC’s work programme for 2009, they aim that the “EU takes concrete measures to address the potential risks of nanotechnologies in consumer products”, “awareness for need for measures to be put in place to provide for safe use of nanotechnology” in food, and “development and use by the EMEA of a specific risk-assessment methodology for nanomedicine.” (BEUC, 2009)

**Environmental NGOs** can express their concern about potential risks of nanotechnology. E.g. several environmental NGOs are pleading for application of the precautionary principle. Others are asking for moratoriums for application of free nanoparticles in certain types of consumer products (cosmetics, washing machines, food and food packaging). (See also EEB & BEUC, 2008) Friends of the Earth pleads for a moratorium on the further commercial release of food products, food packaging, food contact materials and agrochemicals that contain manufactured nanomaterials until nanotechnology-specific safety laws are established and the public is involved in decision making. (FOE, 2008)

In general, **civil society groups** can not only issue statements on nanotechnology, but also take legal action against policies or products they consider against the current legislation, or try to influence corporate policies by buying shares and filing motions during shareholder meetings. E.g. a broad international coalition of 69 NGOs and research organisations has not only published “Principles for the Oversight of Nanotechnologies and Nanomaterials,”

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17 See: [http://www.etuc.org/a/5139?var_recherche=nano](http://www.etuc.org/a/5139?var_recherche=nano)
(Nanoaction, 2007), but has also filed a legal petition with the (US) Environmental Protection Agency EPA demanding it to stop the sale of consumer products incorporating nanosilver.19 Critical shareholders of companies who are expected to use nanotechnology in their products are getting involved by asking for openness on use of nanotechnology and potential nanorisks. Sanford Lewis and colleagues of the Investor Environmental Health Network IEHN (Lewis et al, 2008) argue that many companies, who use nanomaterials in their products, do not communicate adequately about potential risks to their shareholders. They recommend institutional and individual shareholders to ask for information about these issues. Pat Rizzuto (2009) reports that resolutions have been filed asking for disclosure of information on products in which nanomaterials are being used and the company’s policy on nanomaterials, for the annual meetings of Avon Products, Kellogg Company, Kraft Foods and McDonald Corporation. Apparently, NGOs are trying to stimulate a new group of stakeholders (shareholders) to take responsibility for nanotechnology.

5.3 Nano and the poor, justice

Considering the analysis of ObservatoryNano technical trend reports (chapter 4 above), justice issues including nano and the poor are relevant to nanotechnology applications in agricultural production, textiles, regenerative medicine and the construction sector.

In the international discussion on nano and the poor, the UN Millennium Goals are often cited as the framework for selecting relevant technologies and applications which can contribute to fighting poverty. In this section, these Millennium Goals are taken as guiding principles.

Which stakeholder groups are responsible for distributive justice of nanotechnology?

The EU and Governments are the addressees of and carry most responsibility for implementing the UN Millennium goals (2000)20 which aim to halve poverty by 2015. Other groups including charities, academic groups and companies have also subscribed to the Millennium Campaign or are funding or carrying out relevant projects or cooperation activities.

Which stakeholder groups are held responsible for distributive justice of nanotechnology?

Industrialists (large companies and SMEs) are explicitly invited by the UN to join governments in a public-private partnership for development (UN Millennium Goal 8). NGO’s and individual citizens are calling upon governments to keep their promise.

How can different stakeholder groups take their responsibility?

The EU and Governments can invest part of their resources in nanotechnology in projects contributing to the UN Millennium Goals and stimulate R&D cooperation between researchers from their country and from developing countries. E.g. the EU has opened its Framework Programme for RTD to participants from “International Cooperation Partner Countries”: developing countries and emerging economies worldwide.

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19 See news item of 1 May 2008: [http://www.nanoaction.org/nanoaction/page.cfm?id=244](http://www.nanoaction.org/nanoaction/page.cfm?id=244)
An example of relevant agricultural research policies: The International Assessment of Agricultural Knowledge, Science, and Technology for Development has analysed trends in science and technology for agrofood including nanotechnology. “Integrated advances in nanotechnology, remote sensing, geographic information systems, global positioning systems and information and communication technology could provide opportunities for more resource-efficient and site-specific agriculture. [Chapter 6]” … “The potential for precision agriculture, ICTs, ecological production, nanotechnology and other emerging technologies to help advance development requires institutional development to create the conditions in which such technologies can generate opportunities for resource-poor producers in divers local conditions… [Chapter 3]” (IAASTD, 2008)

**Nanoscientists** can target their research towards applications which address the UN Millennium Goals. E.g. there are several projects and initiatives to develop nanotechnology for sustainable energy, clean water, therapies and diagnostics for infectious diseases, food security etc (e.g. Grimshaw & Stilgoe, 2006). There are also international research projects in which researchers from North and South cooperate on nanotechnology.²¹

**Multinational companies** could invest more in R&D in developing countries, thereby stimulating innovation and economic development in those countries as well as in the North.

**Civil society groups** could participate in the discussion on priorities in nanotechnology, pleading for targeting nanotechnology development to the needs of poor people in developing countries. Such groups could also fund nanotechnology projects addressed to the millennium goals and invest in research and innovation in developing countries (as charities or loans). Finally, they can participate in debates on implications of nanotechnology for developing countries. E.g. Trade Unions, Environmental NGOs and social scientists from Latin America and working on international level are critical of the potential of nanotechnology to fulfil the needs of poor people in developing countries. They also tend to plead for strong interpretations of the precautionary principle²². ETC group and Meridian Institute have brought potential impact of nanotechnology on commodities markets in discussion (ETCgroup 2005).²³

### 5.3.1 General nanojustice debate

Social scientists including Guillermo Foladori (personal communication) have proposed not to limit the debate on responsible nanotechnology to technological trends, but also to critically assess the current economic context in which nanotechnology is being developed. They criticise the concentration of production of nanotechnology and nanomaterials, and of nanopatents, in the hands of a small number of multinational companies, and expect that under these circumstances, nanotechnology can only increase the concentration of wealth on one side and inequality on the other. The solution pleaded for is to distinguish stakeholders with an interest in nanotechnology development from stakeholders without a say in decision making on nanotechnology, and empowering the latter. Gregor Wolbring also pleads for greater involvement of marginalised groups.

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²¹ E.g. see [www.icpc-nanonet.org](http://www.icpc-nanonet.org)
²² E.g. Latin American Network on Nanotechnology and Society ReLANS: [http://www.estudiosdeldesarrollo.net/relans/](http://www.estudiosdeldesarrollo.net/relans/)
As has been discussed in section 5.1 above, there are several projects and initiatives aimed at upstream public or stakeholder engagement with nanotechnology, involving different collections of societal groups. Most of these initiatives can be considered pilot projects and as yet there is no coherent strategy to developing a common approach to broadening the circle of stakeholders involved in decision making on priorities in nanotechnology research.

5.4 Innovation, intellectual property

Innovation and intellectual property issues are relevant to nanotechnology applications in agricultural production and textiles.

Intellectual property rights for nanotechnology form an emerging issue in nanoethics. Anthony So and colleagues (2008) have critically analysed the effectiveness of the US Bayh-Dole patent law in promoting commercialisation of public funded research results, and derive recommendations for developing countries and emerging economies currently introducing legislation promoting patenting of publicly funded research. They warn for patent thickets obstructing research in multidisciplinary areas of research including nanobiotechnology. The authors recommend introducing a number of safeguards serving the public interest, including:

- “No Exclusive Licensing Unless Necessary for Commercialisation;
- Transparency;
- Government Authority to Issue Additional Licenses;
- Government Use Rights;
- Access to End Products.”

Clarkson and De Korte (2006) and Bawa (2007) have discussed the problem of patent thickets in nanotechnology (“nanothickets”). Patent thickets are bundles of patents on platform technologies or other inventions which are needed for continued research and development in areas like nanotechnology and biotechnology. This leads to a complex system of cross licensing and patent litigation, and hampers scientific progress and innovation rather than stimulating commercialisation of public research results.

Diana Bowman (2007) has analysed the role of the Trade Related Intellectual Property Rights Agreement (TRIPS) of the World Trade Organisation in the development of nanotechnology. She foresees that early recognition of uncertainties will enable policy makers to achieve a more appropriate balance in IPR regulation for emerging areas like nanotechnology between the needs of commercial investors and innovation against the broader interests of society. The European Group on Ethics (2007) highlighted the need for debate on a more just balance between access to therapy and stimulating innovation in the case of Intellectual Property Rights for nanomedicine. UNESCO (2006) notes that a lack of scientific evidence makes it uncertain to identify risks or benefits from protecting intellectual property. They consider three controversies related to intellectual property of nanotechnology: over-liberal granting of patents, leading to a complex system of litigations and cross-licensing; new database laws, granting corporations ownership rights over facts; and the rise of “business-method” patents in information technology. The critical NGO ETC group has been campaigning against broad patents for nanotechnology, warning against patenting nature and potential detrimental effects for developing countries. (ETC group, 2005; Shand, 2003) Some commentators have suggested that the process of a nanotechnology patent 'landgrab' is coming to an end (partly because of the backlog of applications with the USPTO).

The European Commission organized an International Workshop on IPR issues in nanotechnology, 16 April 2007 in Brussels. They concluded that IPR issues like nanothickets and patent landgrab are not typical for nanotechnology and don’t merit separate policy
solutions. South-South and North-South cooperation should assist developing countries in setting up adequate patent systems. (Hullmann & Frycek, 2007)

6 Conclusions

The philosophical debate on responsibility in technological choices started around 1979, when it became clear to philosophers that modern science and technology enabled humankind to damage the biosphere on earth. Philosophers are currently discussing the concepts moral, role and collective responsibility. This discussion includes the questions whether responsibility can be ascribed to individuals in corporate organisations: what is the responsibility of members of unstructured groups such as white males or nationals of a particular country; and difficulties of ascribing responsibility to national states.

Since around 1992, the precautionary principle has been playing a role in global and European discussions on handling uncertain risks including risks of engineered nanomaterials. There is still not one commonly accepted definition of precaution, and not everyone sees a need for a precautionary approach. Alternatives including stakeholder engagement and applying principles like “As Low As Reasonably Achievable” and “Best Available Control Technology” have also been proposed.

Sustainability is again a multidimensional concept, open to different interpretations. The most authoritative definition is the one proposed by the Brundtland commission: “To meet the needs of the present without compromising the ability of future generations to meet their own needs.” Sustainable development of nanotechnology requires more future oriented Technology Assessment and Life Cycle Analysis. Some authors focus on environmental sustainability, whereas others also want to include social sustainability. Achieving sustainability requires participation of a wider range of societal actors. A useful concept is responsible or sustainable governance of nanotechnology. The IRGC started a debate on risk governance of nanotechnology in 2005, distinguishing frame I risks of passive nanostructures requiring traditional risk assessment; and frame II, more complex risks, requiring concern assessment as well as risk assessment. The subsequent discussion focused on timing and classification of different risks and the roles of different stakeholders in governance of nanotechnology.

Several organisations, including the European Commission, have proposed codes of conduct for nanotechnology. Such voluntary codes are a form of soft law, which may in the future play a role in European court cases against companies manufacturing products with nano inside if these products have caused damage. In this sense they can be seen as an interim risk governance measure in a stage where it is not possible to introduce or adapt formal legislation due to uncertainty. Some codes including the European Commission code also plays a role in international debate on responsible nanotechnology development between governments. In that sense they may help avoid trade conflicts by stimulating the development of common norms and standards in a dialogue process.

In the draft ObservatoryNano reports on technical and economic trends in nanotechnology, a number of ethical and societal issues have been identified, including: governance issues; innovation and intellectual property issues; precaution, risk and dual use issues; and global justice issues. These issues are related to choices in the research, development, application, and market entry of nanotechnology and its products and are therefore covered in the present
For governance issues, the scientific community, governments and industrialists have and are attributed most responsibility. Parliaments share in the governments’ responsibility as legislator, but as representatives of the people, they also have a role in public participation in decisions on priorities in research. This role could be made more visible. Some NGO’s including trade unions, environmental NGO’s, Patients organisations and church related organisations have made statements related to governance of nanotechnology, but so far these organisations have played a less prominent role in choices in nanotechnology research priorities than in the debate on precaution and potential risks. Media report on large investments in research, scientific breakthroughs and the risk debate, but not so much on strategic choices in research. According to some, the general public should play a more prominent role in decisions on research priorities, but this view is contested. In any case, most ordinary people don’t show much interest in nanotechnology.

Issues of precaution and risks receive most attention currently, and most stakeholders have or take some form of responsibility for it. Most responsibility for safety of workers and consumers is attributed to industrial companies, but the scientific community and governments also have major responsibilities, e.g. for risk assessment studies and for regulation and control. Parliaments and different types of NGOs are participating in debates on interpretations and practical implementation of the precautionary principle and of legislation. A new group entering the debate is formed by critical shareholders to companies expected to sell products with nano-inside. Regularly, the media report on the nanorisk debate. The general public again does not show much interest, but when asked, most people expect more benefits than risks from nanotechnology. Dual use aspects are mainly discussed for (nano)biotechnology. Governments, the scientific community and companies are involved in it. Others don’t show much interest, except for some specialised NGOs.

In this report, we have limited the discussion of nano-justice issues to discussions of nanotechnology for poor people in developing countries. The UN Millennium Goals (2000) constitute the framework for the ongoing debate on this among experts and stakeholders. These Millennium Goals are primarily addressed to governments (and intergovernmental organisations including the EU). Several research projects aiming to develop “nanotechnology for the poor” are ongoing, and the EU as well as national governments are stimulating international research cooperation between scientists from North and South (as well as South-South cooperation). Scientists and companies participating in such cooperation or project do this voluntarily. Several NGOs and social scientists are contributing to the discussion on these and other nano-justice issues.

The discussion on intellectual property rights and nanopatents is emerging among experts. It appears that the emergence of interdisciplinary areas of research including nanotechnology shifts the balance of interests of different stakeholders inherent in the current system of intellectual property rights. Nanothickets and legal and economic problems related to cross licensing as well as conflicts between companies, researchers and people in developing countries are being discussed and several solutions proposed.
The European Commission has been involved in initiatives for responsible nanotechnology development at least since 2001, through conferences, a Commission Communication, Action Plan and Recommendation for a Code of Conduct, and through funding ELSA, EHS, public communication and international cooperation activities. These activities will continue. Some issues identified in this report may be given more attention by European policy makers in the future:

- Several principles of the EC Code of Conduct (e.g. precaution, sustainability) are not well-defined and experts as well as stakeholders disagree on the interpretation and usefulness. The EC or international organisations might consider clarifying their interpretation of the terminology used;
- Dual use aspects of nanotechnology in general (not only those covered by biosecurity legislation and codes of conduct) could be discussed and the issues not yet covered by existing policies highlighted. This could be stimulated by funding research on economic, legal, ethical and social aspects and by organising expert conferences to bring research results to the attention of policy makers;
- A relatively new discussion on intellectual property rights could be stimulated more by funding research on economic, legal, ethical and social aspects. A new EC funded IP project expected to start soon may bring forward this debate;
- More stakeholder groups would like to be involved in decisions on research priorities than is currently the case. Pilot projects testing upstream engagement should be evaluated, their effectiveness analysed and best practices disseminated.

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About ObservatoryNano

The observatoryNANO project is funded under FP7 for four years from April 1st 2008. Its primary aim is to support European decision-makers with information and analysis on developments in nanoscience and nanotechnology (N&N). It will collate and analyse data regarding scientific and technological (ST) trends (including peer-reviewed publications, patents, roadmaps, and published company data) and economic realities and expectations (including market analysis and economic performance, public and private funding strategies). The ST and economic analysis will be further supported by assessment of ethical and societal aspects, impacts on environment, health and safety, as well as developments in regulation and standardisation. Although much of this work will be performed within the consortium, the project is working cooperatively with other initiatives to ensure that effort is not duplicated and that resource sharing and output are maximised. To date liaisons have been established with international organisations including the EPO, OECD, and ISO, and will continue to be established with other relevant organisations such as European Technology Platforms (ETPs), ERA NETs, and other EU-funded projects.

The observatoryNANO project is led by the Institute of Nanotechnology (IoN) (UK), and includes: VDI Technologiezentrum (DE), Commissariat à l’énergie atomique (CEA) (FR),
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