European Environment Agency

Report of the EEA Scientific Committee Seminar on emerging Systemic Risks

Copenhagen, 24 February 2016

Acknoweldgements

This report is based upon presentations and discussions that took place at a seminar of the European Environment Agency's (EEA) Scientific Committee, held on 24 February 2016 in Copenhagen. Seminar participants included:

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Key messages from the seminar

Why do we need to understand systemic risks?

The 7th Environmental Action Programme of the European Union[1] sets out the ambition that by 2050, we live well within the limits of the planet and at the same time commits the EU to a transition to a green economy. Achieving these ambitions will require transitions in our socio-technological systems in order to address the drivers of environmental degradation and climate change and re-calibrate these systems to operate within planetary boundaries. Such transitions offer significant opportunities to improve resource efficiency and promote circularity, while at the same time entailing complex risks that stretch across our social, economic and environmental systems. In the European Environment State and Outlook 2015 (SOER 2015)[2] EEA also calls for a transition towards a green economy. The goal of effecting long-term systemic transitions creates the need for improved understanding of the emerging systemic risks and opportunities likely to be associated with changes at this scale.

Characteristics of emerging systemic risks

During the seminar, several presenters commented on the characteristics common to emerging systemic risks:

- Systemic risks can result in **total system collapse**, as opposed to breakdown in individual components of a system. When environmental pressures exceed **tipping points** in systems this generates **cascade failures** both within and across systems, resulting in large scale shocks.
- These pressures are often driven by **multiple causal factors** that operate through both direct and indirect causation and with **interdependencies** and **amplification** across co-causal factors.
- Systemic risks are therefore characterised by **complexity,** which creates **uncertainties** in our understanding of causality.
- Complexity, uncertainty and issues of scale make it difficult to track **causality**, in tracing back from pressures to drivers and in **assigning responsibility** for these drivers.
- Uncertainty and complex causality lead to **dissent** amongst stakeholders regarding the allocation of responsibilities, appropriate policy responses and the associated trade-offs to be made across policy domains.
- Stretching across systems, these risks manifest differently at **multiple scales** and are **transboundary** in nature.
- Complexity, uncertainty, ambiguity make it challenging to communicate systemic risks. Communication must be tailored to audiences at different spatial scales and in different cultural contexts.
- Emerging risks may be completely new risks or old risks with new dimensions, different scales or in new conditions.

[1]EC, 2013, General Union Environment Action Programme to 2020 'Living well, within the limits of our planet'
[2]EEA, 2015, SOER 2015 — The European environment — State and outlook 2015, European Environment Agency, Copenhagen, Denmark

The role of social science in understanding environmental controversies

Research in the social science domain suggests that mapping the evolution of past and ongoing controversies in the area of risks to environment and health can support policy makers in negotiating current discourses and forecasting future issues.

- In response to systemic risks for which both drivers and subsequent impacts stretch across boundaries, policy makers need to be able to **articulate policy responses across multiple geographical scales**, including local, national, European and global.
- **New forms of expertise** can support knowledge development on complex issues, drawing on a range of actors that represent different interests, using multidisciplinary approaches and providing a space for the development of different scenarios regarding possible futures.
- Mapping the emergence of early warnings through to the development of controversies, to the political mobilisation of stakeholders and finally government intervention has provided insight into how **interactions between environmental, social and technological systems** drive the evolution of environmental controversies and influence policy decisions. Participants reflected on how to compress the time required to move from early warnings to policy interventions.

Framework for the governance of emerging systemic risks

The work of the International Risk Governance Council provides valuable insight into the kinds of procedures and processes that can help to key challenges in managing emerging systemic risks.

- The transboundary and often diffuse nature of causality implies that systemic risks cannot by tackled by single organisations or individual policy silos. **Broad partnerships of actors from different communities** are required to manage systemic risks.
- Policy makers are required to **collaborate across domains** to avoid systemic risks slipping through the gaps between mandates. Once these risks are identified, risk managers need to make the shift towards collectively assessing and managing them.
- **Transparency** is essential, with regards both to the procedural aspects of risk governance and the evidence used to support decision making.
- Policy makers are required to prioritise emerging risks on the basis of a transparent measure of **how much risk society is willing to accept**.
- The decision as to **whether evidence of harm is sufficient to warrant action** is a risk management decision, heavily influenced by the socio-political climate. Where there are uncertainties regarding causality, but evidence suggests effects may be severe, ubiquitous or irreversible, precautionary management strategies, such as the inclusion of safety factors, can respond to uncertainties.
- Flexibility, monitoring and feedback loops in the risk governance process can ensure the process remains open to the **integration of new knowledge**, as well as changes in the relevance of existing knowledge.
- **Scenario building** can be used to develop possible futures and determine the value of different policy options. Scenarios can also inform timing, by allowing the identification of pre-defined intervention points.
- **Risk perception** is more important than facts in determining the acceptability of risk management options. This highlights the importance of effective risk communication in improving stakeholder understanding of risks and the trade-offs associated with different policy responses.
- **Stakeholder participation** can foster a transparent conversation around the normative values involved in decision making on systemic risks.

Global Risks in 2016

The World Economic Forum's 2016 Global Risk Report[3] found **the failure of climate-change mitigation and adaptation** to be the global risk with the highest likelihood and impact in 2016. This top risk is linked to water crises, conflicts and forced migration. The report recognises the urgent need to identify approaches to withstand, mitigate, adapt to and build resilience against global risks through collaborative efforts.

Identifying emerging risks and linking risks across systems

The re-insurance industry provides instruments for the transfer of risk between society and the private sector, whereby industry must attach a price tag to risks. Emerging risks and complex risks are characterized by **uncertainty, presenting a challenge to the quantification of risk**. Munich Re uses a range of different tools to understand these risks and has developed a forward-looking tool that uses expert judgement to map the systemic inter-linkages between separate events, the **Complex Accumulation Risk Explorer (CARE)**. This tool provides a method for untangling complex causalities and inter-dependencies across system, so mapping causality and supporting complex scenario analysis.

Systems, resilience, risks and accounting

With regards to their role in understanding systemic risks, official statistics can bring order into confused debates. In measuring complexity in systems, there is a need to filter out noise in large data sets and **harvest critical information** to include in indicators and so create knowledge. While micro-level accounting tends to undervalue natural capital, macro-level accounting can capture systemic interactions between environment, society and economy.

Views from the EEA Scientific Committee

Members of the EEA Scientific Committee reflected on emerging systemic risks in their areas of expertise. This session harvested a wide range of risks candidates, including the degradation of ecosystem services, poor air quality and resulting pressures on health care systems, the multiple impacts of climate change, human and environmental exposure to chemicals and the broad area of environment, health and well-being.

What role should the EEA play in creating knowledge on emerging systemic risks?

In his opening presentation, Hans Bruyninckx identified areas where knowledge is needed to support the governance of emerging systemic risks.

- How can we better understand, frame and assess emerging systemic risks?
- How can we filter out crucial information on causal factors and the interlinkages between them?
- How can we integrate knowledge on planetary boundaries, tipping points and safe operating spaces into our understanding of the resilience of systems to risks?
- Can we develop systematic approaches to managing trade-offs between opportunities and risks over time?
- What tools exist that allow us to look forward and identify emerging systemic risks?

[3] World Economic Forum, 2016, 2016 Global Risk Report, Geneva, Switzerland

Discussions during the seminar did not produce definitive answers to these questions, but rather expanded on them and in doing so shaped up possible pathways for future EEA knowledge development in the area.

- The EEA could consider **working collaboratively with Eionet** to undertake horizon scanning for the identification of emerging risks based on expert elicitation. This could be followed by a process to identify the linkages that allow risks to flow within and across systems. A broad range of knowledge is required to map the range of impacts that can cascade across environmental, social and economic systems when tipping points are reached, with the EEA well-positioned to access knowledge from a range of environmental policy areas.

- A key point that emerged from discussion is the need to establish a **collective understanding of emerging risks and systemic risks**. While strict definitions may prove inflexible, efforts are needed to create a common language, in particular when working across environmental, social and economic domains.

- The EEA has a role to play in linking knowledge on the integrated, systemic dimensions of risks to knowledge on single stressors to environment and health. This will involve the development of methods to interpret **the implications of planetary boundaries for risk governance at lower geographical scales**, including European, national and at the scale of the ecosystem. Such methods could then inform the translation of broader policy objectives, such as the 7th EAP objective of living well within the limits of the planet, into policy levers at the level of thematic legislation.

- The EEA has a lead role to play in developing a common understanding of how policy makers take decisions on risks in the context of complexity, uncertainty and ambiguity. This involves a reflection on the **range and quality of evidence required to justify action** to address different types of environmental risks, as well as on the proportionality of response measures. This knowledge would support the application of **precautionary approaches** in the context of systemic risk governance, likely to be subject to uncertainties.

- The field of **environmental accounting**, in which the EEA is a key player, provides opportunities for mapping complex, non-linear interactions across systems at the macro level, including measuring impacts against tipping points and planetary boundaries. An improved understanding of resilience, flows, interactions and critical points in systems is required to support such analyses.

In **building knowledge for SOER 2020**, the EEA will need to combine quantitative and qualitative information from multiple scales and from across different disciplines in order to convincingly characterise the systemic challenges identified in SOER 2015. Where the EEA calls for transitions towards a green economy and a low carbon economy, the reflection on the opportunities offered by those transitions needs to be coupled with a robust discussion of possible risks and trade-offs. Forward-looking tools such as horizon scanning and foresight will be important in identifying possible impacts, while scenario development can support an assessment of different pathways.

Finally, contributions from the **EU institutions provided a useful framing** for how the EEA can work to generate knowledge in support of core policy files. In particular, the EEA will look to strengthen ties with EFSA regarding methods for the identification of emerging risks, as well as working through the Environmental Knowledge Community in support of DG Environment's work on a systematic approach to risk governance.

1. Introduction

This report provides a summary of a European Environment Agency (EEA) Scientific Committee Seminar on **emerging systemic risks**, held at the EEA in Copenhagen, Denmark on February 24th 2016. Participants at the seminar considered the knowledge base for identifying, assessing and tackling emerging systemic risks to the environment and human health.

Discussions at the seminar were set within the framework of the General Union Environment Action Programme to 2020[4], also referred to as 7th Environmental Action Programme (7th EAP), which is intended to guide action on the environment up to and beyond 2020. The 7th EAP sets out the following long-term, ambitious vision:

> *"In 2050, we live well, within the planet's ecological limits. Our prosperity and healthy environment stem from an innovative, circular economy where nothing is wasted and where natural resources are managed sustainably, and biodiversity is protected, valued and restored in ways that enhance our society's resilience. Our low-carbon growth has long been decoupled from resource use, setting the pace for a safe and sustainable global society."*

The 2050 vision of the 7th EAP is inseparable from its broader economic and societal context. Achieving this vision will involve significant changes to our socio-technological systems, and how they interact with and impact on the environment. Such transitions offer considerable opportunities for reducing human impacts on natural capital, but at the same involve risks that stretch across our social, economic and environmental systems. This goal of long-term systemic transitions creates the need for improved understanding of the emerging systemic risks and opportunities likely to be associated with changes at this scale.

Specifically with regards to risk governance, the 7th EAP highlights the need for an improvement in our understanding of and ability to evaluate and manage emerging environment and climate risks. This is to be achieved by:

> *"adopting a systematic and integrated approach to risk management, particularly in relation to the evaluation and management of new and emerging policy areas and related risks, as well as the adequacy and coherence of regulatory responses."*

The 7th EAP also commits the EU to stimulating the transition to a green economy and striving towards an absolute decoupling of economic growth and environmental degradation, giving proper consideration to the interplay between socioeconomic and environmental factors.

The EEA Multiannual Work programme[5] responds to the 7th EAP and frames the EEA contribution under three Strategic areas. *Strategic area 1* focuses on providing information to support implementation of both established and emerging policy frameworks. A number of areas under *Strategic area 1* explicitly tackle risks to human health via the environment, including: air pollution transport and noise; industrial pollution; climate change impacts, vulnerability and adaptation; and water management, resources and ecosystems.

The longer time horizon and the systemic approach to identifying and understanding risks are embedded in *Strategic area 2* on *assessing systemic challenges*. EEA provides knowledge to support EU

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[4]EC, 2013, General Union Environment Action Programme to 2020 'Living well, within the limits of our planet'

[5]EEA, 2014, Multiannual Work Programme 2014-2018: Expanding the knowledge base for policy implementation and long-term transitions, European Environment Agency, Copenhagen, Denmark

policy makers in identifying systemic risks, understanding the multiple causal factors behind them and acknowledging the associated uncertainties. It is also foreseen under *Strategic area 2* that the EEA will make an essential contribution to the knowledge base for the transitions a green economy, including a reflection on the associated systemic risks.

Under *Strategic area 3*, EEA responds to the demand for new insight and understanding by working with key partners in a process of knowledge co-creation, including our Scientific Committee, institutional partners, and our Eionet partners. This seminar provides an example of how we actively seek input when planning our activities in order to build knowledge that responds to the needs of policy makers.

In the European Environment State and Outlook 2015 (SOER 2015)[6] EEA calls for a transition towards a green economy. The profound changes involved in a systemic transition provide opportunities to secure long-term sustainability, halt environmental degradation and increase human well-being. However, such changes also entail systemic risks and demand a reflection on how to identify, assess and manage those risks.

In October 2015, the EEA Scientific Committee produced a note for the EEA Management Board[7] following up on SOER 2015, where, *inter-alia*, it argued that:

> *"Greater efforts are needed to address multiple stressors and design systemic approaches to managing established and emerging risks, technological and other, using foresight techniques. The uncertainties inherent to systemic challenges should be more explicitly recognised in future assessments. They also justify the need for continued application of the precautionary principle in cases where stakes are high and/or effects potentially irreversible."*

The seminar provided a forum for addressing these issues through open discussion as a contribution to EEA's strategic planning of work on emerging systemic risks.

1.1. Objectives of the Seminar

The overall objective of the seminar was to engage in a discussion on emerging systemic risks across society, and in doing so to guide the EEA on where to focus knowledge developments in this domain in the coming years.

Participants at the seminar were invited to reflect on how we as a society identify and balance emerging risks and opportunities, and how these are distributed across our social, economic and governance systems, as well as our ecosystems.

In addition, participants reflected on how systemic risks are tackled differently across geographical scales – national, European, global – as well as policy domains, such as climate, biodiversity and chemicals. Participants were asked to consider whether *systematic* approach to risk governance is required to improve our governance of emerging systemic risks, with the aim of achieving consistency in how we identify, assess, manage and communicate risks.

The debate served to inform the Agency's ongoing work on the governance of emerging systemic risks across a range of environmental policy domains, as well as across broader social, economic and ecological systems. In the longer term, the inputs and outcomes from this seminar will be targeted

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[6]EEA, 2015, SOER 2015 — The European environment — State and outlook 2015, European Environment Agency, Copenhagen, Denmark

[7]Update by the Scientific Committee Chair to the 74th EEA Management Board, 18 November 2015, Doc.EEA/MB/74/05, Knowledge for sustainability transitions in Europe

towards helping EEA improve its knowledge in this domain in the run-up to the 2020 Report, European environment — state and outlook (SOER 2020).

Specific objectives for the seminar included the following:

- Learning from experts and practitioners what **approaches, processes and tools** are currently being applied to emerging systemic risks.
- Receiving input from our Scientific Committee regarding how to target ongoing EEA work on risk governance across different policy domains.
- Listening to contributions from our key institutional partners regarding their ongoing activities to manage emerging systemic risks with the aim of informing **how EEA can build knowledge to support EU policies**.

1.2. Structure of the Seminar

The seminar was organised around four sessions, entitled:

- Session 1: Views at the science/policy interface
- Session 2: Views from the Scientific Committee
- Session 3: Views from business
- Session 4: Knowledge needs for identifying and managing emerging systemic risks

Under each session, a number of experts provided presentations. These were then followed by discussions, mediated by the co-chairs Hans Bruyninckx, EEA Executive Director, and Sybille van den Hove, Chair of the EEA Scientific Committee.

This meeting report provides a summary of the presentations and discussions structured according to the programme of the workshop (see Annex 1), including: opening remarks; the three sessions; and concluding remarks. Some overall reflections are then provided on how the seminar addressed the original objectives and on future knowledge needs regarding emerging systemic risks.

2. Opening Remarks

Sybille van den Hove, Chair of the EEA Scientific Committee, opened the seminar and welcomed participants. She highlighted the increasing relevance of the seminar topic for science and policy-making, including the interface between the two domains. She invited participants to contribute actively to the discussions so that a wide range of views could be aired and shared.

Hans Bruyninckx, EEA Executive Director, noted that society is facing complex challenges characterised by multiple interactions that cannot be captured in simple causal relationships. The systemic dimensions of risks have implications for our knowledge needs in assessing risk, as well as for the design of policy responses. In addition, we need new tools to enable us to identify emerging risks, such as the use of weak signals. The seminar provided an opportunity for a science-based discussion on how to frame complex systemic linkages and on the role the EEA can play in building knowledge to support the assessment and management of emerging systemic risks.

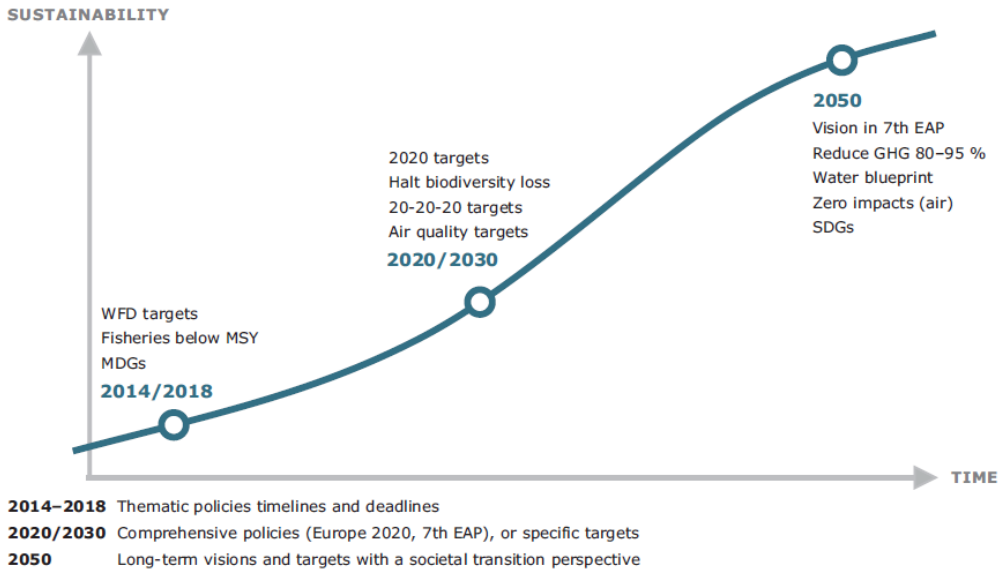
3. Session 1: Views at the science-policy interface

3.1. Long-term societal transitions and systemic risks

Noting that the EEA operates at the science policy interface, Hans Bruyninckx explained how EEA collaborates with an extensive network to gather, synthesize and translate knowledge to policy makers. Thinking on systems transitions cuts across the three strategic work areas of EEA's Multiannual Work Plan, including informing policy implementation, assessing systemic challenges and co-creating, sharing and using knowledge. In particular, the goal of Strategic area 2 is to assess systemic challenges in the context of transitions, and to signal opportunities for (re)framing or recalibrating environmental policy to facilitate transitions towards a more sustainable society.

Based on a thorough review of Europe's environmental trends and outlook, SOER 2015 reflects on how to bring policies, knowledge, investments and innovations into line with Europe's 2050 sustainability vision. In assessing progress, SOER addresses the three time horizons captured by the EU policy context and shown in figure 1 below, namely timelines and deadlines in thematic policies in the short-term, the 2020/2030 framing with a broader scope and the longer-term visions and targets, including the 7th EAP objective of living well within the limits of the planet. Implementing the 7th EAP long-term vision entails three critical elements: shifting the economic paradigm from linear to circular; protecting biodiversity and natural capital; and achieving low carbon growth.

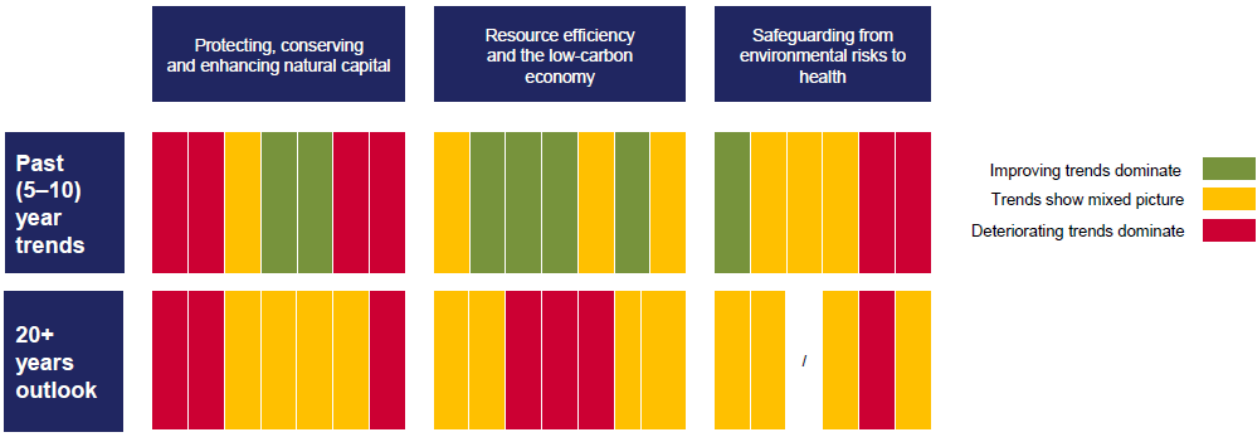
Figure 1: the EU policy context



Source: EEA Multi-Annual Work Programme 2014 to 2018

As shown in figure 2 below, the SOER 2015 analysis of trends over the past five to ten years show that resource efficiency improvements have not translated into increased ecosystem and social resilience. In addition, the long-term outlooks are often less positive than recent trends suggest, with no evidence of improving future trends, pointing to enhanced systemic risks for the EU.

Figure 2: Past trends and outlooks



Source: SOER, 2015

Two major factors explain the uneven progress and prospects. Firstly, the global context is changing, with increased competition for resources, environmental pressures originating from outside Europe and environmental pressures at a global level approaching the boundaries that the planet can sustain. Innovations in knowledge creation and in governance are required to fully understand and respond to these challenges with policy solutions. Secondly, environmental challenges exhibit systemic characteristics, including complexity and uncertainty, as well as interdependencies with social and economic factors. A key challenge for the EEA is how to understand, manage and embrace complexity in integrated assessments of environmental challenges both today and for the future.

Living well within the environmental limits of the planet will demand systemic transitions, whereby we re-organise our society within the boundaries set by the carrying capacity of our ecosystems. While, transitions offer opportunities for significant environmental, social and economic benefits, such profound changes also entail risks.

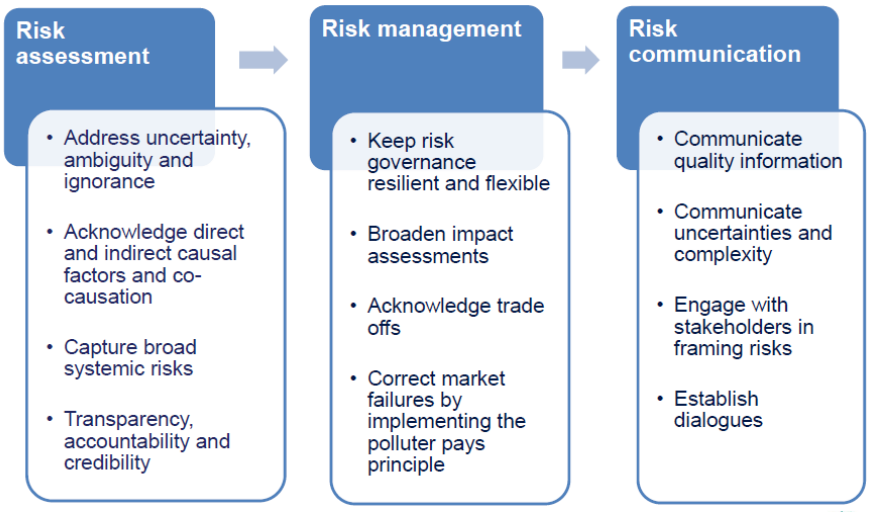
Two EEA publications, Late Lessons from early warnings: the precautionary principle 1896-2000 (2001)[8] and Late Lessons from early warnings: science, precaution, innovation (2013)[9] together provide a retrospective analysis of case studies where early warnings of negative impacts on the environment and human health were not heeded, resulting in significant damage to ecosystems and human health. In particular, the analysis explores the relationship between scientific evidence, risk assessment and risk management and concluded by drawing some general findings on risk governance. The case studies showed that if the precautionary principle had been applied on the basis of early warnings from science, many lives would have been saved and damage to ecosystems avoided. In addition, businesses may have been steered away from harmful technologies towards green innovations.

In carrying this work forward, EEA and DG Environment held a workshop on risk governance in May 2015, during which participants explored the relevance of findings from the late lessons reports in the context of current EU approaches to the assessment, management and communication of risks. The workshop aimed to inform DG Environment's work on a systematic approach to risk for environment

[8] EEA, 2001, Late lessons from early warnings: the precautionary principle 1896-2000, Environmental issue report No 22/2001, EEA, Copenhagen, Denmark
[9] EEA, 2013, Late lessons from early warnings: science, precaution and innovation, EEA Report, EEA, Copenhagen, Denmark

policies, as called for under the 7th EAP. Figure 3 provides a summary of key findings from the Late Lessons reports.

Figure 3: Summary of key Late Lessons findings against entry points in risk assessment, management and communication



Source: Presentation provided by Hans Bruyninckx at the seminar

With regards to emerging systemic risks, there is a need to define terms as a basis for a common understanding. Systemic risks can result in total system collapse, as opposed to breakdown in individual components of a system. When environmental pressures exceed tipping points in systems this generates cascade failures both within and across systems, resulting in large scale shocks. These pressures are often driven by multiple causal factors that operate through both direct and indirect causation and with interdependencies and amplification across co-causal factors. Systemic risks are therefore characterised by complexity, ambiguity, uncertainties and are often large-scale and transboundary in nature. This creates problems in understanding causality, in tracing back from pressures to drivers and identifying the actors responsible for these drivers. In conclusion, Hans Bruyninckx outlined some of the key knowledge challenges to be addressed by seminar, are presented in box 1 below.

Box 1: Key challenges to be addresses at the seminar

- How can we better understand, frame and assess emerging systemic risks?
- How to identify crucial information on causal factors and interlinkages between them?
- How can we integrate knowledge on planetary boundaries, tipping points and safe operating spaces into our understanding of systemic risks?
- Can we develop systematic approaches to managing trade-offs between opportunities and risks over time?
- What tools exist that allow us to look forward and identify emerging systemic risks?

Source: Presentation provided by Hans Bruyninckx at the seminar

3.2. Towards a new matrix of risks: learning from multi-scale controversies

Francis Chateauraynaud, Pragmatic and Reflexive Sociology Group, School of Advanced Studies in Social Sciences, France, explained how the social science perspective can inform our understanding of key controversies in the area of environmental risk governance. By analysing the evolution of past and ongoing controversies, we can learn how to forecast future issues.

Our understanding of environmental challenges has also evolved, from addressing single issues resulting from linear cause and effect, to a recognition of **systemic risks** generated by multiple, connected causal factors. This demand a shift in our analysis when assessing risks and has consequences for risk governance.

According to mainstream geologists, the understanding of environmental issues is entering a new period, the **"Anthropocene",** where outcomes are shaped by ongoing processes at multiple levels, from local to global. There is an increasing tension between the expansion of environmental standards and norms on the one hand, and the emergence of multiple sources of conflict on the other. The term "Anthropocene" was coined by Paul Crutzen and Eugene Stoermer in 2000[10] to denote the current epoch, in which geological conditions and processes are being profoundly altered by human activities. This concept has been met with contentious debate, since it focuses on the intersection between humanity and the environment, the impacts and opportunities of technology and prospects for the future.

This global perspective on risks that threaten our very civilisation provides a top-down view of how our socio-technical system generates environmental risks and influences the types of knowledge required to describe and manage those risks. However, it can be dangerous to assume that local conditions follow global trends. In fact, the local scale also creates new problems and solutions, with the various articulations between the multiple scales posing a challenges for policy makers tackling systemic risks.

There is a plurality of interpretations of what "systemic" means in the context of risks. Key characteristics include:

- Global networks connecting risks;
- Local interdependencies in ecosystems;
- Interactions between causal factors;
- The involvement of multiple actors with both converging and opposing interests;
- Multiple drivers originating in different sub-systems; and
- Non-linear complex causality.

Mr Chateauraynaud stressed that a **common definition of "systemic"** is required in order to move forward with a coherent approach to the governance of systemic risks. Framing systemic risks will require a shift from monotonic reasoning to non-monotonic reasoning that can capture non-linear associations, remain open to a plurality of interpretations and respond to feedback.

With regards to **accessing expertise to inform risk governance**, the classical approach to gathering expertise has criticised for a lack of transparency, a failure to address conflicts of interest, a reliance on single disciplines and old knowledge and a demand for repetition to verify results. Over the past 15 years, new forms of expertise have emerged to support knowledge development on complex issues, including counter, collective, distributed and participatory expertise. These various models of expertise are further described in table 1 below.

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[10] Crutzen, PJ and EF Stoermer, 2000, The "Anthropocene", Global Change Newsletter 41: 17–18

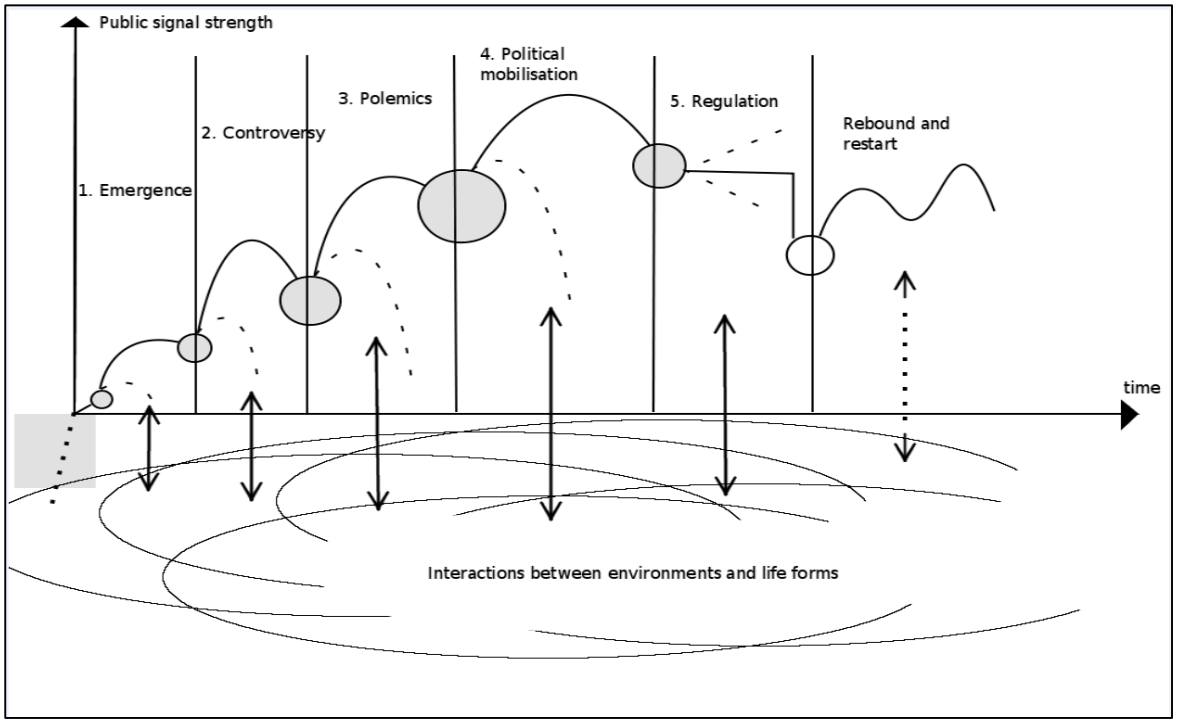
Table 1: New models of expertise for risk governance

Models of expertise	Characteristics	Decision making modalities	Outcomes
Expertise and counter-expertise	Dissent and conflict on facts and matter of facts	Legal suits on courts Political debates	Resolving the conflict with a decision
Collective expertise	Plurality of viewpoints and multidisciplinary approach oriented to a consensus-based assessment	The procedure is conducted by a national or international agency, generally after new scientific publication or marking events creating a shift in assessment	Making a strong consensus
Distributed Expertise	A diversity of actors with different skills and tools, interests and knowledge, agencies, private labs, NGOs, contribute to a trend in balancing certainties and uncertainties, knowledge and ignorance, standard evaluations and specific experimentations or experiences	Flux of studies, reports, research and reviewing, which define, without a central organizer, the common knowledge and the collective norms	Convergence and divergence which produce a space of relevant scenarios
Participatory expertise	Direct interactions between scientists, engineers, stakeholders and the public	Open consequentialism by which lay experiences and the plurality of life forms are taken into account for collective assessment	Reframing trust in public expertise and decision

Source: F. Chateauraynaud, J. Debaz, J.P. Charriau, A. Luneau and C. Marlowe, servatoire socio-informatique en santé environnementale, Une pragmatique des alertes et des controverses en appui à l'évaluation publique des risques, Rapport final, GSPR/ANSES, December 2014

The evolution of early warnings on environment and health risks into environmental controversies that result in regulatory actions has been mapped by social scientists, with a model of the general transformation of warnings and controversies over time provided in figure 4. The model provides insight into how interactions between environmental, social and technological systems drives the evolution of controversies.

Figure 4: General model of transformation for warnings and controversies



Source: F. Chateauraynaud, 2009, Public controversies and the pragmatics of protest - toward a ballistics of collective action, Culture Workshop, Harvard University, February 2009

Controversy emerges from conflicting of visions of the future held by different actors in the process, who use a range of tools and models in order to predict or forecast these various futures. There are a number of constraints on possible visions of the future, including the:

- temporal scale of the vision;
- feasibility of the pathway leading from A to B;
- the logic behind required actions; and
- the need to foster support for this vision amongst networks of actors.

Key processes that can impact on the evolution of controversies and cause ruptures or transformation of the process include:

1. Ruptures produced by natural disasters.
2. Ruptures resulting from technological failure.
3. Gradual modification of a socio-ecosystem to create new emerging problems, risks or vulnerabilities.
4. Gradual modification of the coalitions of interests and representation in the politico-social arena.
5. Strategic shifts in the balance of power, such as the emergence of a new set of players.
6. Shock strategies, whereby certain players intentionally disrupt or destroy processes.

Ruptures in the evolution of controversies may be produced by nature, by technology, or by a combination of the two, whereby extreme events reveal vulnerabilities in our technological systems. As an example of the latter, the nuclear disaster at Fukushima in 2011 was catalysed by the tsunami that hit the east coast of Japan's main Island Honshu, causing failures in cooling equipment that ultimately resulted in three nuclear meltdowns. The Fukushima accident raised questions regarding safety mechanisms and procedures and caused a rupture in the debate on the safety of nuclear energy

that rippled around the globe. For example, two months after the accident Germany's Angela Merkel responded with a commitment to phase out nuclear power by 2022[11].

Technology can also change the direction of debate on controversial issues. The 2010 explosion at the off-shore drilling rig in the Gulf of Mexico, Deep Water Horizon operated by BP, resulted from a failure of a series of technical measures designed to control blowouts. The burning rig subsequently sank and caused the largest oil spill in US waters, with an aftermath of unprecedented scale and complexity in terms of clean up and litigation. The unprecedented environmental and economic cost of the Deep Water Horizon disaster to local communities and the associated corporate liability forced a reassessment of risk in the global insurance and reinsurance markets and led to a review of the conditions against which off-shore drilling licenses are awarded in the US and Canada.

Actors in the discourse on a particular controversy can also transform the discussion, by forming coalitions of interests or by deliberately introducing shocks, for example by promoting new knowledge. The introduction of new players, such as the global power shift towards China, can also transform the balance of power between coalitions of actors.

Policy makers involved in the governance of systemic risks can benefit from understanding how controversies evolve and **how the critiques of different players drive their evolution**. Six types of critique that actors may direct at ongoing controversies are listed in table 2 below, together with examples from the discourse surrounding the exploitation of shale gas.

Table 2: Types of critique that influence controversies

Type of critique	Examples of arguments against the exploitation of shale gas
Technical critique: counter-expertise, technical or epistemic controversy	• Technical Fracking and Water pollution • Used Water and difficulties of recycling • Earthquakes Risk
Procedural Critique: Modes of consultation, deliberation and dispute resolution	• Lack of consultation • Denying local institutions and representatives
Accusation towards a specific entity: claiming against an injustice or discrimination produced by a named entity (naming, claiming, blaming)	• Noise and Pollution at specific locations due to trucks • Pressure on water supply
Critique of injustice created by a "system": struggles against inequalities, environmental justice	• Health Consequences • Quality of landscape • Tourism Consequences
Radical criticism against the "system" based on an alternative "system": deep disagreement, conflicting values and opposing worldviews with alternative visions of the futures	• US corporations in France • No utility for energy • Global Warming
Radical criticism without alternative vision: catastrophism and prophecy of doom	• Destruction of the Earth through resource extraction and capitalism

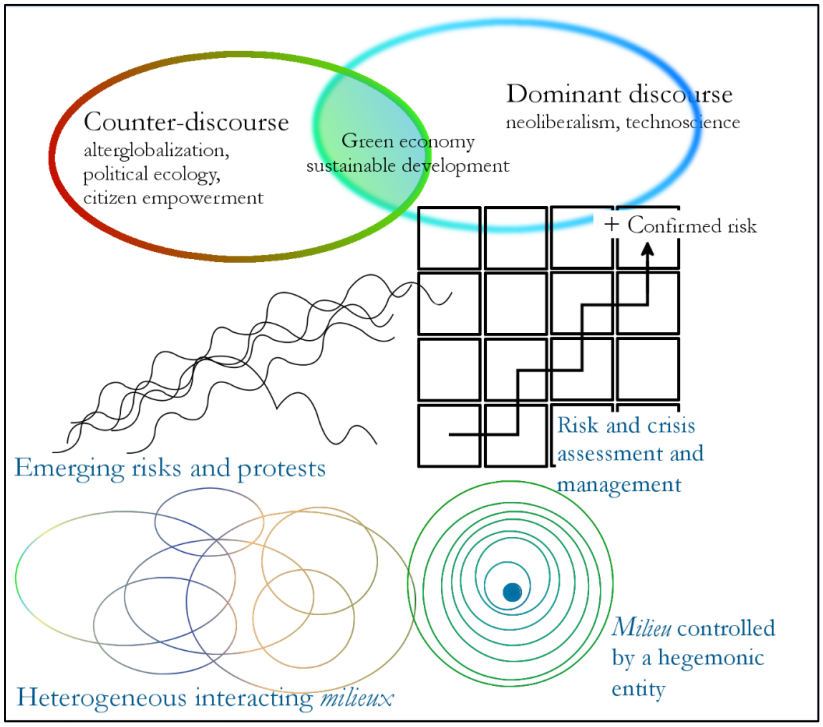
Source: F. Chateauraynaud and P. Zittoun, 2014, The future they want – or do not want: Shale gas opponents vs. proponents between local motives and global scenarios, 9th International Conference on Interpretive Policy Analysis, Wageningen University, July 2014

The channels through which these different critiques intersect and operate to influence and transform risk and crisis assessment and management are depicted in figure 5 below. The figure also captures

[11] Annika Breidthardt, May 30, 2011, German government wants nuclear exit by 2022 at latest, Reuters

the emergence of new risks and associated protests from the various milieu in which controversies are nested.

Figure 5: The transformation of controversies



Source: F. Chateauraynaud and J. Debaz, Aux bords de l'irréversible (On the brink of irreversibility), Forthcoming book, 2016

Chateauraynaud provided an example of the risks posed to the coastal ecosystem of a newly established Natural Marine Park in the Gironde estuary in France, summarised in box 2 below.

Box 2: Systemic risks to a coastal ecosystem

Established in 2015, the Natural Marine Park of the Gironde estuary and the sea of Pertuis on the French Atlantic coast faces several environmental threats that interact to pose systemic risks to the local economy. Firstly, the coastline is threatened by ongoing **coastal erosion**. Climate change is expected to increase the threat and transform the estuary ecosystem, by requiring the introduction of artificial features to the landscape to control erosion. Secondly, the Gironde Estuary is **contaminated with chemicals**, with persistent organic pollutants detected in marine bivalues in the estuary[12]. Finally, there is a nuclear facility in Blayais, a town upstream in the estuary. The first and second **nuclear reactors were flooded** in 1999 and raised concerns regarding the emergency systems in place to control possible contamination, as well as potential effects on the supply of energy to the region. Additional concerns focused on the potential **socio-economic impacts** of these environmental risks on local agriculture, in particular wine production.

Source: Presentation provided by Francis Chateauraynaud at the seminar

[12] Luna-Acosta, A, Bustamante, P, Budzinski, H, Huet, V, Thomas-Guyon, H, 2015, Persistent organic pollutants in a marine bivalve on the Marennes-Oléron Bay and the Gironde Estuary (French Atlantic Coast) - part 2: potential biological effects, Science of the Total Environment, 2015 May 1; 514: 511-22

In conclusion, Chateauraynaud stressed that most of the long-running discourses on environmental risks are non-linear processes that have been subject to multiple transformations. Understanding these past processes in the long run can help policy makers to unravel current controversies and follow their evolution at multiple scales, including the local, regional, national and global.

In the **discussion**, the following points were made:

- Stressing that policy makers should not get lost in complexity, participants reflected on how to compress the time required to move from discourse to action in the evolution of a controversy.
- Participants questioned whether the aim should be to halt controversies or to stimulate them and use the network of involved actors to help to identify solutions.
- Developments in information technology provides new tools for managing information. How can we best use large data flows of data in improving the understanding of systemic risks? How can we best communicate this information to stakeholders use the opportunities for provided by the internet?
- One participant suggested that hyper-connectivity and big data could serve to reduce the time scales over which controversies stretch.

3.3. Public sector governance of emerging systemic risks

Piet Sellke, International Risk Governance Council (IRGC), Stuttgart University, **Germany** began by identifying some key characteristics of systemic risks, including that they are:

- transboundary;
- Socially amplified via perception and social mobilisation;
- Subject to expert dissent regarding risks and benefits;
- Unmanageable by single organizations; and
- Difficult to communicate.

A number of **factors contribute to emerging risks**, with both social and technological dimensions. Scientific unknowns and systems complexity can blind us to emerging risks, while rapid technological advances create new challenges. The social dimension can include conflicts of interests, differences in values and contested science that cloud understanding and slow action. Actors may suffer from asymmetries in terms of access to information, and may act on perverse incentives or deliberately introduce misinformation to a discourse.

There are a number of **key challenges in managing emerging risks**. Firstly, policy makers are required to collaboration across policy domains in order to deal with interconnections and interdependencies. However, for emerging systemic risks causality and possible consequences are often unknown. Responsibility for systemic and novel risks frequently falls between the gaps, since it does not correspond to organisational structures. Incentives are required to encourage cross-organisation risk management.

Secondly, multi-actor partnerships are required to address risks running across systems and draw in actors with the relevant knowledge experience and resources to define the problem and propose solutions. This raises the question of which actors to involve and to what extent, in a context where we do not fully understand the scope of the risk. Stakeholders from both private and public sectors should be involved, as well as non-governmental organisations (NGOs), and an effective collaborative risk management culture is require to bridge differences in approach.

Finally, policy makers need to move from identifying emerging issues to assessing them and taking decisions on risk management in the context of uncertainties. This demands a systematic approach to prioritising risks, based on an agreed tolerance regarding how much risk society is willing to accept.

Crucial **elements of good governance** of emerging risks include drawing relevant actors into a process that is transparent. Transparency should apply to both procedural aspects and substantive knowledge, and is a prerogative for effective communication and ensuring accountability. This last element is not legal liability, but rather concerns how the burden for action falls upon different actors. These actors require incentives to take on accountability, with shared accountability being easier to carry and promoting trust amongst actors.

In addition, risk managers need new interdisciplinary methods for assessing risks, including how to marry information from different scales and how to combine qualitative and quantitative evidence. Assessment methods are required that can integrate disparate impacts across policy domains.

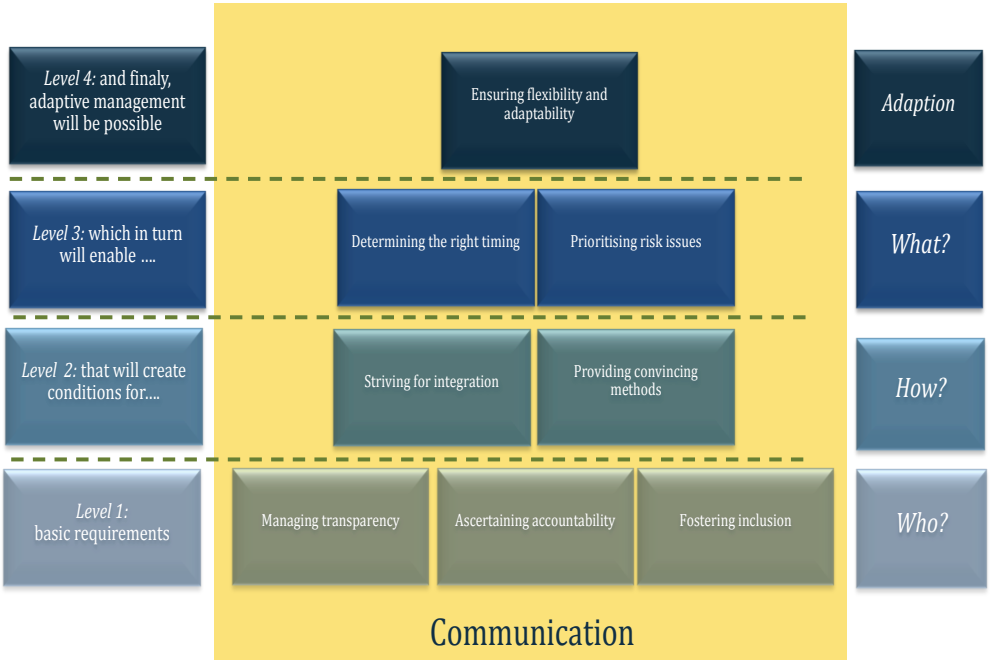
In prioritizing risks for action, risk managers should be sure to capture all causal factors and consequences, including those that lie outside their traditional framework. **Scenario building** can be used to develop possible futures and determine the value of different policy options. Scenarios can also inform timing, by allowing the identification of pre-defined intervention points.

Both assessing and managing risks will require collaborate across departments and across public and private actors, based on trust. **A lack of trust creates an obstacle to integration**, both within public institutions and between public and private. Risk governance approaches will need to be flexible and adaptable, informed by continuous and independent monitoring and open to the integration of new knowledge, as well as changes in the relevance of existing knowledge. Feedback loops should be established in the risk governance process in order to promote ongoing evaluation.

Finally, clearly defined communication approaches should be tailored to the process, the risk and the context. Ad hoc communication will fail. When crisis communication is required, this should be guided by a different set of rules reflecting the social dimensions of crisis perception.

These elements of good governance are organised into four levels in figure 6 below, focused on who, how, what and the capacity for adaptation.

Figure 6: Roadmap for the governance of emerging systemic risks

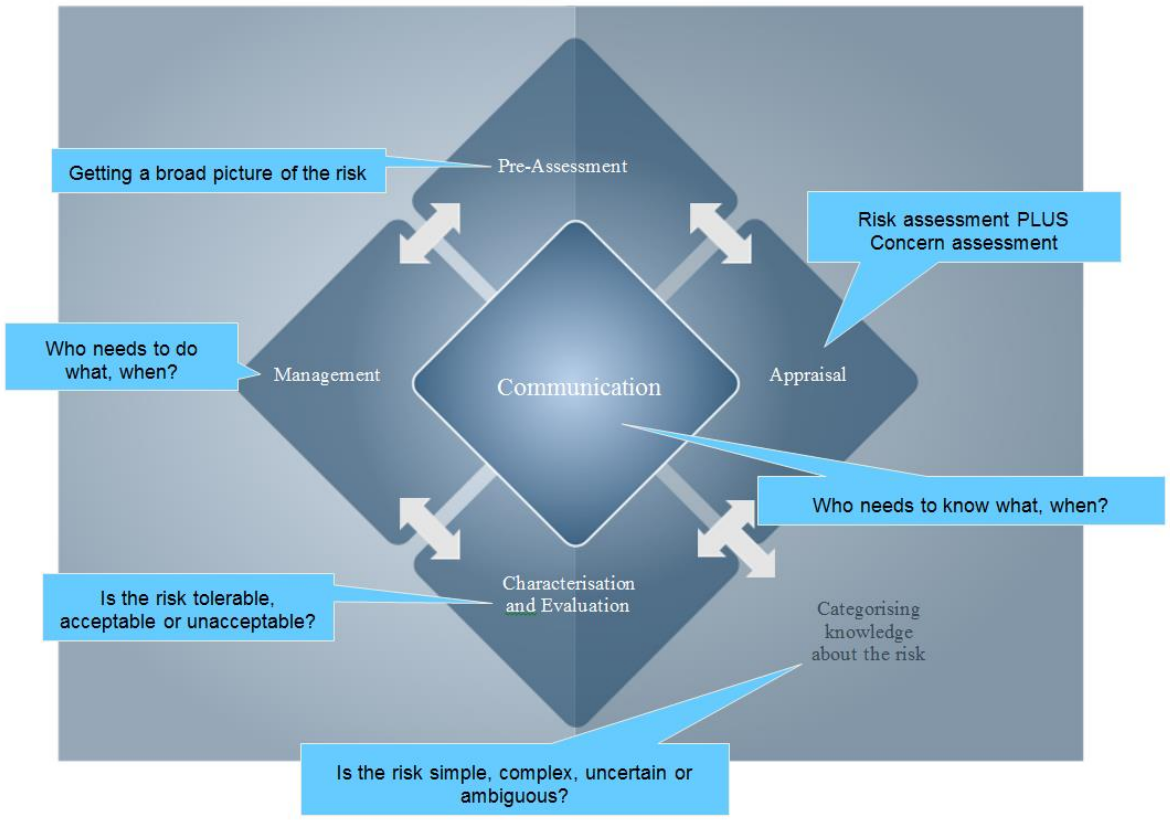


Source: Presentation provided by Piet Selke at the seminar

Selke went on to present the **IRGC's risk governance framework**[13] (see figure 7), which includes five distinct phases, including:

1. Pre-assessment;
2. Appraisal;
3. Characterisation and evaluation;
4. Risk management; and
5. Communication.

Figure 7: IRGC risk governance framework



Source: Presentation provided by Piet Selke at the seminar

Phase 1, risk framing, involves capturing the social and cultural perspectives on whether the issues is a problem, whether it is perceived as an opportunity or a risk, and whether intervention is required. The early framing of an issue can lead to very different risk response outcomes, an example being the very different responses to managing genetically modified organisms in the US and the EU. Specific parameters to be addressed in the framing stage are included in box 3.

[13] IRGC, 2012, Introduction of the IRGC Risk Governance Framework, Lausanne, Switzerland; IRGC, 2005, White Paper on risk governance: towards an integrative approach, Geneva, Switzerland

Box 3: Parameters to be addressed in risk framing

- Time and duration - future generations, sustainability
- Location and space - the universe, international, national, regional, local
- Social class and stratus - vulnerable groups, the poor, immigrants
- Types of adverse effects - physical, mental, social, cultural
- Primary or secondary impacts - ripple effects
- Criteria taken into account - risk reduction, cost, benefit, equity, environmental justice, value violations

Source: Presentation provided by Piet Selke at the seminar

Phase 2 is risk appraisal and entails two steps, risk assessment and concern assessment. In the first step, available evidence on hazard and exposure is collated and assessed to provide an estimation of risk. In doing so, the evidence must be characterised according to complexity in assessing causal and temporal relationships, uncertainty and ambiguity. Dimensions of uncertainty include:

- variation among individual targets;
- measurement and inferential errors;
- genuine stochastic relationships; and
- system boundaries and ignorance.

Ambiguity reflects dissent amongst actors regarding the interpretation of evidence, as well as normative judgements regarding whether or not a risk is tolerable.

In the concern assessment, socio-economic impacts are estimated together with economic benefits and stakeholders are consulted in order to understand their specific concerns and the perceptions that lie behind them.

Public controversy surrounding the planned disposal of the Brent Spar oil storage buoy in the deep Atlantic by Shell provides an example of how a failure to understand and respond to public perception regarding risk can generate opposition to risk management measures. Greenpeace's campaign against the disposal plan included occupation of the platform but did not include calling for a consumer boycott. Nonetheless, Shell is estimated to have lost between £60-100 million, mostly from lost sales across northern Europe, while petrol stations were fire-bombed in Germany. There was a significant disparity between the technical risk assessment and public risk perception, with public perception ultimately influencing the final risk management outcomes.

Human behaviour depends on how a risk is perceived and not on scientific facts. Qualitative factors such as dread, familiarity with risk, the immediacy of risk and values play into risk perception. An individual's ability to control risk, whether exposure is voluntary or involuntary, trust in risk managers and equality in the distribution of gains and losses all influence that individual's risk perception.

Phase 3 involves the characterisation and evaluation of risk, capturing broader, value-based questions regarding costs, benefits and trade-offs. Key questions are included in box 4 below.

Box 4: Key questions for the characterisation and evaluation of risks

Characterisation:

- What are the societal and economic benefits and risks?
- Are there impacts on individual or social quality of life?
- Are there ethical issues to consider?
- Is there a possibility of substitution?

Evaluation:

- What are possible options for risk compensation or reduction?
- How can we assign trade-offs between different risk categories and between risks and benefits (or opportunities)?
- What are the societal values and norms for making judgements about tolerability and acceptability?
- Do any stakeholders have commitments or other reasons for desiring a particular outcome of the risk governance process?

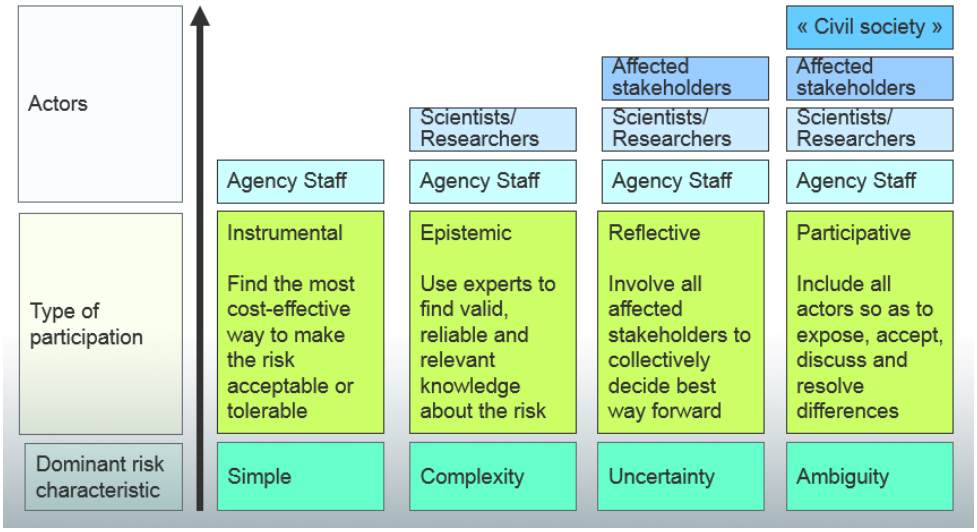
Source: Presentation provided by Piet Selke at the seminar

Phase 4 on risk management involves taking decisions on who does what and when, recognising that the "what" can also be a decision not to act. In the case of systemic risks, decision makers have to manage complexity, uncertainties and ambiguities communicated to them from previous phases. The decision as to when we have enough evidence to act is a risk management decision, heavily influenced by the socio-political climate. This decision is particularly challenging for complex, systemic risks, where there are often uncertainties regarding the links between cause and effect. Robust management strategies, for example approaches that include safety factors, can be used to absorb risk in this context, coupled with close monitoring of outcomes and flexible adaptation.

In a context of high uncertainty or ignorance where adverse effects are plausible but cannot be reliably quantified, risk managers can response with precaution-based management with the specific aim of avoiding severe, ubiquitous or irreversible effects.

Discourse based management provides a means for coping with high ambiguity, with the aim of finding consensus, or at the least tolerance. Instruments include public debate coupled with targeted risk communication and stakeholder involvement. Figure 8 provides an overview of how to organise stakeholder participation, in terms of the dominant risk characteristic, the type of participation and the actors to involve.

Figure 8: A model for stakeholder involvement in risk management



Source: Presentation provided by Piet Selke at the seminar

Risk management decisions are a result of both the scientific technical and the social perception of risk, with communication providing the means of managing risk perception. **Phase 5 is focused on communication** and runs throughout the four other phases. Objectives of risk communication include:

- Enabling stakeholders to understand risks and systemic interactions between risks;
- Raising awareness of potential risks and benefits to enable people to change their behaviour;
- Building and sustaining trust; and
- Involving stakeholders in the risk-benefit evaluation and resolving conflicts.

In conclusion, Selke stated that risk culture needs to incorporate new approaches to governing emerging risks and systemic risks that cross both policy domains and national borders. The trade-offs inherent in managing these risks should be openly acknowledged and justified.

In the **discussion**, the following points and questions were raised:

- With regards to stakeholder participation, it is challenging to reconcile the different world views and different values of stakeholders. Policy makers need to foster a conversation around the normative values and produce understanding, if not agreements. The aim is not to foster acceptance but rather tolerance of other world views.
- Systems for the identification of emerging risks can generate concern in areas where there is no need and divert resources to non-risks.
- Assessing public perception at EU level is very challenging, due to scale and variation in perceptions across member states. Risk governors also need to deal with misinformation and unequal stakeholder access to media.
- When new information become available, decision making tools need to be flexible in responding. The pre-assessment phase needs to gather together the people who need to be in the process and define the rules and the approaches. They can decide how to deal with new knowledge and establish rules for how to capture new knowledge.
- How much risk are we willing to take? This is a normative and ethical decision, that requires public dialogue to address trade-offs.
- How can we identify a proportionate response to a risk in a context where the evidence is characterised by uncertainty and ambiguity?

4. Session 2: Views from the Scientific Committee

This session involves a tour de table, whereby EEA Scientific Committee members had an opportunity to comment on emerging systemic risks in their areas of expertise. Their reflections are summarised in box 5 below, according to the governance of systemic risks, knowledge needs and thematic areas.

Box 5: Summary of reflections from EEA Scientific Committee Members on emerging systemic risks

Governance of systemic risks:

- The EU policy process should also be transparent in communicating the values that lie behind decisions on whether and how to manage systemic risks, in particular regarding the trade-offs between environmental, social and economic priorities.
- In identifying emerging risks, are we willing to accept the allocation of resources towards "false positives"?
- There is a need to educate the society about the complexity of emerging systemic risks. Public understanding of systemic risks and the associated probabilities is very poor and this limits the value of public participation in risk discourses. Could we establish a body to review the evidence on systemic risk provided in the media and make a statement on the value of that information in order to inform public debate? There is a need for policy makers to better understand how risk perception is embedded in the different Member States of the EU.
- Public confidence in science as a basis for decision making is low. There is a need for improved dialogue between the scientific community and the public.
- Government can support technological innovations that may address systemic risks directly, by providing incentives for private actors.
- Risks in different domains should not necessarily require the same approach in terms of governance. Risks for which causality is clear may be better handled through command and control methods, while systemic risk may require indirect channels, such as incentives to private actors to build understanding of inter-linkages and act over the long-term.

Knowledge needs:

- The area of risk governance is characterised by myths, for example the myth regarding our ability to control complex technological, social and financial systems. In fact, systemic risks emerge from our failure to adjust our economic, social and governance systems to reflect the ecological constraints set by the planet.
- The EEA has a lead role to play in promoting an understanding of the implications of living on a finite planet for our economic and social systems. This knowledge should support the application of precautionary approaches in the context of systemic risk governance. An example would be moving beyond measuring progress in terms of Gross Domestic Product (GDP), to measuring the outcomes of different systems for society in terms of parameters such as capacity, resilience and health.
- Further progress in the development of ecosystem accounting and its systematic application at different scales can serve to inform the governance of systemic risks. The Ecosystem Natural Capital Accounts Quick Start Package [14] published by the Secretariat of the Convention on Biological Diversity provides a valuable tool. The methodology can be used at the local level or by corporations.

[14]Secretariat of the Convention on Biological Diversity, 2014, Ecosystem Natural Capital Accounts: A quick start package, CBD Technical Series No. 77

- A range of financial tools are available to capture climate and environmental risks, including ranking pension funds on the basis of their sustainability, climate change debts, green bonds and the Climate Disclosure Project[15], which provides information on the climate impact associated with investment portfolios.
- We need clarity regarding the distinction between "systemic" risks, "emerging" risks and single issue risks, as well as regarding the tools and knowledge needed to address them. For single issue risks with which we are already familiar, science-based approaches may be appropriate.
- There are substantial information asymmetries, as well as conflicting interests. Society needs to take a collective stance on systemic risks, underpinned by sound assessment, good management, and coherent communication.
- In building knowledge, we need to effectively harness the opportunities provided by information communication technology (ICT) in the domain of environmental statistics and information, while at the same time managing security risks to society and individuals.
- We are using the tools of the past to understand the future. We need new methods that enable us to understand the future, based on real world data rather than experimental evidence. We are at risk of basing our decisions on emerging systemic risks on incomplete, outdated knowledge.

Ecosystem services:

- The concept of ecosystems services is captured in EU legislation, but Member States are provided with significant freedom in implementation. The result is an arbitrary and diverse application of the concept of ecosystem services, whereby methodologies are not consistent and not all ecosystem services are included.
- With regards to well-being, aesthetic services are frequently not incorporated into policy making.

Air quality:

- Systemic risks resulting from poor air quality include impacts on health and resulting pressure on health care systems.
- Transitions in urban transport systems provide opportunities to improve air quality by reducing vehicular emissions.
- Public perception of air quality is not accurate, with people failing to recognise improvements.

Climate change:

- The health impacts of climate change include increased deaths due cardio-vascular or respiratory illnesses, in particular amongst the aging population and those for whom adaptation is restricted by socio-economic constraints. Complex interactions between climate change and vulnerabilities associated with socio-economic status and existing health concerns are co-producing severe health impacts. Chronic health impacts places a significant burdens on the health care system, resulting in a systemic failure to maintain the quality and delivery of health care that society expects. Current financial constraints on state budgets make finding solutions extremely challenging. We face challenges in managing the co-causality that stretches across systems, such as climate, health and finance.
- Additional systemic risks associated with climate change include the effects of sea-level rise, changing distribution patterns of invasive species and vector borne diseases, as well as the

[15]Climate Disclosure Project website available at: https://www.cdp.net

impacts of increased flooding and drought. The use of geo-engineering to mitigate climate change represents an emerging systemic risk.

Chemicals:

- Chemicals enter our body through multiple exposure routes from different sources, combine in our bodies and alter our biology. Effects may accumulate over time, with the long term health effects of aggregated exposures largely unknown.
- In terms of emerging chemical risks, new chemicals are constantly being developed and incorporated into products and formulations in a context where knowledge of the associated toxicological properties may be weak. The safety assessment for chemicals in products that are imported do not follow the same strict regulations as in Europe. In the frame of the circular economy, recycling and reuse is promoted, with potential impacts on human exposure to chemicals that accumulate in material cycles.
- Further data is required on the relative contribution of environmental, dietary, occupational and consumer exposures over time. Tools and methods are needed for science-based mixtures risk assessment that take simultaneous and consecutive exposures into account, followed by horizontal approaches to managing chemicals across policy domains.

Human health and well-being:

- Changing patterns of chronic disease associated with life style factors, such as eating habits, exercise, socio-economic status, environmental conditions and exposure to chemicals. There are significant knowledge gaps regarding the relative contribution of these risk factors. Systems that can track individual risk factors could generate data to disentangle risk factors and understand their relative importance. This needs to be combined with data privacy. This knowledge can then provide a basis for policy interventions to prevent exposures and improve social resilience.
- Our reliance on a small number of crops coupled with the loss of biodiversity creates vulnerability in our food supply in a context of climate change.
- The overuse of antibiotics in human and in animal husbandry creates the risk of increased microbial resistance to antibiotics, which would produce severe systemic risks to society.

5. Session 3: Economics and finance

5.1. 2016 Global Risk Report

Margareta Drzeniek Hanouz, World Economic Forum presented the 2016 Global Risk Report[16]. She explained that this 11th edition of the Global Risk Report was produced by a consortium and is based on the annual Global Risks Perception Survey, completed by almost 750 members of the World Economic Forum's global multi-stakeholder community. In identifying the 29 risks to include in the survey the consortium was obliged to draw boundaries, a challenging process due to the interconnections between risks. Categories of risk include environmental, economic, geopolitical, societal and technological. According to the World Economic Forum a global risks is defines as follows:

> *"A **global risk** is an uncertain event or condition that, if it occurs, can cause significant negative impact for several countries or industries within the next 10 years."*

In the annual Global Risks Perception Survey, experts are asked to score the impact (social and economic) and likelihood of global risks on a scale of 1 to 6. The survey is complemented by focus groups, including experts from the business community, as well as from academia.

The 2016 report maps the 29 global risks against expert perception of their impact and likelihood, with the results shown in figure 9 below, the **Global Risks Landscape 2016**. Those global risks considered by experts to have the highest impacts and likelihood are captured in the top right corner of figure 9, shown expanded in figure 10. In 2016, all categories of risk are captured in the upper right category, demonstrating the interconnectivity of risks and their systemic linkages. The top five risks for 2016 are provided in table 3, based on their ranking for likelihood and impact. The **failure of climate-change mitigation and adaptation** is ranked 1st in terms of impact and 3rd in terms of likelihood in 2016.

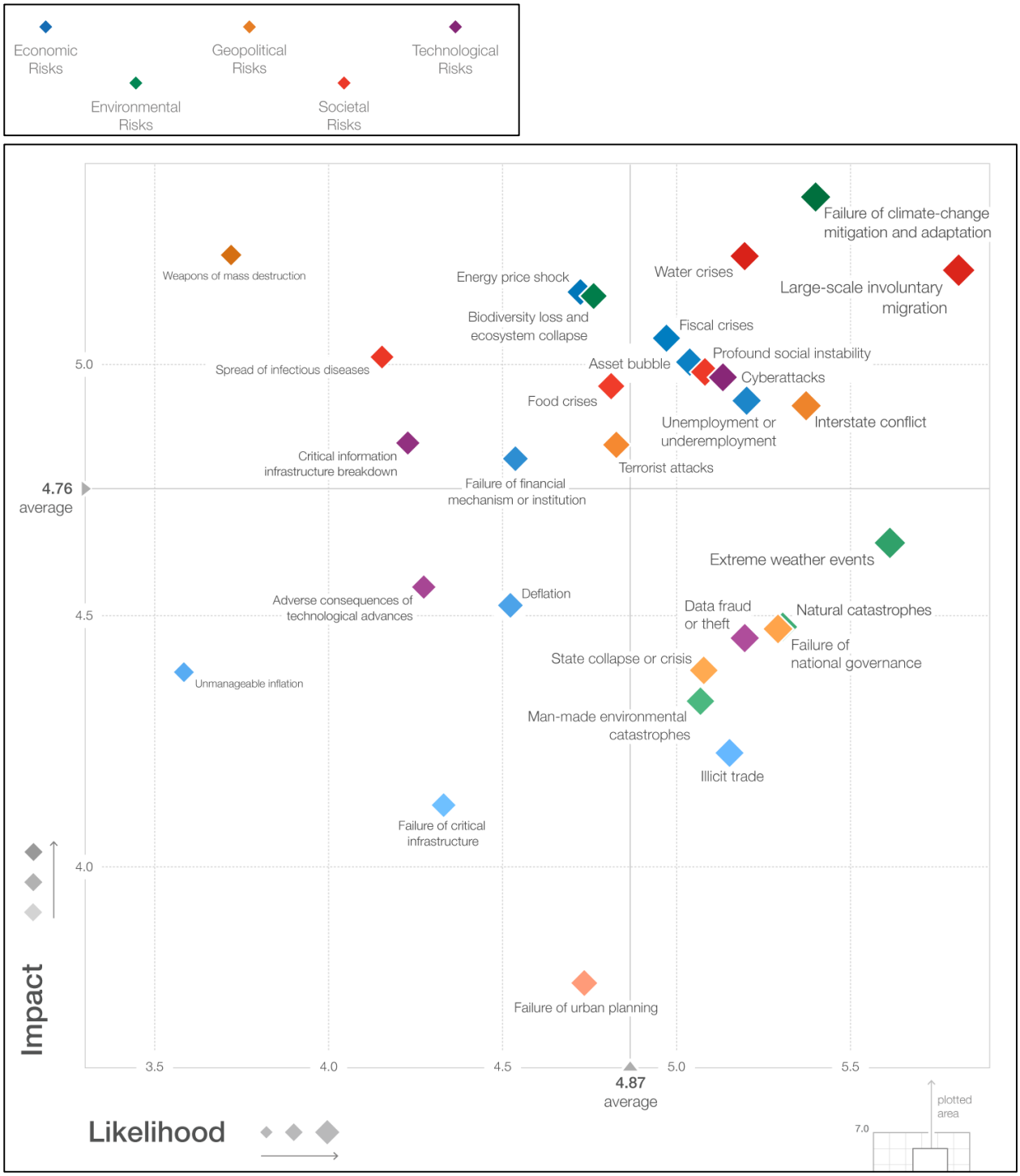
Table 3: 2016 top 5 global risks in terms of perceived likelihood and impact

Rank	Impact	Likelihood
1st	Failure of climate change adaptation and mitigation	Large-scale involuntary migration
2nd	Weapons of mass destruction	Extreme weather events
3rd	Water crises	Failure of climate change adaptation and mitigation
4th	Large-scale involuntary migration	Inter-state conflict with regional consequences
5th	Severe energy shock	Major natural catastrophes

Source: World Economic Forum, 2016 Global Risk Report

[16] World Economic Forum, 2016, 2016 Global Risk Report, Geneva, Switzerland

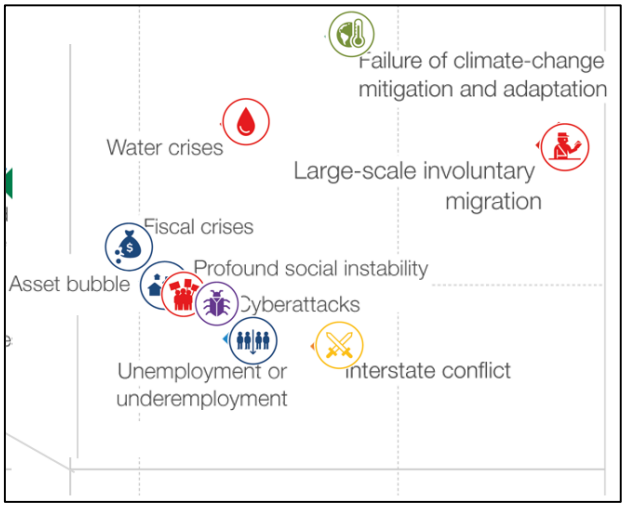
Figure 9: Global risks landscape 2016



Source: Presentation provided by Margareta Drzeniek Hanouz at the seminar, also available on the World Economic Forum 2016 Global Risk Report webpage[17]

[17] Available at: http://reports.weforum.org/global-risks-2016/global-risks-landscape-2016/#landscape

Figure 10: Global risks perceived to have the highest impact and likelihood in 2016



Source: Presentation provided by Margareta Drzeniek Hanouz at the seminar

With regards to how the perception of global risks has evolved, environmental risks have become more prominent since 2011, while societal risk have become more prominent since 2012. The global risk landscape has evolved to capture a broader mix of risks since 2013.

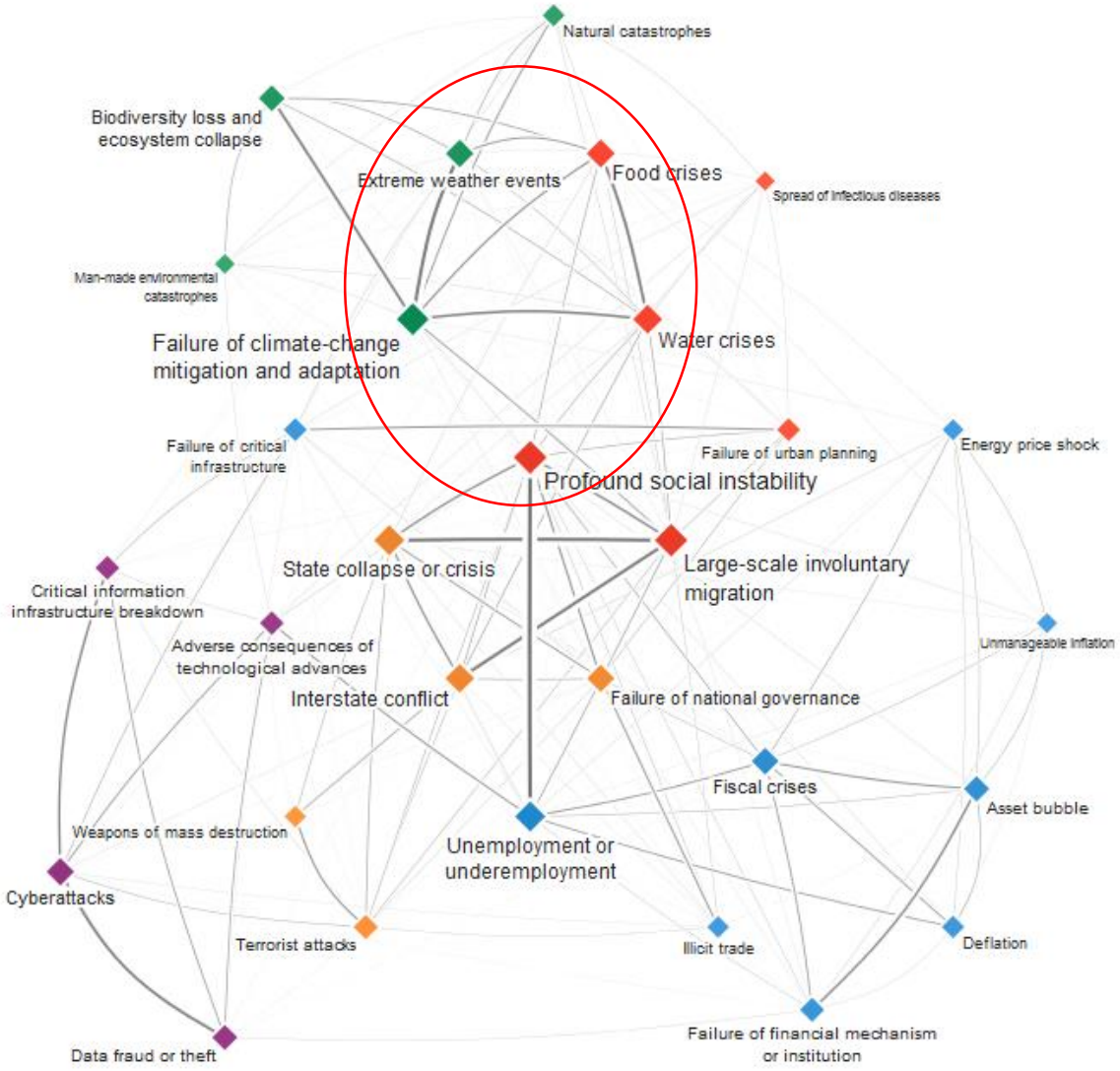
The **Global Risks Interconnections Map** (figure 11) shows the perceived linkages between different risks. Profound social instability is the most interconnected single risk, while the most interconnected pairs of risks is profound social instability and unemployment or underemployment.

With regards to climate change mitigation and adaptation, linkages highlight the potential for climate change to exacerbate water crises, with impacts including conflicts and forced migration. These linkages are captured in the red circle in figure 11.

In addition, the interlinkages between inter-state conflict, state collapse or crisis, the failure of national governance, social instability and large-scale involuntary migration highlight the urgent need to address the global refugee crisis, through policies that build long-term resilience as well as responding the immediate crisis.

Linkages in the lower left hand corner of figure 11 connect adverse impacts of technological advances, breakdown in critical infrastructure, cyberattacks and data fraud or theft, and are critical to understanding the risks of the fourth industrial revolution for society and economies at a time of sluggish economic growth. This point to the need to manage the social and economic impacts of technological advances and ensure that they contribute to growth and the functioning of our public institutions.

Figure 11: Global risk interconnections map 2016



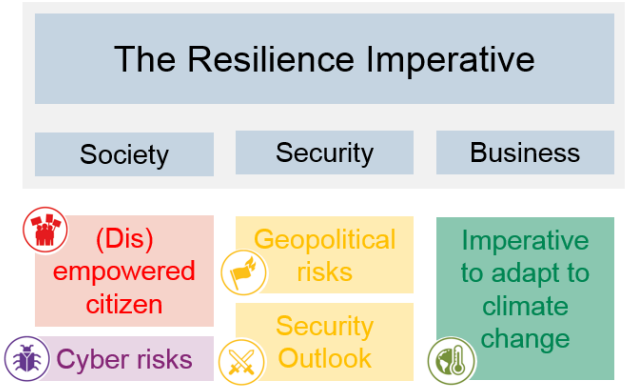
Source: Presentation provided by Margareta Drzeniek Hanouz at the seminar, also available on the 2016 Global Risk Report webpage[18]

The Global Risks Report also addresses the impact of **global risks for doing business** across different regions and countries, drawing on the views of executives in the 140 economies covered by the World Economic Forum's Executive Opinion Survey. With regards to environmental risks, only one country ranked environmental risks as the number one risk to doing business, the Philippines.

In conclusion, Margareta Drzeniek Hanouz explained that the Global Risks Report 2016 calls for a "Resilience Imperative", recognising the urgent need to identify **approaches to withstand, mitigate, adapt to and build resilience against global risks** through collaborative efforts. The imperative to build resilience to global risks, in terms of the resilience of society, security and business to specific risks, is depicted in figure 12.

[18] Available at: http://reports.weforum.org/global-risks-2016/global-risks-landscape-2016/#risks

Figure 12: The Resilience Imperative



Source: Presentation provided by Margareta Drzeniek Hanouz at the seminar

In the **discussion**, the following points were raised:

- Participants reflected on the difference between the perceptions of global risks in the business community versus perceptions in the scientific community. The results of the Global Risk Reports should be interpreted in the context of the methodology used, which surveys the perception of a pool of experts predominately from the business community. As such, they provide a valuable measure of global risk perception amongst global business women and men.
- The perception of global risks involves Issues of scale, whereby actors in different geographical regions or operating at different levels of governance may perceive risks differently.

5.2. Approaches, processes and tools in the re-insurance industry

Rainer Sachs, Munich Re, explained how the re-insurance industry provides instruments for the transfer of risk between society and the private sector, whereby industry must attach a price tag to risks.

There is a need to distinguish between known or mature risk and uncertainty, whereby risk can be quantified into probabilities and uncertainty cannot be quantified. At Munich Re, mature risks are accumulation risks, while emerging risks and complex risks are characterized by uncertainty at different levels. Munich Re gathers evidence to understand these risks using a range of different tools (see table 4). Sachs noted that climate change is no longer considered an emerging risk at Munich Re and is actively managed.

For **emerging risks** associated with new technologies and trends in society and characterized by uncertainty, approaches are required that enable Munich Re to describe the risks qualitatively, with the ultimate aim of quantifying them.

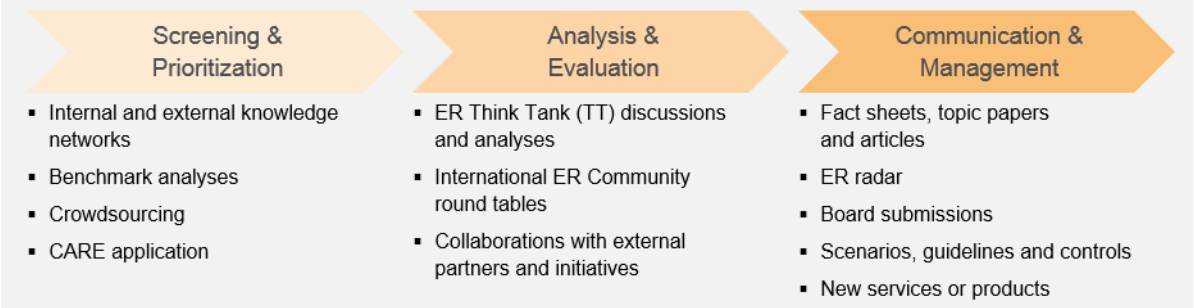
Table 4: Risk management methods for three categories of risk

Type of risk	Tools	Objectives
Accumulation risks	Single/multi line scenarios Cross balance sheet scenarios	Risk appetite Steering Validation
Emerging risks	Emerging risk radar Psychology of risk Crowdsourcing	Anticipation Systematic identification Objective / unbiased assessment processes
Complex risks	Complex Accumulation Risk Explorer (CARE)	Understanding interdependency Systematic identification Scenario generation

Source: Presentation provided by Rainer Sachs at the seminar

The process for managing emerging risks at Munich Re involves three steps: screening and prioritization, analysis and evaluation and communication and management. The tools and processes used under each step are captured in figure 13.

Figure 13: Munich Re's emerging risk management process



Source: Presentation provided by Rainer Sachs at the seminar

For example, a method used in prioritisation is crowd sourcing, whereby individuals are presented with pairs of risks to rank. This is repeated iteratively by multiple individual to generate a stable overall rank of the risks.

In another example, the analysis and evaluation step uses an Emerging Risk Think Tank; a group of experts that act as a scientific advisory board providing input on specific topics and informing decisions on whether to develop more detailed scenarios.

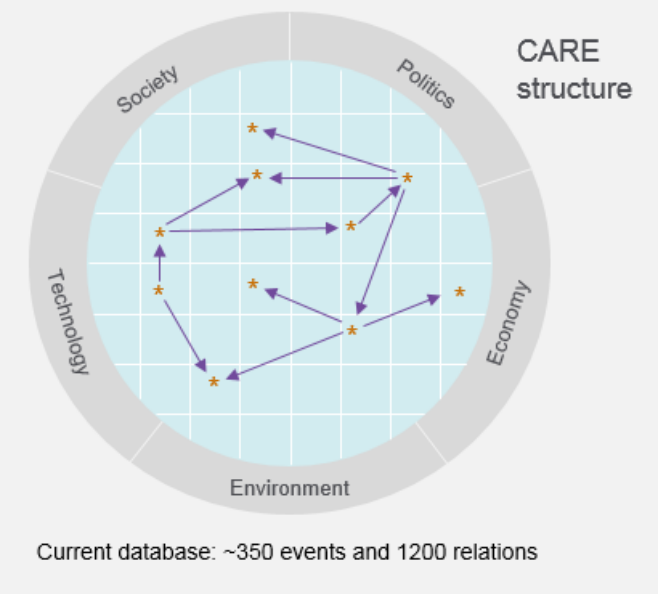
The efficient and effective use of **expert knowledge** is key to designing processes to build understanding of emerging risks. Expert systems can be used to collect and analyse widely distributed knowledge in an efficient manner.

At the same time, this raises challenges in manage the "human factor" in group exchanges; avoiding bias and ensuring that group exchanges focus on actually sharing knowledge rather that discussions at the intersection of different knowledge types. An actor's risk perception depends on how a risk is framed and how actors perceive potential costs and rewards. In contrast, the insurance industry wants to base their strategy on an objective understanding of risk, and not on perceived risk. This raises the question of how to design expert elicitation processes that eliminate perceptions.

Emerging risks tend to be linked to other risks, driven by global trends such as economic growth, geopolitical and economic crises around the world and international trade. The strategy of spreading risks in the re-insurance industry is effective when risks are independent. However, when risks become more complex and connected, this presents a threat to the diversification of the portfolios of re-insurance companies and demands better understanding of the dependencies between risks and the indirect consequences that can results from these linkages.

Munich Re developed a forward looking tool that makes use of expert judgement to improve understanding of how risks influence each other and interact, the **Complex Accumulation Risk Explorer (CARE)**. CARE elicits expert judgment on potential trigger-consequences relations between critical events and collates it in a structure database, depicted in figure 14. Experts from a range of disciplines identify connections and feed into a complex mapping of cause and effect, as well as providing input on the likelihood and severity of resulting effects. Effects are categorised into different categories, namely social, environmental, technological, political, and economic. Over time, CARE builds connections across systems and allows for the identification and analyses of complex loss scenarios, where risks combine in hidden accumulations.

Figure 14: CARE structure

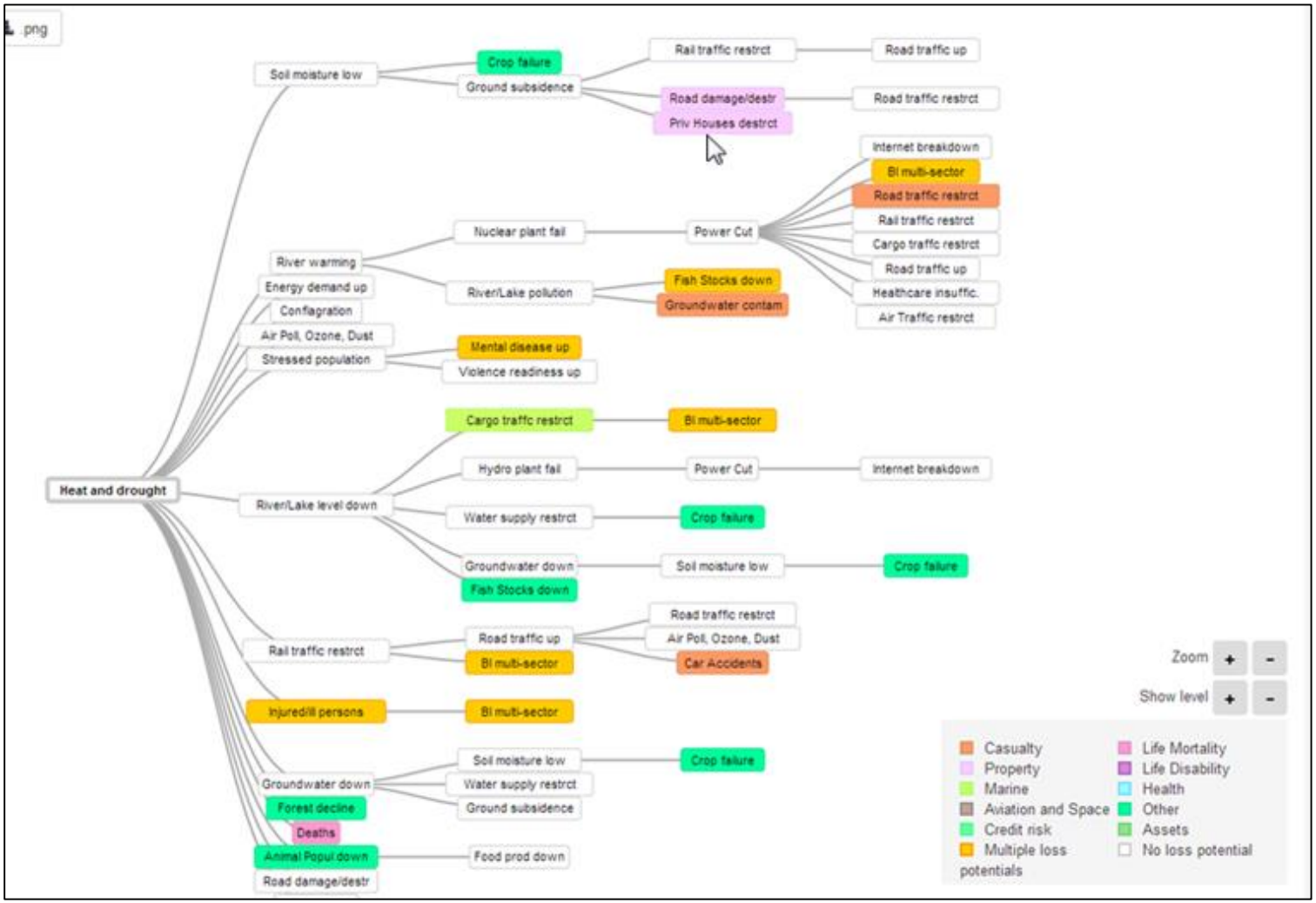


Source: Presentation provided by Rainer Sachs at the seminar

CARE uses a cloud-based service to enable experts to view the events and identify interlinkages between them in order to map causality and provide a background for scenario analysis. The scenarios can then be sorted according to those perceived to have the highest impacts. Figure 15 provides a scenario mapping out the key events linked to heat and drought, as well as associated consequences.

In conclusion, Rainer Sachs noted as emerging risks becoming less predictable and more complex, managing uncertainty become more important and creating the need for new risk management strategies that can capture complexities.

Figure 15: CARE scenario for heat and drought



Source: Presentation provided by Rainer Sachs at the seminar

Discussion focused on the role of risk perception in influencing our understanding of risks and the interdependencies between then. In particular, public understanding of probabilities is very weak and serves to distort public perception of the likelihood of different risks.

5.3. Systems, resilience, risks and accounting

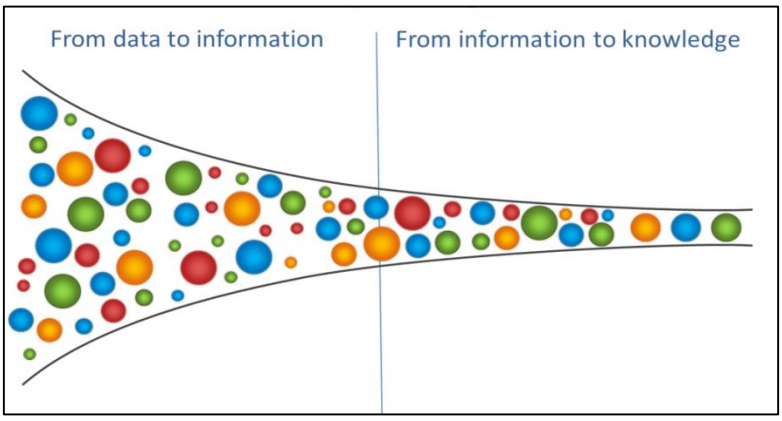
Noting that statistic services are the arm of the state, Walter Radermacher, Director General of Eurostat, explained that the language of official statistics can play a role in defusing controversies by bringing order into confused debates.

Since the introduction of Gross Domestic Product (GDP), the limits of this approach for the valuation of capital have been recognised. Current discussions focus on how to broaden the scope of capital accounting to capture social and environmental accounting, and how to best measure progress in these domains.

There are three main challenges. Firstly, economic theory has de-coupled from statistics, weakening the triangle between statistics, economic theory and political practice. Secondly, current management ideologies demand measurements of progress in the public sector, in a context where many dimensions cannot currently be quantified. Finally, while big data is seen as a solution to improving our understanding of how our social, economic and environmental systems intersect, this overlooks the need to refine data and ensure quality before drawing conclusions.

We need to expand our ability to **measure complexity in systems**. Figure 16 focusses on how reducing complexity poses challenges, in the need to filter out noise and harvest critical information to include in indicators and create knowledge.

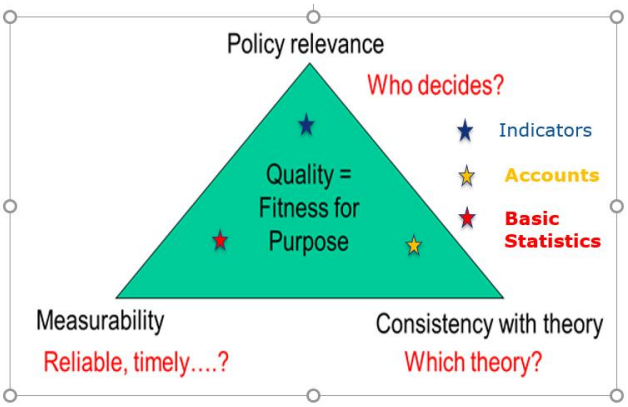
Figure 16: Reduction of complexity



Source: Presentation provided by Walter Radermacher at the seminar

Data can be turned into three tiers of knowledge, namely basic statistics, account and indicators (see figure 17). Indicators provides a mean of turning a coherent treasury of statistical data in knowledge in order to inform policy development.

Figure 17: Three tiers of knowledge built on data

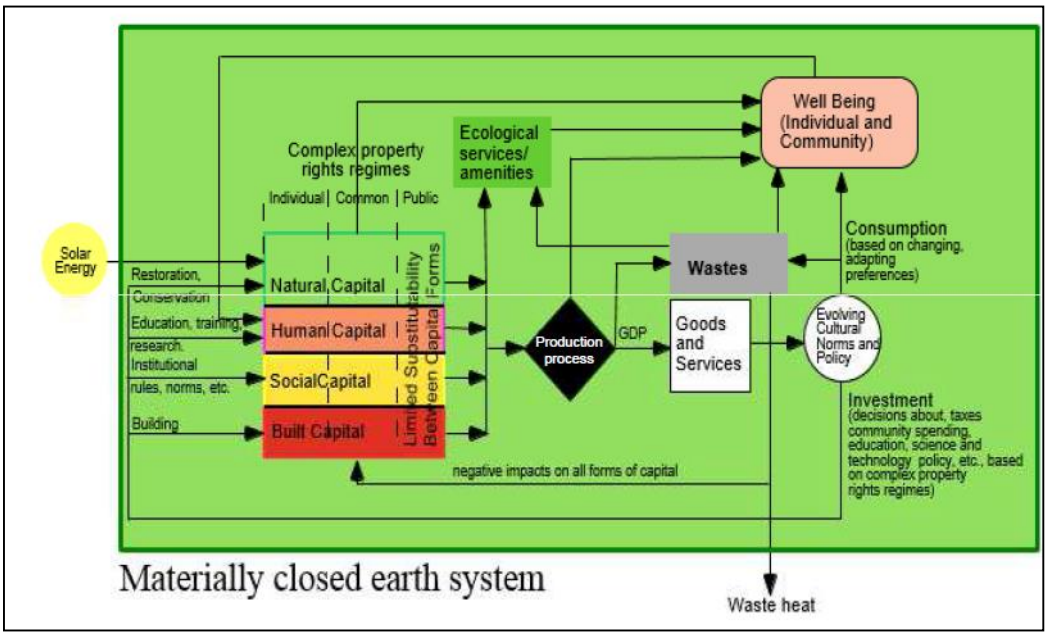


Source: Presentation provided by Walter Radermacher at the seminar

With regards to micro-accounting, economists perceive nature as part of their capital base and seek to internalise externalities. However, accounting looks at value changes in terms of input and output, not into the qualitative changes in the capital. While we assume that natural and social capital can be valued, nature does not operate in stocks but rather in flows. In addition, micro-accounting struggles to capture the complexity and interdependencies between environmental social and economic systems. These discrepancies lead natural capital to be undervalued in micro-accounting.

A full world vision of the complete interactions between natural, human, social and build capitals is provided in figure 18 below, drawn from the work of Enrico Giovannini.

Figure 18: Interactions between natural, human, social and built capitals



Source: E. Giovannini, Well-being and sustainability: from statistics to analytics, WSC2015, Rio de Janeiro

Macro-level accounting can capture systems and the complex, non-linear systemic interactions between environment, economy and society and as such macro-accounting can inform the assessment

and management of systemic risks. A range of statistical tools and indicators can be used to measure impacts against tipping points and planetary boundaries.

Policy makers generate knowledge through interaction with stakeholders, including scientists, private actors and statisticians. Together, these actors in engage in the co-construction of society and a statistical base in support of that society.

Indicators need to be tailored to the reality of systems, based on new methods of measuring and monitoring reality. There is a need to re-focus the measurement tools designed to support neoclassical economics towards methods that can capture linkages and dependencies amongst risks and resilience in systems, as well as being sensitive to the changes required to drive transitions. In conclusions, Walter Radermacher highlighted the work of the **European Systemic Risk Board**[19], established in 2010 in response to the financial crises to prevent and mitigate systemic risks to the financial system. He suggested that the organisation may provide examples of practice that could be transferred to other systems.

In the following **discussions**, participants considered the follow points:

- How to combined quantitative and qualitative methods in analysis?
- How to integrate natural capital in accounting systems? Progress is underway. Complementary to the indicator work.
- Need a macro-economic approach to natural capital accounting that captures systems dimensions.

[19]See https://www.esrb.europa.eu

6. Session 4: Knowledge needs for identifying and managing emerging systemic risks

Guests from the EU institutions provided an overview of their ongoing and planned activities on emerging systemic risks.

Elena Montani, DG Environment, explained that the 7th EAP sets a mandate for the Commission to develop a systematic approach to risk management, especially in the field of emerging risks linked to new technology developments. This is in a context where environmental risks are increasingly complex, or we have become better at recognising this complexity, which makes responding to early warnings more difficult. The systemic nature of emerging environmental risks implies integrated policy solutions that reach across policy silos. Questions remain about how to prioritise risks for action.

She noted that it is not enough to base policies on science alone, rather there is a need to reflect values when selecting policy options. Transparency and public trust are fundamental to ensuring public acceptance of policy outcomes, implying that policy makers need to understand public risk perception. A 2014 Future Brief of Science for Environment Policy study entitle "Public risk perception and environmental policy"[20] explored options for incorporating public risk perceptions into policy making. A more recent Thematic Issue focused on "Integrating environmental risk assessment"[21] and explored overlapping knowledge areas in risk assessments, including new application and significant gaps.

In carrying forward the mandate set by the 7th EAP, the first objective is to establish a systematic framework for the identification of emerging risks. DG Environment is working with partners in the Environmental Knowledge Community to identify and build on existing tools and to contribute to a coherent system. The aim is to incorporate different sources of information from the scientific community, the public and the media.

Tobin Robinson, European Food Safety Authority (EFSA), explained EFSA's role as a risk assessment body with a mandate that captures the food chain, from primary production through to consumption. He explained how changes to systems both within and outside the food system can generate risks and/or cause the re-emergence of old risks.

For example, social disruption outside the EU impacts EFSA's work in the area of animal and plant diseases, since it results in weakened disease control, surveillance and monitoring just outside EU borders. In addition, food fraud is a problem that is exacerbated by economic instability, which encourages illegal activities. Efforts to manage and reduce food waste can exaggerate existing risks in the food system and impact on food safety. In addition, reductions in animal testing in response to animal welfare concerns can also re-introduce old problems that had been eliminated. Animal testing generates valuable information on toxicity and new robust methods are required to fill the information gap in a context where animal testing is reduced.

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[20] Science Communication Unit, University of the West of England, Bristol (2014). Science for Environment Policy Future Brief: Public risk perception and environmental policy. Report produced for the European Commission DG Environment, September 2014

[21] Science for Environment Policy (2015) Integrating Environmental Risk Assesssment. Thematic Issue 53. Issue produced for the European Commission DG Environment by the Science Communication Unit, UWE, Bristol

Tobin Robinson noted how the EU institutions tend to split tasks according to the mandate and associated expertise of different agencies and in doing so complex problems get divided up so that the different components are addressed in isolation. The consequence is that the overarching complex problems are not addressed. For example, bee health has been tackled under multiple pieces of legislation, addressing factors such as pesticides, invasive species and infectious disease as drivers of declining bee populations. However, the overall problem of reduction in bee populations is complex and results from these factors acting in combination. The assessment of systemic risks requires inter-agency collaboration. For example, humans are exposed to chemicals via multiple routes, implying that the different agencies involved in chemical risk assessment need to come together in order to capture all exposure routes and identify the aggregate exposure.

In identifying emerging risks, EFSA follows a specific procedure based on engagement with networks of experts and stakeholders, a process that requires time, patience and trust. An element of identifying emerging risks involves anticipating future data and knowledge needs, and passing these priorities on to be captured by the EU research agenda, namely Horizon 2020.

EFSA is also current engaged in mining the European Chemical Agency's database of registered substances, looking for hazardous chemicals that can be found in significant quantities in the environment on the assumption that they will then also be found in the food chain. Another ongoing activity focusses on emerging marine biotoxins, organisms endemic to the tropics and now found in European waters.

Peeter Pärt, Joint Research Centre, explained that the Joint Research Centre hosts a Disaster Risk Management Knowledge Centre, including the Disaster Risk Reduction Portal[22], which serves to collect information on natural hazards and bridge to other Commission work on natural risk and disasters.

Providing some personal reflection on systemic risks, he noted that such risks can results in irreversible damage. For example, early exposure to chemicals in foetal development can results in effects later in life making them very difficult to anticipate. There are currently no relevant testing methods available to identify long-term latent effects and establish causality. At the same time, the volume of chemical used in society is continuously increasing, and every individual in society is exposed. Providing another example, he explained how continuous over-fishing can push fish stocks over tipping points and disrupt the balance in the marine environment with knock-on effects for the food chain.

Jörgen Talkop, DG for Climate Action, noted that climate change policy represents a tool for managing systemic risks, including both mitigation and adaptation.

The current EU policy framework for up to 2030[23] is based on the goal of limiting global temperature rise to below 2°C. The 1.5°C limit to global temperature rise included in the agreement made at the 21st Conference of the Parties to the United Nations Framework Convention on Climate Change in Paris, France changes the picture for policy makers. On the one hand, the commitment demonstrates the possibility of going beyond necessity, on the other hand, we face significant knowledge gaps.

[22] Available at: http://drr.jrc.ec.europa.eu/

[23] EC, 2014, Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions 'A policy framework for climate and energy in the period from 2020 to 2030', COM(2014) 15 final of 22 January 2014

Policy makers now need to understand how to translate this more ambitious goal into policy. The Energy Roadmap 2050[24] provides the framework for concrete steps over the long term. Policies have to be well balanced and compromises will have to be made at EU level, to prevent the risks associated with implementation becoming too high.

Adaptation enables the EU to be better prepared and more resilient to climate change impacts. The steps that Member States are taking to implement National Adaptation Strategies and Plans represent positive progress.

Jesús Alquezar Sabadie, DG Research and Innovation, explained how his DG has a long tradition of supporting knowledge building on risks in different policy areas. However, the use of project results in policy making is variable, due to issues with quality and poor communication of outcomes. In particular, the use of foresight in projects can serve to increase our understanding of risks, with foresight imbedded in the current work programme. Horizon 2020 is focused on innovation and societal impacts, with the aim of creating knowledge and creating knowledge for the future.

[24] EC, 2011, Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions — Energy Roadmap 2050, COM(2011) 885 final, Brussels, 15.12.2011

7. Concluding Remarks

Jock Martin, Head of the Integrated Environmental Assessments Programme, EEA, noted that the discussions had contributed to framing a systems perspective of environmental risks and would feed into the production of new knowledge on emerging systemic risks to include in the EEA's 2020 Report on the European Environment – State and Outlook.

Hans Bruyninckx, EEA Executive Director, expressed his appreciation to the participants for their valuable contributions to the discussions. Understanding emerging systemic risks entails the developing robust knowledge components to fill current gaps, based on inter-disciplinary approaches that combine quantitative and qualitative data. The crucial role of risk perception in influencing risk management outcomes suggests that we should foster a common understanding or systemic risks, by involving experts, citizens and economic actors. Actors representing the institutions of power in society should also be involved in a transparent dialogue on risk in order to establish accountability and build trust. Current discourses on systemic risk often focus on producing knowledge at the global level, a top down approach that is de-contextualised from the local level and does not resonate with individuals.

In conclusion, Hans Bruyninckx explained that the EEA will continue to build a knowledge base in support of the core environmental policy files at EU level. A current focus falls on the potential for the transition to a circular economy to generate systemic risks, for example through the accumulation of hazardous substances in material flows. Additional thematic areas of focus include chemicals, biodiversity, climate and energy and human health and well-being.

Annex 1: Seminar agenda

Wednesday 24 February 2016, 8.30 to 17.00hr

European Environment Agency, Kongens Nytorv 6, Copenhagen, Denmark

08.30 - 09.00	**Registration and Coffee**
09.00 - 09.15	**Welcome and introduction by the Co-Chairs** Dr. Sybille van den Hove, Chair EEA Scientific Committee Dr. Hans Bruyninckx, Executive Director, EEA
Session 1: Emerging systemic risks and responses: views at the science/policy interface	
09.15 - 09.45	**Long-term societal transitions and systemic risks** Hans Bruyninckx, EEA Executive Director (15 min) *Discussion and input from other participants (15 min)*
09.45 - 10.30	**Towards a new matrix of risks: learning from multi-scale controversies** Francis Chateauraynaud, Groupe de Sociologie Pragmatique et Réflexive, Ecole des Hautes Etudes en Sciences Sociales, Paris (30 min) *Discussion and input from other participants (15 min)*
10.30 – 11.00	***Coffee break***
11.00 -11.45	**Public sector governance of emerging systemic risks** Piet Sellke, International Risk Governance Council, Stuttgart University (30 min) *Discussion and input from other participants (15 min)*
Session 2: Emerging systemic risks and responses: views from the Scientific Committee	
11.45 - 12.45	**Tour de table of EEA Scientific Committee members (45 min)** *Discussion and input from other participants (15 min)*
12.45 - 13.45	***Lunch break: informal fruit & sandwiches lunch***
Session 3: Emerging systemic risks and responses: economics and finance	
13.45 - 14.30	**2016 Global Risk Report** Margareta Drzeniek Hanouz, World Economic Forum (30 min) *Discussion and input from other participants (15 min)*
14.30 - 15.15	**Approaches, processes and tools in the re-insurance industry** Reiner Sachs, Munich Re (30 min) *Discussion and input from other participants (15 min)*
15.15 – 15.45	**Systems, resilience, risks and accounting** Walter Radermacher, Director General, Eurostat *(15 min)* *Discussion and input from other participants (15 min)*

15.45 – 16.15	***Coffee break***
Session 4: Knowledge needs for identifying and managing emerging systemic risks	
16.15 – 17.00	**Reflections from the EU institutions** Other participants reactions and suggestions and general discussion
17.00 - 17.15	**Concluding remarks by EEA**
17.15	***End of seminar***