Methodological advances in integrated environmental assessments

14 December 2012

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0. Summary

The objective of this paper (including the Annex) is to provide an overview of methodological advances in integrated environmental assessments (IEA) in the past ten years. With this paper as one of the inputs, the EEA aims to take stock of related recent scientific and methodological advancements, to better inform its own integrated environmental assessments, and to have a basis to underpin future internal training of in-house staff and capacity building within Eionet.

The methodological advances made in recent years covered in the paper are: addressing structural uncertainties and grand challenges; tools for IEA; integrated sustainability assessment and transition management approaches; involving stakeholders and making the most out of participation; and using IEA (in a policy context). The following trends and their implications for IEA are discussed:

From IEA to ISA: The trend in the last years has been from integrated **environmental** assessment to integrated **sustainability** assessment with an integrated systemic perspective.

From "closed" to "open" knowledge systems: The strong trend of increasing stakeholder participation in assessments recognizes that scientists and researchers are not the only holders of knowledge.

From simplification to complexity: There is an increasing recognition that societal challenges are extremely complex and that methods and tools are required that embrace this complexity.

From linearity to non-linearity: Increasingly the discussion of environmental changes refers to "tipping points", planetary boundaries, abrupt non-linear changes and regime shifts and tackling these non-linearities clearly requires new approaches.

From book to web: The broadening of participation in assessment processes and the moves towards an open knowledge society necessitate a move from the publishing of large assessment reports as books to online and on-going documentation of assessment outcomes.

From global to local: The move towards participatory approaches and the increased attention to linking knowledge with action has engendered a shift to assessments at the local and regional levels, where stakeholders have a particular interest.

From "what is the problem?" to "how can we solve it?": The trend towards linking knowledge to action means that assessments are increasingly "implementation-oriented".

From top-down to bottom-up: The problem areas to be considered in an assessment process are no longer defined "top-down" by the science community. A major consequence of this is the need to design and facilitate effective processes and evidence suggests that considerable capacity building is required to meet this need.

1. Introduction and context

The European Environment Agency (EEA) is a boundary organisation at the policy-science interface. It aims to 'support sustainable development and to help achieve significant and measurable improvement in Europe's environment through the provision of timely, targeted, relevant and reliable information to policy-makers, public institutions and the public'.[1]

Among the set of methodologies and approaches applied by the EEA to meet this aim is the development of integrated environmental assessments. Integrated assessments can be broadly described as the interdisciplinary process of structuring knowledge elements from various scientific disciplines in such a manner that all relevant aspects of a complex societal problem are considered in their mutual coherence for the benefit of decision-making.

Key examples of EEA integrated environmental assessments include the five-yearly report 'The European Environment: State and Outlook' (published in 2005 and 2010); scenario analyses including a project on 'Prospective Environmental analysis of Land Use Development in Europe'; as well as a range of thematically focused, yet integrated analyses. The methodological foundations for integrated environmental assessments at the EEA have been described in dedicated reports and background papers available on the EEA website.

In the past ten years, i.e. since the foundations for integrated environmental assessments at the EEA have been laid, the scientific basis for carrying out integrated environmental assessments has developed further and the set of related methods and approaches has been expanded. Noteworthy in this context are, for example, the emergence of 'Sustainability Science[2]' as well as several dedicated EU research projects.

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Somewhat more than 10 years ago, a workshop on effective environmental assessments was held at the EEA (Eckley 2001) together with the Global Environmental Assessment (GEA) Project[3] and the European Forum for Integrated Environmental Assessment (EFIEA). Significantly, for the purposes of this paper, the GEA project had examined the relationships among science, policy, assessment, and management in societies' efforts to address global environmental change. Understanding the effects and effectiveness

[1] According to the EEA mission statement. By its governing regulation the EEA is tasked to provide the Community and the Member States with objective, reliable and comparable information at European level enabling them to take the requisite measures to protect the environment, to assess the results of such measures and to ensure that the public is properly informed about the state of the environment.

[2] In October 2000, a small international group of scientists met in Sweden to discuss the emergence of 'sustainability science' (Kates et al. 2001). In response to earth system challenges, it was agreed that approaches are needed that consider the human-environment system as a whole. Because of the need to bridge knowledge and action, the focus of the research must be on a particular place (and the human-environment interactions at that place but also with other places) or a particular sector (again taking into account the interactions with other sectors). It was recognized that fundamental advances would be needed in order to address such issues as the behaviour of complex, self-organizing systems, as well as the responses of the human-environment system to multiple and interacting stresses (Jäger 2009). In Europe, in particular, sustainability science has evolved towards being strongly implementation-oriented in areas dealing through a participatory process with persistent problems of unsustainability that have a high level of complexity.

[3] http://www.hks.harvard.edu/gea/

of assessment, distinguishing more from less effective assessments, and analysing what makes certain assessments more effective than others were the central challenge of the GEA Project. Through examining a broad range of assessments on different environmental issues, the GEA Project identified three attributes that distinguish what participants consider more effective assessments from those that are less effective. These attributes are 'credibility', 'salience', and 'legitimacy'. An assessment that is viewed as more credible, salient, and legitimate to a particular user, therefore, is more likely to change his or her beliefs, and thus be effective for that user. These attributes are discussed in detail in subsequent publications (see GEA website) and by Cash et al. (2003). They form an important guide for assessing methodological advances in IEA over the past decade.

The main advances discussed in this paper have been made in collaborative research projects supported by the various Framework Programmes of the European Union, up to and including the ongoing 7th Framework Programme for Research. Methodological advances were discussed in fora such as the EFIEA[4] and the Integrated Assessment Society (TIAS[5]). The websites of the Sustainability A-Test and LIAISE projects (see Table below) provide detailed information on the tools and methods used in a wide range of projects in recent years.

The projects discussed in this paper are briefly described in Table 1. The projects that discuss tools for IA are also presented in more detail in the Annex.

Table 1: Projects discussed in more detail in this paper

Acronym	Full Title of Project	Project Duration	Coordination and home page
SEAMLESS	System for Environmental and Agricultural Modelling; Linking European Science and Society	2005 - 2009	Dr. Martin van Ittersum, Wageningen University, The Netherlands http://www.seamless-ip.org/
SENSOR	Sustainability Impact Assessment: Tools for Environmental, Social and Economic Effects of Multi-functional Land Use in European Regions	2004 - 2009	Leibniz-Centre for Agricultural Landscape Research (ZALF)(DE) http://www.sensor-ip.org/
Sustainability A Test	Advanced Techniques for Evaluation of Sustainability Assessment Tools	2004 - 2006	IVM, The Netherlands http://www.sustainabilitya-test.net/
I.Q. Tools	Tools for Assessing the Sustainability of Proposed Policies	2004 - 2005	Dr. Klaus Rennings, ZEW Germany http://ec.europa.eu/research/fp6/ssp/iq_tools_en.htm
EVIA	Evaluating Integrated Impact Assessments	2006 - 2008	Klaus JACOB Freie Universitaet Berlin http://ec.europa.eu/research/social-sciences/projects/262_en.html

[4] http://www.ivm.vu.nl/en/projects/Archive/EFIEA/index.asp
[5] http://www.tias-web.info/

LIAISE	Linking Impact Assessment Instruments to Sustainability Expertise		Alterra, Sander Janssen http://www.liaise-noe.eu
MATISSE	Methods and Tools for Integrated Sustainability Assessment	2005 - 2008	Dutch Research Institute for Transitions, Netherlands. J. Rotmans www.matisse-project.net
InContext	Supporting Environments for Sustainable Living	2010 - 2013	Ralph Piotrowski, Anneke von Raggamby Ecologic Institute www.incontext-fp7.eu/ www.lebensklima.at
ECOCHANGE	Biodiversity and Ecosystem Changes in Europe	2007 - 2011	Pierre Taberlet (Centre National de la Recherche Scientifique – France) www.ecochange-project.eu
RESPONDER	Linking SCP and Growth Debates	2011 - 2014	WU Wien, Research Institute for Managing Sustainability http://www.scp-responder.eu/

Many of the challenges that IEA currently faces are covered in the recently published report of the RESCUE initiative[6]. The *"Responses to Environmental and Societal Challenges for our Unstable Earth" (RESCUE)* foresight initiative aimed to help Europe address the societal and scientific challenges related to global environmental change.

The broad environmental context within which humans live currently is unique, as it is increasingly and globally the *result* of human activities. The implications of this are more than ever a human and social problem in terms of mitigation of, and adaptation to, its consequences. This requires moving beyond the traditional, narrow consideration of the "natural environment" in both academic and public discourses. It requires transdisciplinary approaches and institutions centred on the perspectives and the insights of the humanities and the social sciences. The interdisciplinary and transdisciplinary approaches, discussed in the RESCUE report, require new methodologies, methods, knowledge and data.

The RESCUE report also discusses the requirements for a transformed, more open knowledge system, including processes that allow societal agenda setting, collective problem framing and integration of a plurality of perspectives. The proposals for change that have emerged from the RESCUE initiative (reframing, deep interdiciplinarity and transdisciplinarity, societal engagement and attention to process) will all require a significant amount of capacity building.

Meeting these needs was the focus of a Webinar organized by the Integrated Assessment Society (TIAS) in July 2012 based on the report of the ESF/COST foresight initiative RESCUE[7]. The participants concluded

[6] www.esf.org/rescue
[7] **Recorded webinar:** http://breeze.serv.uni-osnabrueck.de/p14707093/ (Audio-visual link to the session).

that funding organizations should support a set of long-term, regionally based demonstration projects, funded for a period of at least 10 years, to demonstrate how new approaches to research and capacity building begin a process of learning and of transitions to sustainability.

These challenges and methodological advances made in recent years are covered in the remainder of this paper. Section 2 focuses on five significant areas of relevance to IEA:

- ✓ Addressing structural uncertainties and grand challenges;
- ✓ Tools for integrated assessment;
- ✓ Integrated Sustainability Assessment and Transition Management approaches;
- ✓ Involving stakeholders and making the most out of participation; and
- ✓ Using IEA (in a policy context).

This is followed by a set of reflections in Section 3, in which relevant directions for both application and capacity building at the EEA are discussed.

2. Key methodological advancements in IEA

2.1 Addressing structural uncertainties and grand challenges

The need to address structural uncertainties arises because of the probability of the occurrence of an unanticipated event due to the particular configuration of a system. Deep uncertainty concerning model structure and parameter values is often pursued through **scenario analysis**. A scenario can be thought of as a "coherent, internally consistent, and plausible description of a possible future state of the world" (McCarthy et al., 2001). By illuminating the span of future outcomes with respect to key design variables, they can reduce decision-makers' overconfidence in their mental models, highlight the variables to which policies are most sensitive, and provide guidance to the robustness of policy options.
The development of a set of scenarios allows the participants in an assessment process to explore possible environmental changes as a result of different system configurations (e.g. a markets-based world, a sustainable world, a policy-oriented world etc).

Numerous assessment processes use scenario development and analysis. These initiatives have been summarized in recent reports (e.g. Verlaan 2010; EEA 2011).The key methodological advance in recent years has been "**participatory scenario development and analysis**". Bohunovsky et al. (2011) reviewed their experience in participatory scenario development in three assessment processes. They argue that participation is essential, especially for scenarios at the regional/local level.

The SCENES project[8] used participatory scenario development with a focus on water and on pan-Europe, and implemented a combined qualitative/quantitative scenario approach. The method was based on the "Story and Simulation approach" (Alcamo 2008; Alcamo and Henrichs 2008) with the development of storylines during a series of stakeholders' workshops. These qualitative scenarios were subsequently translated to a set of quantified parameters that were used as the input of a quantitative model. Key to the method is an iterative procedure during which storylines and models are improved (Kok and Vliet 2011). The development of narrative storylines had a high level of stakeholder involvement. The project evaluated the process in detail providing recommendations on the scope of participation and workshop organization (see the SCENES website; Deliverable 5.2 Design of participatory scenario building process and their linking to dissemination activities).

The SCENES methodology has been developed further and implemented in the ongoing CLIMSAVE[9] project. Kok et al. (2011) evaluate a range of previous scenario processes and use the results of the evaluation to design a participatory scenario process that has now been implemented on the European level and for a case study in Scotland with a focus on vulnerability and adaptation to climate change.
Important lessons learned include:

- A considerable effort in stakeholder analysis at the beginning of the process;
- Professional facilitation of the scenario development process combined with content support from experts;
- Designing a process that supports a dialogue with the stakeholders and bridges the qualitative and quantitative aspects in an iterative way.

[8] SCENES Project: http://www.environment.fi/default.asp?contentid=379147&lan=EN

[9] CLIMSAVE project: www.climsave.eu

Addressing "grand challenges" has become a key focus of European research (Box 1).

Box 1 Grand challenges (Source Jäger and Jäger 2011)

At a conference held 2009 in Lund, Sweden, hosted by the Swedish Presidency of the Council of the European Union, approximately 350 participants agreed on a declaration[10] stating that European research policy should focus on global 'grand challenges' such as climate change, water shortage and pandemics.

The declaration states: 'The global community is facing grand challenges. The European Knowledge Society must tackle these through the best analysis, powerful actions and increased resources. Challenges must turn into sustainable solutions in areas such as global warming, tightening supplies of energy, water and food, ageing societies, public health, pandemics and security.' Furthermore, 'It must tackle the overarching challenge of turning Europe into an eco-efficient economy.'

Horizon 2020, the next Framework Programme for EU research has one pillar devoted to 6 societal challenges:

- Health, demographic change and well-being
- Food security, sustainable agriculture, marine and maritime research and the bioeconomy
- Inclusive, innovative and secure societies
- Climate action, resource efficiency and raw materials
- Smart, green and integrated transport
- Secure clean and efficient energy

As Jäger (2011) has pointed out, the societal challenges which are characterized by enormous complexity and deep uncertainties need to be addressed through **processes** such as those discussed in Section 2.2. Because of the nature of the challenges, these processes must engage stakeholders in finding a common perception of a problem area while providing a systemic view. The development of a common vision drives the search for pathways to solutions. Engaging in a process of dialogue supports social learning and sustainability learning. An iterative design supports adaptive approaches, recognizing that addressing societal challenges takes time, experimentation and acceptance of trade-offs.

The so-called "grand challenges" all concern the coupled human-environment system. A further approach to addressing the challenges is to consider the **resilience of the system** to both internal and external pressures. Assessing resilience has made strong advances during recent years, not least due to the activities of the Stockholm Resilience Centre (SRC). As defined by SRC, resilience is the long-term capacity of a system to deal with change and continue to develop. The resilience approach focuses on the dynamic interplay between periods of gradual and sudden change and how to adapt to and shape change. The **transdisciplinary** collaboration and research at SRC focuses on these challenges through a framework that emphasizes the following features:

- Society and nature represent truly interdependent social-ecological systems;
- Social-ecological systems are complex adaptive systems;

[10] The Lund Declaration: EUROPE MUST FOCUS ON THE GRAND CHALLENGES OF OUR TIME. July 2009 (http://www.era.gv.at/space/11442/directory/11495/doc/12942.html Accessed 6 Nov. 2011)

- Cross scale and dynamic interactions represent new challenges for governance and management in relation to interdependent social-ecological systems and ecosystem services.

Methodological advances have been also been made in the related area of “vulnerability assessment” – improving the resilience of an ecosystem, societal group or economic sector is achieved through reducing its vulnerability to environmental and societal changes. There have been numerous reviews of vulnerability assessment methodologies (see for just a small sample, Birkmann 2006; Jäger and Kok 2007; Omann et al. 2010).

Overall lessons learned:

- Addressing structural uncertainties and grand challenges benefit from carefully designed and facilitated participatory processes;
- Assessments must focus on the coupled human-environment system.

2.2 Tools for integrated assessment

Integrated environment assessment requires tools that can structure the available knowledge in terms of drivers of change, pressures on the environment, the state of the environment, the impacts on the environment and responses to all of these. Most frequently this structuring takes place using **models**. In recent years, several of the projects listed in Table 1 and the Annex to this paper have catalogued and evaluated the available tools. The ongoing LIAISE project[11] provides a toolbox, which provides meta-descriptions of 85 IA models to aid users in the selection and possible combinations of models. The toolbox also includes:

- A database with experts;
- A database with examples of Good Practice of Impact Assessment;
- Background information on the Impact Areas;
- Background information about generic methods which can be used in Impact Assessment;
- Background information about the requirements for IA in a wide range of countries.

An interesting new tool for IEA is demonstrated by the CLIMSAVE project[12] , which is combining the use of a **web-based integrated assessment tool** with a participatory assessment process. The Integrated Assessment Platform (IAP), accessible through the CLIMSAVE web-page, consists of a set of coupled meta-models allowing the user to explore the cross-sectoral impacts of a set of scenarios developed by stakeholders or to develop new socio-economic scenarios and explore their effects.

An approach that has been increasingly introduced in assessment processes in recent years is **agent-based modelling (ABM)**. As described by Bonabeau (2002), in ABM a system is modelled as a collection of autonomous decision-making entities (agents). Using a set of rules, each agent individually assesses its situation and makes decisions. Agents can execute various behaviours appropriate for the system they represent. Even a simple agent-based model can exhibit complex behaviour patterns and provide valuable information about the dynamics of the real-world system that it emulates. Sophisticated ABM sometimes incorporates neural networks, evolutionary algorithms, or other learning techniques to allow realistic learning and adaptation (Bonabeau 2002).

While the use of ABM in IEA is not yet as frequent as the use of more standard Integrated Assessment Models, it is increasingly being used in European research projects. For example:

- The FIRMA project (1999 – 2003) was concerned with improving water resource planning by developing and applying agent-based modelling to integrate physical, hydrological, social and economic aspects of water resource management;
- An innovative participatory agent - based modelling tool was developed as part of the EU project MATISSE[13];
- The aim of the HarmoniCOP project (2002 -2005) was to increase the understanding of participatory river basin management planning (RBMP) in Europe and the handbook produced by the project provides a basis for the development of improved integrated models and decision support tools, including agent-based modelling;

[11] http://www.liaise-noe.eu
[12] http://www.climsave.eu/climsave/index.html
[13] http://www.matisse-project.net/projectcomm/uploads/tx_article/Working_Paper_25_3.pdf

- In the ECOCHANGE project (2007-2012) an ABM was used within the experimenting phase of the ISA. It was used for to assess the impacts of environmental change on ecosystem goods and services (EGS) at the regional scale within selected case study areas. The ABM simulated land use and land cover change based on the decision processes of individual land use agents underpinned by theories of cognitive strategies and social interaction. Agent profiles were determined from the social survey data using Participatory Community Appraisal (PCA) and cluster analysis. Historic land use maps were derived from aerial photographs and satellite data. Statistical analysis of these data has been used to define probability surfaces of land use change trajectories that define the biophysical constraints (soils, climate, slope) to land use decisions within the ABM.

Overall, the advantages of ABM are seen in its ability to capture emergent phenomena[14], its ability to describe a system and methodological flexibility (Bonabeau 2002). Recently, it has been shown that ABM of complex economic systems can generate important and policy-relevant insights (Gerst et al. 2012). Gerst et al. (2012) developed an agent-based model that links international climate policy formation with underlying domestic economic, technological, and social dynamics. In this model, a diverse set of agents (negotiators, firms, and consumers) engages in purposeful behaviour by observing and interacting with their surrounding environment and other agents. The model has been used for defining ensembles of plausible futures using alternative assumptions and hypotheses concerning system behaviour. The scenarios can help identify policy vulnerabilities and opportunities, thus supporting the design of robust climate change mitigation strategies.

Overall lessons learned:

- An increasingly wide range of tools is available to be used in IEA processes. These are catalogued and evaluated in online databases, providing guidance regarding selection of tools;
- Several projects note, however, the need to provide training in the selection and use of tools (e.g. in the LIAISE project in Summer/Winter schools)[15];
- New tools such as agent-based modelling are extremely important for dealing with the complexities and non-linearities of changes in human-environment systems in IEA.

[14] Instead of looking for optimal outcomes, agent-based models focus on the evolution of large-scale properties that 'emerge' from the lower-level behavior (Miller and Page, 2007).

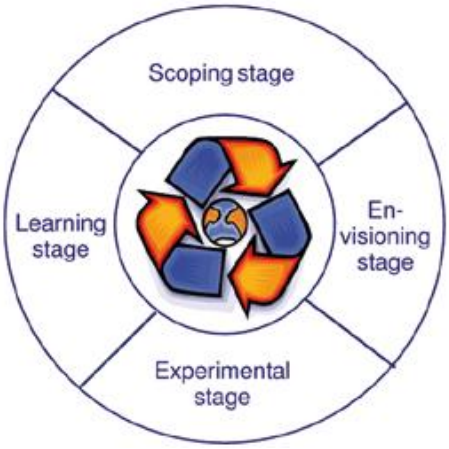
[15] Another source for training is the Integrated Environmental Assessment (IEA) on-line interactive training resource platform. The platform provides IEA tools, methods, case studies and available reports. http://hqweb.unep.org/ieacp/iea/

2.3 Integrated sustainability assessment and transition management approaches

One of the main difficulties in dealing with the grand challenges faced by society is that most of them arise through system failures (Rotmans 2006). Dealing with these challenges in isolation risks finding solutions for one problem that causes problems elsewhere. Furthermore, the complexity and uncertainties associated with these societal challenges mean that trade-offs will have to be made when solutions are sought. To deal with the need for a holistic approach in which trade-offs can be discussed, the process of **integrated sustainability assessment (ISA)** was developed and tested. While the process was initially developed in the MATISSE project[16], it has been used in a number of subsequent projects. For example, in the ECOCHANGE[17] project an ISA process was used in order to evaluate the potential impacts of climate and land use changes on human social systems. Ecosystem services are services provided to humans by the ecosystem such as timber, recreation areas, pollination, etc. and are essential for the well-being of humans. The ISA was carried out in three regional case studies located in Belgium, Switzerland and Romania. Local stakeholders were integrated in order to define the main problems and challenges, to think about sustainability visions and scenarios, and to draw conclusions from the ISA process.

ISA is an iterative process of scoping, envisioning, experimenting and evaluation/learning (see Figure 1). The iteration means that after the learning stage, the lessons learned would be incorporated into the next phase, in which all stages are repeated. During the scoping stage a systems analysis is carried out and used in a dialogue with selected stakeholders to develop a common understanding of the problem to be addressed in the assessment. In the envisioning stage, a common vision is developed together with the stakeholders, a normative view of the world that they want (in which "the problem" has been solved). During the experimentation stage assessment tools are used to explore the possible pathways to achieving the vision and uncovering the potential trade-offs that would have to be made. The evaluation stage consists of an evaluation of the results and of the process itself and through learning, the next iteration can then be started. In the MATISSE project ISAs of hydrogen mobility, of water problems in the Ebro Delta area in Spain and of resource use in the Czech Republic were carried out, documented and evaluated (Tuinstra et al. 2008).

Figure 1: Integrated Sustainable Assessment as a cyclical process (Source: Jäger et al. 2008)



[16] MATISSE project: www.matisse-project.net
[17] ECOCHANGE project: www.ecochange-project.eu

Transition management (TM) approaches have received increasing attention during recent years, since they are designed to deal with complex societal problems and the governance of these problems. The approach is very similar to the ISA approach described above. The biggest difference is in the "experimentation phase", which is largely based on the use of IA tools in an ISA, while it involves real, "on-the-ground" testing of measures in the TM approach. TM initiatives are taking place in many places but with most initial experience in the Netherlands, the UK and Belgium, and with a wide range of focus: e.g. energy, building, healthcare, water management and mobility. As noted by Wittmayer et al. (2011): "Because of the focus on integrated sustainability problems and the applied nature of transition research, the natural interaction between science and policy has led to a continuously coevolving theory and practice of transition management, following the tradition of post-normal and sustainability science."

The community of scholars working on transition research are networked within the Sustainability Transitions Research Network.

The TM approach is designed to be iterative. The components of the iterative cycle are: (i) structure the problem in question and establish and organize the transition arena; (ii) develop a transition agenda, images of sustainability and derive the necessary transition paths; (iii) establish and carry out transition experiments and mobilize the resulting transition networks; (iv) monitor, evaluate and learn lessons from the transition experiments and, based on these, make adjustments in the vision, agenda and coalitions. The approach is participatory and depends on the careful selection of stakeholders to be engaged in the process. A number of TM examples have been published (e.g. Loorbach and Rotmans 2010), but many processes are ongoing and not yet discussed in journals or books.

One very interesting example of an ongoing project using the TM approach is demonstrated by the InContext project[18]. In this project the TM approach is being used in three pilot studies: in a district of Rotterdam, in Wolfshagen in Germany and in Finkenstein – a rural area in southern Austria. Importantly, the methodology has been described in detail on the project website[19] together with the results of the first phases. The methodological guidelines demonstrate the wide range of participatory approaches that can and should be used in a TM process. In the appendix to the InContext methodological guidelines there is also a detailed description of how to perform a system and an actor analysis at the beginning of a TM process.

Overall lessons learned:

Tuinstra et al. (2008) made a detailed evaluation of lessons learned in the MATISSE project. Among the important lessons learned are:

- An ISA process can be a change agent itself, building coalition networks;
- ISA offers an interdisciplinary context, which triggers creativity and creates new insights, but at the same time asks for time investments in understanding each other's language and way of working;

[18] InContext project: http://incontext-fp7.eu

[19] http://incontext-fp7.eu/sites/default/files/Methodological%20guidelines_final.pdf

- Researchers often underestimate how much complexity users can handle and how complex the material is;
- Engaging stakeholders in ISA makes sustainability as a social process explicit and knowledge production is not just restricted to scientists;
- Organizing and managing stakeholder processes is time- and resource-consuming.

There are also some interesting lessons learned from TM processes of relevance for IEA:

- As pointed out, for example, by the Sustainability A-Test project, the approach is extremely valuable in introducing a long-term perspective for structural changes ;
- It is clear, however, that iterative processes with meaningful stakeholder engagement "require more time than usually is available" (Sustainability A-Test);
- There is an interesting challenge articulated by the InContext project regarding the role and perceived role of the "researcher" in this kind of action-research initiative. TM activities have a normative ambition of seeking to promote paradigmatic change and creation of innovation networks as an instrument to guide and accelerate societal change towards sustainability. The researcher becomes part of this process and faces challenges in doing so.
- Experience has demonstrated the importance of the first phase of framing the issue to be dealt with in the TM process (see box).

BOX: The Scoping Phase of a TM Process (Source: Wittmayer et al. 2011)

The starting point in a transition management process is to structure or reframe an existing societal issue in terms of the underlying problems to go beyond obvious and partial problems. The premise is that sustainability transitions require a new way of thinking and acting, which are intertwined. As different individuals or organisations have different ways of looking at reality (e.g. cultural theory, literature on problem structuring, literature on inner context), they often interpret sustainability problems differently and advocate different solutions. The core idea is that by making individual perspectives and paradigms explicit and confronting these with each other in a creative process of developing a joint problem definition on a common system level, individuals' inner contexts are influenced. In other words, by opening up to other ways of defining a problem or reality and developing a broader more encompassing way to define a problem to which individuals can relate their frame, they open up mentally to a wider array of solutions as well as accepting the existence of other ways to address a similar problem.

- Finally, as is emphasized in the following section as well, process design is of central importance.

2.4 Involving stakeholders and making the most out of participation

The need for **stakeholder involvement** has been addressed in most of the projects discussed in this paper. It is based on the need to include more knowledge than just "scientific knowledge" and on the recognition that bridging the knowledge – action gaps is supported by participatory processes. This is also addressed by the proponents of transdisciplinary research (see for example TD-net[20]) and also expressed in the following quote:

"Explain it to me and I shall forget. Show me how and I shall remember. Involve me and I shall understand". Y. Iljine[21]

There is considerable experience in recent years regarding involving stakeholders and designing **participatory processes** (see also Annex to this report and previous sections). Methods have been extensively documented, for example by the participation portal (see Footnote 21), which describes methods appropriate for different sizes of groups (up to 15 persons, about 20 – 30 persons. Larger groups).

In addition to experiences discussed in the previous section, some further insights have been gained in recent projects. In the ECOCHANGE project, for example, it was found that in order to raise the interest of stakeholders and to create a sense of ownership for the project, it is important to clearly show them the benefit of being involved in the process. The stakeholders were mainly people from the local governments that are responsible for land use, agriculture, forestry and nature and who work at a very concrete and applied level. The project was to a large extent basic research and thus hard to translate into a language that reaches the stakeholders and to show them the purpose and the sense of the project. Also, in the ECOCHANGE project there was a big difference in the way the stakeholders acted in the Romanian and the two western European (Switzerland and Belgium) case studies. In Romania the stakeholders did not question the methods used in the ISA but tried to give their best and did what the facilitator was asking them. This was only partly the case in the other countries, where many doubts about the quantitative methods and the need for the basic research were expressed.

In Sustainability A-Test, stakeholder involvement was found to be crucial in multiple kinds of ways: first of all, because the relevance of indicators might be more important than precision taking into account stakeholders interests. It is important to mobilize and channel knowledge but also to enhance trust of modelling tools.

Overall lessons learned:

- It is important to consider time, resources and experts in a theoretical, purely scientific project that wants to involve stakeholders, to translate the science for them and to show the usefulness of the project. This is important to consider when the process is designed.

- It is important to carry out a thorough check of the cultural background of the region and the stakeholders in the scoping phase.

[20] http://transdisciplinarity.ch/e/About/

[21] http://www.partizipation.at/index.php?english

- As pointed out above, main reasons to include stakeholders in IEA processes is to ensure both a certain responsibility towards the project (e.g. people from local governance) as well as the translation of scientific findings on a more applied level in order to provide useful information for decision-makers for future decisions. To guarantee the development of useful indicators and methods for every day appliance, the involvement of stakeholders is considered crucial since there might be great differences between scientific and applied approaches. The relevance of indicators has been found crucial as well as trust enhancement of modelling tools for users.

- Detailed processes have been developed to select stakeholders for assessments. A detailed process design has been documented, for example, by the CLIMSAVE project. A stakeholder analysis considers, who is likely to be affected most by the issue in question but also who has the largest influence on this issue. The selection then has to take into account factors such as geographical and sectoral distribution as well as gender balance.

- For an effective (credible, salient, legitimate) Integrated Environmental Assessment, methodologies and participatory approaches must be chosen carefully. Two examples of rather different participatory approaches in terms of addressed levels and stakeholder groups can be found in the projects RESPONDER and InContext. RESPONDER offers both online and face-to-face mechanisms for knowledge brokerage and uses participatory system mapping based on the concept of system dynamics. This approach combines the advantages of systems thinking, soft system analysis and modelling. The methodology is focusing simultaneously on a more general level and on five different consumption fields, thus using a rather expert-based participatory approach.[22] InContext on the other hand uses a more community-driven approach, building local transition arenas which develop specific visions addressing locally relevant problems and particular solutions. The InContext project has produced a very detailed documentation of the participatory approaches to be used.

- Experience in a variety of projects has shown the importance of a careful process design. Three factors need particular attention: length, timing and place of meeting. If policy-makers are to be engaged in the assessment process, experience has shown that the meeting cannot be longer than one-and-a- half days. Indeed, a one-day meeting or shorter is more likely to attract policy makers. Engaging stakeholders is easier, if the meeting is timed to pick up on issues that are high on public agendas. Regarding the place of the meeting, experience suggests that in these increasingly hectic times, participation is higher if the meeting place is easily reachable. Furthermore, for some stakeholders it appears to be important that the meeting is not held in some exotic place that they have difficulty justifying to their colleagues.

- The participatory assessment processes require careful preparation and implementation. Experience shows that excellent facilitation skills are needed and that a detailed “script” of the process should be prepared and even tested. The tools to be used (models, scenarios, system mapping) must also be tested in the context of the approaches to be used. The facilitation not only ensures that the goals of the process can be achieved as smoothly as possible but also that the participants feel secure within the process and that a positive atmosphere contributes to a successful outcome.

[22] http://www.scp-responder.eu/about/methodology

2.5 Using IEA (in a policy context)

By definition, IEA is bringing together information in a way that is useful for decision-making. Experience with **using IEA in a policy context** has been gathered in a number of recent projects. In addition to examining experience in IEA, it is important to learn from a recent set of initiatives on **knowledge brokerage**, since these have begun to address the challenge of linking knowledge to action in a systematic fashion.

In the SEAMLESS project, an important point was credibility and available information about sensitivity and uncertainty, thus the transparency of the knowledge base, the use of meta-information and an extended peer review).

The Sustainability A-Test project noted a disconnection of policy processes from assessments, with the assessments only producing information for decision-makers without them really participating in the assessment processes. The project concluded that a closer link between assessment processes and policy makers is needed, with attention to modes and timing of engagement. The uptake of outcomes in the political process has to be at the right time so the time frame of the project is important.

The LIAISE project found that better training for policy actors especially concerning quantitative tools was a crucial factor for a successful assessment. In addition, a better understanding of cultural, institutional and political factors affecting the appropriateness of certain tools has to be developed as well as better communication between researchers and officials. The general concern of policy actors about everyday micro-level problems may lead to the fact that the understanding of "improvement" of IA tools varies widely.

In short, the main topics being addressed in the above projects are concerned with appropriate handling of the tools by users, better communication between scientists and the policy community, a variation of tools developed by scientists from various disciplines increasing the credibility of the method and the importance of participation in order to guarantee a development of appropriate tools for everyday use.

At a workshop that took place in June 2007 entitled "*Research for sustainable development – How to enhance connectivity*"[23] EU Member States and Associated Countries agreed on a need to follow up on 1) reinforcing the synergies between national and European strategies for putting research at the service of sustainable development, 2) monitoring to what extent the sustainable potential of FP7 will be translated into reality and 3) improving the role of research in policy making **introducing the idea of knowledge brokerage**.

In FP7, this topic of knowledge brokerage was included in the Work Programme on Environment (including climate change). The knowledge brokerage projects started in 2009, 2010 and 2011[24]. The topics covered cover a broad range of issues related to sustainable development. Some of the teams are broader than just scientific institutions, also including policy-makers and civil society organizations. Several of the projects are testing particular tools to be used in knowledge brokerage processes; others are looking at the design of the science-policy interface. Terms such as integrated adaptive management, participatory approaches, evaluation and learning are frequently used in the project

[23] Research for Sustainable Development: How to enhance connectivity? Report of an EC Workshop, Brussels, 7-8 June 2007 (http://ec.europa.eu/research/sd/pdf/background_info/report_halfman.pdf)
[24] For a listing of these projects see Jäger and Jäger (2011)

descriptions. **There is a general recognition that strengthening the connectivity between research and policy-making requires mechanisms than can mediate between different kinds of research knowledge and the concrete needs of specific policy settings.** "Real Life Case Studies" in several of the projects extend this work on building bridges between science and policy or society.

The RESPONDER project is testing the use of systems mapping as a knowledge brokerage tool. Systems mapping with a simple guiding question provides a stimulus for dialogue between experts and policy actors as well as a deepened understanding of the complexity of human-environment interactions.

Overall lessons learned:

- Using IEA in a policy context means that the questions addressed in the assessment process must be salient to policy-makers. The involvement of policy-makers in framing the assessment can ensure that this is the case.
- The involvement of policy-makers in further stages of the assessment process can also support policy implementation of the findings, but it is often difficult to sustain the involvement of policy actors because of their competing time commitments.
- The need for transparency in the assessment process and for capacity building in the use of tools have been found to be important.
- The move towards more local and regional processes enhances the policy uptake of the results.
- Knowledge brokerage (linking knowledge and action) requires carefully designed and facilitated processes.

3. Reflections

From IEA to ISA: The trend in the last years has been from integrated **environmental** assessment to integrated **sustainability** assessment (Section 2.3). The recognition that an integrated systemic perspective is required reflects the need to consider cross-scale and cross-sectoral interactions. Without a systemic perspective, there is a high risk that solutions will be formulated, which actually lead to problems elsewhere. Furthermore, taking a systemic perspective is moving the focus of assessments from consideration of individual environmental issues to overriding issues of human well-being and quality of life.

From "closed" to "open" knowledge systems: The strong trend in recent years of increasing stakeholder participation in assessment processes recognizes that scientists and researchers are not the only holders of knowledge (Section 2.4). The design of participatory approaches that support a joint problem-framing and an exchange of knowledge between all participants enhances the credibility, salience and, most importantly, the legitimacy of the processes. Participation also supports the subsequent "buy in" of all participants in the implementation of measures to deal with the problems prioritized within the process.

From simplification to complexity: There is an increasing recognition that societal challenges are extremely complex and that methods and tools are required that embrace this complexity rather than simplify to make the problem tractable (Section 2.1). This is reflected in the trend towards using agent-based modelling, new approaches like system mapping and participatory scenario development (Section 2.1 and 2.2). These approaches are being considered in particular by the ongoing Global Systems Dynamics and Policy project[25].

From linearity to non-linearity: Part of the complexity that is referred to in the previous paragraph is a result of the non-linearities of global (social, economic and environmental) changes. Increasingly the discussion of environmental changes refers to "tipping points", planetary boundaries, abrupt non-linear changes and regime shifts (see Jäger and Patel 2012 for a recent review). Tackling these non-linearities clearly requires new approaches, since, for example, models based on assumptions of equilibrium cannot deal with the non-linear changes manifested by global change (Section 2.2). The need to consider so-called "high end" scenarios and the possibilities of abrupt non-linear changes in assessments was considered in UNEP's Global Environmental Outlook-5 and is included in the final call for proposals in the Environment (including climate change) programme of the EU 7th Framework Programme.

From book to web: The broadening of participation in assessment processes and the moves towards an open knowledge society (see especially the RESCUE report discussed in the introduction of this paper) necessitate a move from the publishing of large assessment reports as books (door-stoppers) to online and ongoing documentation of assessment outcomes. This entails consideration of how to make outcomes accessible to a broader public, also in terms of using non-technical language and making use of social media to collect and disseminate knowledge.

From global to local: A decade ago the most well-known assessments were global assessments – e.g. the IPCC, Millennium Ecosystem Assessment and the Global Environmental Outlooks. The move towards participatory approaches (Section 2.4) and the increased attention to linking knowledge with action (Section 2.5) has engendered a shift to assessments at the local and regional levels, where stakeholders have a particular interest. From a sustainability point of view, integrated assessments at all spatial levels

[25] http://www.gsdp.eu/about/

are necessary and a nested framework of assessments is important for linking local actions to considerations of planetary boundaries.

From "what is the problem?" to "how can we solve it?": The trend towards linking knowledge to action through processes that are "implementation-oriented" means that assessments increasingly focus on policy relevant recommendations (Section 2.3 and 2.5). While the assessment processes are not policy prescriptive and sit at the science-policy or science-society interface, there is an expectation that they support implementation of policies, measures and even behavioural change rather than just identifying problems.

From top-down to bottom-up: Participatory assessment processes mean that the stakeholders are engaged from the beginning in problem-framing, scenario development and analysis and assessments of impacts, vulnerabilities and response options (Section 2.3 and 2.4). The problem areas to be considered in an assessment process are no longer defined "top-down" by the science community. A major consequence of this is the need to design and facilitate effective processes and evidence suggests that considerable capacity building is required to meet this need.

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