Scenario Building and its Application

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Introduction and 'State-of-the-art'

Assessing uncertain futures Perceived uncertainties and risks can be considered to be the main motivation behind 'Futures Thinking' or 'Futures Studies' to assess potential economic, environmental, social or technical developments and their expected consequences on society and environment (or from a systems perspective – feedbacks between the components of complex social-ecological systems, e.g. Liu et al., 2007). A broad range of approaches such as Forecasting, Predictions, Trend Analysis, Visions, Collages or Mental Models is used to assess future developments and their consequences on the economy, society or the biophysical environment, of which scenarios are just one, though frequently applied method of 'Futures Thinking' (see: Audience Dialogue, 2014 for a glossary or World Futures Studies Federation, 2015). Many of the approaches and methods can be combined, which is frequently done in practice e.g. (participatory) scenarios and mathematical models. In the context of 'global change – policy – impact assessment' studies (OpenNESS belongs to this category), scenarios are one of the dominant approaches for assessing uncertain futures, for example the IPCC SRES scenarios, the scenarios of the Millennium Ecosystem assessment or UNEP's Global Environmental Outlook.

What are scenarios? The term scenario is widely used in different ways and contexts, making it necessary to arrive at a common understanding of how the term is used. Based on the OpenNESS Glossary (2016), scenarios are defined as "plausible, but simplified descriptions of how the future may develop, based on a coherent and internally consistent set of assumptions about key driving forces and relationships. Scenarios are no predictions of what will happen, but ore projections on what might happen or could happen given certain assumptions about which there might be great uncertainty".

There are several **types of scenarios** that can be distinguished along different lines (van Notten et al., 2003). *Trend scenarios* explore the continuation of (and deviations from) currently dominant trends in society and policy and are often combined with *policy scenarios* to show consequences of future policies, while *explorative scenarios* explore plausible alternative futures. Another option is to develop *normative scenarios*, for instance possible futures versus desired futures. This is often used in combination with *back casting,* aiming at identifying, prioritizing and characterizing management strategies and policies. Which type of scenarios to develop depends on the objectives and the intended use and the users of the scenarios (e.g. quantified drivers as input for models; 'policy-free' storylines to test different policies).

For the **development of scenarios** different *inputs* can be used, e.g. based on stakeholder or expert consultations during workshops, interviews or questionnaires, but also using input from other scenarios or literature in general. Likewise different methods can be applied, like *back casting, visioning, storytelling, fuzzy cognitive maps*, and others (Alcamo et al., 2008; Keune et al., 2013; Kok, 2009). There are also multiple ways to check scenarios for internal consistency, e.g. using *expert rounds, models* or *cross table* approaches. Furthermore, multiple forms exist to present the possible future states, for example as *qualitative storylines* or visualized as sketches, pictures or (hypothetical) maps, or quantitatively as tables or graphs. The applications of scenarios are likewise manifold, common uses include: scenarios as research or decision support tools, for example, to assess possible impacts of alternative climates, impacts of policies or socio-economic changes on ecosystems and ecosystem services, integration of different knowledge domains or the establishment of scientifically based consensus (Acreman, 2005; Kok et al., 2011; Biggs et al., 2007; Liu et al., 2008; Mahmoud et al., 2009; Palomo et al., 2011). In order to ensure legitimacy and relevance of scenarios for the intended users it is considered advantageous to include/involve decision makers and other stakeholders in the identification and selection of key drivers,

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the development of assumptions and corresponding scenarios (Alcamo et al., 2008; Kok, 2009; Priess and Hauck, 2014, Hauck et al., 2015), while in practice stakeholder involvement may vary between expert consultation and full collaboration. In subsequent steps scenarios maybe quantified e.g. using simulation models. Evaluation of simulation results, and in some instances also model development may be components of the participatory discussion process.

This short introduction already shows that many options exist to develop and use scenarios and we do not intend to provide an exhaustive methodological overview here. Instead, we will lay out the approach that we suggest for this cross-cutting methodology in OpenNESS, and explain the suggested approaches.

Scenario development in OpenNESS

Thematic focus of the OpenNESS scenarios: The EU level OpenNESS scenarios show the influence of different drivers of change on natural capital, ecosystems and their services (for an analysis of drivers please see Hauck et al., 2015). The question which policies are considered as relevant drivers is addressed at different levels. First, a team scenario developers, policy analysts and modellers established links between the policy frameworks and governance options at EU and national scale, to determine which policies might have led to the situation described in the various scenarios. Second, the user groups, primarily the OpenNESS case studies, identified and linked policies considered to be relevant at their scale (mostly sub-national or local) for their specific case.

Scenario design: The OpenNESS scenarios serve different purposes. Therefore, the scenario team (of OpenNESS scientists) considered a generic set of EU level scenarios in the form of **storylines** and **quantified drivers** as the most useful approach. Drivers and uncertainties identified by the primary users and the scenario team were organised along axes of key-uncertainties, similar to the IPCC or the GEO4/5 scenarios. Previous studies and scenario-manuals repeatedly pointed out that a low number of scenarios (3-6) is advantageous in participatory processes in order to avoid overburdening voluntary participants, scientists to be consulted, as well as the scenario team (Henrichs et al., 2010). In OpenNESS, four scenarios were developed along two axes of key uncertainties The OpenNESS scenarios (WealthBeing, UnitedWeStand, EcoCentre, RuralRevival) are explicitly addressing midterm (until 2030) and longterm changes (until 2050).

The conceptual framework and methods for integrative scenario development mainly followed Priess and Hauck (2014). They based their participatory scenarios on three components of a scenario framework: 1) User and stakeholder participation, 2) Knowledge integration, and 3) Quality control, all of which are considered prerequisites to developing integrative scenarios that serve as common boundaries for case studies as well as for decision making needs at different levels. Scenarios typically are developed in a series of steps, e.g. the procedures suggested by Alcamo (2001) or Kok (2009). Similarly, a six step procedure has been followed for the participatory scenario development in OpenNESS, including iterative cycles / components: Establishing a scenario team - Review of drivers (Hauck et al., 2015)- Selection of drivers (and indicators) - Development and review of storylines - Application of scenarios at EU / case study levels – Synthesis and feedback to case studies and EU level. Considering the degree of participation as a range between expert rounds (low) and full co-design (high), stakeholder involvement in the OpenNESS development process can be considered intermediate. The scenarios are built on a priori results identifying drivers of change from case study questionnaires and repeated discussions with case studies and an EU-level stakeholder workshop, while most of the details and the quantification of drivers have been elaborated in an iterative quality assurance process by the scenario team involving additional experts, mainly experienced scenario developers and modellers.

Open Problems/Issues to be

1. The development of scenarios in the case studies has been supported by the scenario team during workshops and via repeatedly providing support during the individual processes. Saliency and relevance of the scenarios at the case study scales and the utility of scenario methods in different decision-making contexts will be discussed in the end of the OpenNESS project.
2. As mentioned above, currently drivers of ecosystem change at EU level are being analysed, especially considering the added value of including ES/NC in current (or potential new) EU regulatory frameworks in view of the goals the EU wants to achieve, but also the external impacts of the EU policies on regions

outside Europe. The analyses involve policy analysts, scenario developers and modellers of different OpenNESS teams and shall provide input for the recommendations to decision makers planned as one of the key outreach products of OpenNESS also serving as input to the IPBES Regional Assessment on Europa and Central Asia (Hauck et al. in preparation). Inputs from different stakeholders and experts are expected to ensure relevance and saliency, firstly for the OpenNESS case studies, and secondly for other potential users (Alcamo and Henrichs, 2008; Priess and Hauck, 2014), for example, at EU or other levels.

3. Finally, by providing common boundary conditions for case studies and simulation models (Priess et al. forthcoming) such as CLIMSAVE and GLOBIO / IMAGE, we increased comparability of model simulations (Veerkamp et al. forthcoming) and case studies and facilitate integrative analyses across Europe.

Significance to OpenNESS and specific Work Packages[2]

WP1 (Key challenges and conceptual frameworks): The scenarios and their applications address the four challenges. Beyond, it is expected that the application and stress-testing of the scenarios will reveal different strategies and policy frameworks addressing NC and / or ES.

WP2 – 3 (Regulatory frameworks and drivers of change and Biophysical control of ecosystem services): In WP 2 the scenarios were developed (task 2.3) and also serve as an example in the scenario guidelines (task 2.4). WP3 scientists contributed significantly to scenario development, co-designing the list of scenario drivers and leading their quantification for input into the simulation models of WP3 and others.

WP2 - 5: The objective of Task 2.3, as described in the proposal, is to develop an integrative multi-scale scenario approach to analyse drivers of ecosystem change on the EU level and (Task 2.4) to develop guidelines for undertaking a participatory scenario approach at case study level. Together, tasks 2.3 and 2.4 are called the cross-cutting methodology "**Participatory Scenario Building Methodology**". Thus, the scenarios contribute to achieving the use of common assumptions about factors driving ecosystem change or changes in ecosystem service provision, indicators and methods at EU level, across WPs 2-4, while WP5 case studies can use the OpenNESS EU level scenarios as a starting point for participatory scenario building processes at their regional / local levels, e.g. via adapting / downscaling them to their scales and thematic foci. The final goals of the scenarios are to facilitate and enable synthesizing, e.g. impacts of different modes of governance on different ecosystem services, or compare indicators across regions and cases.

WP6 (Integration: Synthesis and Menu of Multiscale Solutions): The scenarios are being made available on OPPLA and may also serve as input into additional outreach or dissemination processes within and beyond OpenNESS.

Relationship to the four challenges[3]

Governance: The storylines facilitate a (participatory) prioritisation and evaluation of policies and regulatory frameworks ensuring the relevance and usefulness of the scenarios for the intended users. Furthermore, the common framework of scenario assumptions facilitates testing the robustness of policies (Hauck et al. in preparation) e.g. via comparative analyses across OpenNESS case studies.	**Sustainable Ecosystem Management:** In the scenarios very different types of land and ecosystem managements are assumed to assess a broad range of their potential positive and negative impacts. (See simulation results (Veerkamp et al. forthcoming; Priess et al. forthcoming)
Human well-being: The OpenNESS case studies and modelling approaches focus on different contributions to human well-being from ecosystems influenced by different drivers of change. The participatory approach ensures that these drivers are	**Competiveness:** The OpenNESS scenarios make explicit assumptions about changes in different sectors of the economy, lifestyles, demography, urban and rural areas etc., several of them with potentially strong impacts on competiveness. It is

2 For a brief description of the OpenNESS Work Packages see: http://openness-project.eu/about/work-packages

3 There are certainly more societal challenges; the reduced number presented here is due to the four major challenges mentioned in the work programme of FP7 to which OpenNESS responded.

addressed in the scenarios. Subsequently, participatory scenario workshops could explore the human wellbeing of different stakeholders across scenarios.	envisaged that case studies and modellers will analyse the multiple impacts on NC, ES, human well-being etc. in the different scenarios, and their impacts on competitiveness. (See simulation results (Veerkamp et al. forthcoming; Priess et al. forthcoming)

Recommendations for the OpenNESS consortium

User and stakeholder participation: In order to achieve the benefits associated with the scenario development process, such as joint learning, the development of consensus about goals or to improve the ability to deal with uncertainty in decision making, it is necessary to involve the relevant stakeholder groups in the development process (case study leaders, modellers, EU-level stakeholders). So far we have been involving all groups as envisaged, but especially at EU level to a lower degree than originally foreseen, i.e. limited to one though intensive workshop in Brussels.

Knowledge integration: Scenarios integrate knowledge from different disciplines (e.g. developer teams) as well as scientific and other forms of knowledge, e.g. contributed by (inter-)national/local stakeholders. Especially interdisciplinary knowledge integration worked extremely well, most probably benefiting from previous experiences of most of the participants. Some caveats we had to overcome were e.g. related to differing perceptions of what scenarios are (key-components, purpose), and their applicability in some of the case studies, related to differing ideas how detailed or how generic storylines and drivers and the assumptions therein should be (policies, thematic issues).

Scenario application: Case studies, modellers and policy analysts were strongly encouraged to apply and stress-test the scenarios, to increase comparability and facilitate integrative analyses including the identification of promising policies or policy frameworks both at EU and case-study level. Currently, scenarios are being applied in all contexts envisaged, but it is too early to derive final conclusions, e.g. whether they contributed to facilitate case study syntheses. So far, different models parameterized with the OpenNESS scenarios already produced promising results addressing land use changes in Europe and their impacts on several ecosystem services. Additionally, a larger team is working on the links between policies and the pathways assumed in the scenarios.

Three 'Must Read' Papers:

Hauck, J., Winkler, K.J., Priess, J.A. (2015): Reviewing drivers of ecosystem change as input for environmental and ecosystem services modelling. *Sustainability of Water Quality and Ecology* ***5*****:** 9-30.

Liu, J. et al. (2007): Complexity of coupled human and natural systems. *Science* **317:** 3–6.

Priess, J.A. and J. Hauck (2014): Integrative scenario development. *Ecology and Society* **19** (1), 12. [online]: http://www.ecologyandsociety.org/vol19/iss1/art12/

Further Literature and cited References

Acreman, M. (2005): Linking science and decision-making: Features and experience from environmental river flow setting. *Environmental Modelling & Software* **20(2)**: 99-109.

Alcamo, J. (2001): *Scenarios as tools for international environmental assessments*. Environmental issue report 24. European Environment Agency, Copenhagen.

Alcamo, J. and T. Henrichs (2008): Towards Guidelines for Environmental Scenario Analysis. Chapter 2 in: J. Alcamo (Ed). *Environmental Futures: The Practice of Environmental Scenario Analysis*. Amsterdam: Elsevier. pp. 13-35.

Audience Dialogue (2014) Glossary of futures studies terms. (URL: http://www.audiencedialogue.net/gloss-fut.html#foresight; last access: 08/2014).

Biggs, R. et al. (2007): Linking futures across scales: a dialog on multiscale scenarios. *Ecology and Society* **12(1)**: 17. [online] URL: http://www.ecologyandsociety.org/vol12/iss1/art17/.

Henrichs, T. et al. (2010): Scenario Development and Analysis for Forward-looking Ecosystem Assessments. Chapter 5 in: N. Ash et al. editors. *Ecosystems and Human Well-being - A Manual for Assessment Practitioners*, Island Press, Washington, Covelo, London, Pages 151-220.

Hulme, M. and S. Dessai (2008): Predicting, deciding, learning: Can one evaluate the "success" of national climate scenarios? *Environmental Research Letters* **3**:045013.

Keune, H.; Bauler, T. and H. Wittmer (2014): Ecosystem services governance: managing complexity? In Jacobs, S, et al. (Eds.): *Ecosystem Services: Global Issues, Local Practices*. New York: Elsevier, p.135-155

Kok, K. (2009): The potential of Fuzzy Cognitive Maps for semi-quantitative scenario development, with an example from Brazil. *Global Environmental Change* **19(1)**: 122-133.

Kok, K. et al. (2011): Combining participative backcasting and explorative scenario development: Experiences from the SCENES project. *Technological Forecasting and Social Change* **78(5)**: 835-851.

Liu, Y. et al. (2008): Linking science with environmental decision making: Experiences from an integrated modeling approach to supporting sustainable water resources management. *Env. Modelling & Software* **23(7)**: 846-858.

Mahmoud, M. et al. (2009): A formal framework for scenario development in support of environmental decision-making. *Environmental Modelling & Software* 24(7):798-808.

OpenNESS Glossary [edited by Potschin, M.; Haines-Young, R.; Heink, U. and K. Jax] (2016): OpenNESS Glossary (V3.0), 39 pp. Grant Agreement No 308428. Available from: http://www.openness-project.eu/glossary

Palomo, I.; Martín-López, B.; et al. (2011): Participatory scenario planning for protected areas management under the Ecosystem Services Framework: the Doñana social-ecological system in southwestern Spain. *Ecology and Society* 16(1):23. [online] URL: http://www.ecologyandsociety.org/ vol16/iss1/art23/.

van Notten, P.; Rotmans, P.; van Asselt, M.B.A. et al. (2003): An updated scenario typology. *Futures* **35(5)**: 423-445.

van Vuuren, D.P.; Kok, M.T.J.; Girod, B.; Lucas, P.L.; and B. de Vries (2012): Scenarios in Global Environmental Assessments: Key characteristics and lessons for future use. *Global Environmental Change* **22**: 884–895.

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