Copyright © 2011 by the author(s). Published here under license by the Resilience Alliance.
Helming, K., and M. Pérez-Soba. 2011. Landscape scenarios and multifunctionality: making land use impact assessment operational. *Ecology and Society* **16**(1): 50. [online] URL: http://www.ecologyandsociety.org/vol16/iss1/art50/

Guest Editorial, part of a Special Feature on Landscape Scenarios and Multifunctionality – Making Land Use Assessment Operational

Landscape Scenarios and Multifunctionality: Making Land Use Impact Assessment Operational

Katharina Helming [1] *and Marta Pérez-Soba* [2]

ABSTRACT. Ex ante impact assessment can help in structuring the analysis of human-environment interactions thereby supporting land use decision making for sustainable development. The contributions to this special feature focus on some of the challenges of making land use impact assessment operational for policy making. A total of nine papers deal with the needs and uses of assessment tools for policy making at the European level, with the value-based influence in scenario development, and with ex ante impact assessment studies in different contexts, spatial systems, and for different purposes and user groups. The concept of landscape multifunctionality was implicitly or explicitly employed as an integrating entity between socioeconomic and biogeophysical features of a spatial system. Three major aspects were revealed that could improve the relevance of the policy of land use impact assessment: the involvement of decision makers early on in the design of the impact assessment study; the integration of quantitative analysis with participatory valuation methods; and the robust and transparent design of the analytical methods.

Key Words: *impact assessment; landscape; land use; multifunctionality; science-policy interface*

The Council of Europe, in their landscape convention, defined the concept of landscape as a product of human-environment interactions: "Landscape means an area, as perceived by people, whose character is the result of the action and interaction of natural and/or human factors" (Council of Europe 2000). Human action includes land uses such as agriculture, fishery and forestry, water management, urban settlement, recreation, transportation, mining, and waste disposal. The historically multifunctional use of land took account of spatially distinct natural and cultural settings and has led to an overwhelming variety of landscapes, each containing unique characteristics (Brandt and Veijre 2003, Mander et al. 2007).

A developing world economy, demographic growth, and migration trends have resulted in drastically increasing land use demands, which accelerated the speed of landscape changes. Also, attention to the increase of food and renewable resource production is now rapidly re-emerging because of an increasing demand on one hand, and because of soil degradation and yield uncertainties due to weather extremes and climatic changes on the other hand (Leemans et al. 2009). An accelerated migration trend to urban agglomerations makes it difficult for the rural hinterland to satisfy the increasing needs for land-based goods and services, including those of provisioning (production), regulation, supporting, and cultural services as specified, for example, in the Millennium Assessment (MA 2003). A simultaneously increasing demand for those land use services challenges the multifunctional performance of many landscapes, particularly in densely populated countries (Helming and Wiggering 2003).

Sustainable land use implies a balanced consideration of the portfolio of social, economic, and environmental services provided by the land uses in a certain landscape (Wiggering et al. 2006, Pérez-Soba et al. 2008). It also implies a careful consideration of long-term attributes of resilience and robustness that are to maintain underlying ecosystem processes. In an attempt to operationalize sustainable development for the case of land use, the concept of multifunctionality was introduced (Wiggering et al. 2006). The underlying rationale for multifunctional land use is to consider effects of

[1]Leibniz-Centre for Agricultural Landscape Research (ZALF), [2]Alterra WUR

any land use action interactively. Commodity production is analyzed in the context of its negative and positive externalities in a spatial system. The multifunctionality of any land use action lies in the degree to which land use affects the ability of the landscape to perform these various functions interactively (Helming et al. 2008, Paracchini et al. 2009). This interpretation of multifunctionality relates the supply of land use services to the societal demands for land use services and allows for an assessment of the value that multifunctional land use has for society (Helming et al. 2008). By understanding sustainable development as a discourse-based, deliberative process (WCED 1987), this multifunctionality concept can be used as an estimate for sustainability assessment of land use (Pérez-Soba et al. 2008).

The characteristic features of sustainable land development might considerably vary from region to region as do their natural, political, and social characteristics. Also, the question of whether certain land use options are sustainable or not, depends not only on the specific characteristics of the respective region, but also on land use options in other regions. If for example, many regions took the same measure of sustainable development on a larger scale, some key elements of sustainability might vanish because of synergisms and trade-offs between the system components. Therefore, land development requires a comprehensive landscape approach, but needs to be embedded in a wider spatial and geographical system.

To support land use decision making in the light of sustainable development, ex ante impact assessment can help to deal with the high complexity of the land use interactions. For researchers, impact assessment is a means to structure the analysis of human-environment interactions. For policy makers, impact assessment is a means to better target policy decisions toward sustainable development. The integration of both provides scientific evidence to policy making, but requires a mutual understanding of the respective objectives and operational restrictions within the scientific and policy making domains (Helming et al. 2011*a*).

Ex ante impact assessment for policy making includes a series of formalized steps (CEC 2009). After having identified the policy problem, the objectives are defined and the main policy options are developed. For every option, the intended and unintended impacts on social, economic, and environmental system variables are analyzed and compared. Particularly at this step, scientific support can be provided in the form of tools or methods that are easy to use, flexible, and robust (Nilsson et al. 2008, Thiel 2009). Inventories of scientific tools revealed the existence of a comprehensive choice of methods for a variety of policy fields (Böhringer and Löschel 2006, Van Herwijnen 2008). However, most of these tools cover isolated aspects of impact assessment such as scenario analysis or accounting approaches, but do not provide a comprehensive framework for analyzing causal chain relationships between policy-induced system changes and corresponding system responses (Lotze-Campen 2008). Moreover, most impact assessments have focused thus far on better regulation and policy efficiency, whereas less effort has been put into creating a balanced impact analysis of all three sustainability dimensions (Jacob et al. 2008, Paracchini et al. 2009).

An integrated assessment of land use policies implies simultaneous consideration of all spatially relevant aspects of economic sectors and human activities that are linked to land (Helming et al. 2008). These include agriculture and forestry as the main economic sectors, nature conservation and rural tourism as land conserving activities, and settlement, transport, and energy infrastructure as urbanized land uses. All of these sectors and activities compete for land resources, so any policy change affecting one land use has the potential to induce changes in the others (Plummer 2009).

Several interdisciplinary foresight and ex ante assessment studies and tools have emerged over the last decade in the field of land use. A comprehensive review of recent scenario tools is provided by Schaldach and Priess (2008). Generally, the conceptual framework of impact assessment studies of land use changes can be explained with the DPSIR framework (Gabrielsen and Bosch 2003). Driving forces (D) are exogenous forces that describe social, demographic, technological, policy making, and economic developments; these are underlying causes leading to land use change. Via predictive, exploratory, and/or normative scenario story lines, driving forces are translated into land use changes (Pressures) by using spatially explicit integrated land use modeling or simple knowledge rules. The spatial changes in land use induce alterations of the biogeophysical and socioeconomic settings of the system (States) that are usually determined by indicators. These changes in the state

conditions may affect the area's quality of life and sustainable development (Impacts), as determined by aggregation methods such as multicriteria analysis and by monetary or nonmonetary valuation. Finally, anticipation of these changing conditions may elicit societal and policy reactions (Responses). These responses may again affect any part of the DPSIR chain directly or indirectly so that the cycle is closed (Hák et al. 2007). At the science-policy interface, this approach is used to help to structure the analysis of policy effects on human activities and the environment (OECD 2003, Helming et al. 2008). The approach has been widely used for jointly conceptualizing research problems and integrating disciplinary viewpoints.

Helming et al. (2011*b*) analyzed five European-scale land use assessment tools for their methodological approach to integration, policy relevancy, and addressing sustainable development. It was shown that their usefulness for policy and decision support is challenged by a number of factors. These include the decision makers' need for transparency, often conflicting with the complexity of sophisticated modeling systems (Nilsson et al. 2008). Careful scaling to the specific spatio-temporal setting of the decision context is a further challenge. For the sake of precision, researchers tend to study land use changes over long time spans and for small areas, but policy makers are interested in immediate outcomes of their intervention over large spatial areas. Although scaling is an issue researchers have extensively dealt with in recent years (Claessens et al. 2009), solutions are not yet mature. A less explored challenge for ex ante impact assessments is linked to the saliency and legitimacy of the tools used for policy assessment. This includes the need to integrate normative, value-based aspects of assessing human-environment interactions with quantitative analysis (Binder et al. 2010). Particularly for model-based impact assessments, which do not necessarily consider stakeholders' views, attention needs to be drawn to the normative valuation of the analyzed scenario impacts. Stakeholders and decision makers need to be involved in the scientific analysis to valuate anticipated impacts in light of their norms, values, and development targets (Helming et al. 2011*a*).

The objective of this special feature was to address some of the challenges of making land use impact assessment operational and useful in the context of policy making for sustainable development. The special feature consists of nine papers dealing with the needs and uses of assessment tools for policy making at the European level (De Smedt 2010), with the value-based influence in scenario development (Metzger et al. 2010), and with ex ante impact assessment studies in different contexts, spatial systems, and for different purposes and user groups (F&#252rst et al. 2010, Loibl and Walz 2010, Waldhardt et al. 2010, Helming et al. 2011*a*, *c*, Morris et al. 2011, Prins et al. 2011). Except for the policy analysis paper by De Smedt (2010), all papers deal with the development and analysis of landscape and land use scenarios thereby implicitly or explicitly making use of the multifunctionality concept. In the following, the papers are introduced with special emphasis on their contribution to improving impact assessment methods for policy and decision support.

De Smedt (2010) analyzed the use of impact assessment tools to support sustainable policy making in a European context by employing three criteria: accuracy, relevancy, and legitimacy. Results showed that accuracy is inherent in scientific models but is often lost as a cost of transparency. Scientific tools often remain so complex that they appear as black boxes rather than as transparent analytical tools. Political relevancy is often hindered by the fact that research-based tools are generic and not specific enough to be of direct use in a political decision process. Legitimacy can only be achieved if policy makers are involved at an early stage in the tool development and, vice versa, researchers are involved at an early stage in the policy making process. De Smedt concludes that if impact assessment tools are codeveloped in science-policy interaction, their use may be improved and the entire process could be seen as a best practice example for making sustainable development operational (De Smedt 2010).

Scenario design and analysis for impact assessment is the center piece in the paper by Metzger et al. (2010). In their foresight study about the future of European rural regions, they particularly emphasized the role of personal judgment of the executing expert of scenario studies. They argued that personal judgment is inherent in the models used for scenario analysis but it is often not made sufficiently explicit so that its impacts on the results are not obvious. One scenario setting could plausibly be the consequence of different causal chain relationships, which, in the extreme case, could lead to contradicting scenario impacts. Consequently, personal judgment should be made explicit and

stakeholders should be involved in outlining causal chain mechanisms behind scenario analysis to improve legitimacy of the outcomes (Metzger et al. 2010).

Prins et al. (2011) applied a combination of macroeconomic and land use models to assess the impact of European biofuel policies on socioeconomic development in the agricultural sector and on environmental aspects. Of particular importance was the relation between European policies and non-European impacts. Prins et al. (2011) concluded that the most profound impact of European biofuel policies may lay in global environmental aspects, particularly land use changes in Brazil. The paper demonstrated the potentials of a global, quantitative, model-based assessment approach. One important asset of such a global approach is in identifying potential hot spot areas and items of conflict that warrant more careful analysis.

Helming et al. (2011*a*) developed an analytical framework for ex ante impact assessment of policy induced land use changes for European regions. The approach was DPSIR-based in that it (1) linked policy scenarios with land use change simulations, (2) linked land use change simulations with environmental, social, and economic impacts on European regions, and (3) valuated the simulated impacts by means of land use function-based multicriteria analysis. The analytical string departed from a predominantly economic setting of external driving forces, which was translated into a geophysical setting of land use pressures and further into an integrated system of sustainability impacts with equal account of the economic, environmental, and social dimension. The latter was achieved through the concept of land use functions, which, comparable to the ecosystem service approach, translates processes of human-environment interaction into private and public goods and services. In this way, the basis for a nonexpert-based, stakeholder inclusive, normative valuation of scenario outcomes was laid.

Two application examples of the developed framework were provided in Helming et al. (2011*c*): a reform scenario of the European Common Agricultural Policy (CAP) applied to the complete area of Europe and analyzed with the quantitative modeling system, and a bioenergy policy scenario for a region in Poland employing a qualitative, fully participatory approach. Both methods were comparatively analyzed in their potential to meet the challenges of impact assessment and decision support. It was concluded that both approaches may be used in combination to take advantages of the complementary assets of qualitative and quantitative approaches.

Morris et al. (2011) described in detail the methodology of the qualitative, participation-based implementation of the DPSIR assessment cycle that was also used in Helming et al. (2011*c*). Morris et al. (2011) developed a formalized approach to participatory impact assessment and tested it for a case of biodiversity policies in Malta. The paper particularly reflected on the feedback provided by the Maltese stakeholders. It drew implications on the ability of stakeholder-based, local impact assessment exercises to enhance quality, credibility, and legitimacy of higher level policy making, in this case the European level. The paper thereby added a new aspect and also a solution pathway to De Smedt's (2010) elaborations about the characteristics of legitimate tools for impact assessment.

Waldhardt et al. (2010) also focused on a normative approach to scenario development for a landscape study in a central German catchment. Their approach differed from the other scenario approaches in that they first constructed an expert-based "ideal" landscape as a reference case, which completely followed the principles of multifunctionality. The actual landscape situation was compared to the ideal case thereby identifying differences in landscape multifunctionality. Different stakeholder groups were then allowed to design development scenarios that were meant to overcome detected deficits with the ideal case. Specific values, perceptions, and development targets of the different stakeholder groups could be detected and compared with respect to their impacts for landscape multifunctionality.

The design of a tool for spatial planning and land use impact assessment was the core issue in the paper by F&#252rst et al. (2010). The case study region was the Euro Region Neisse, a transnational border area combining the Czech Republic, Poland, and Germany. Each of these countries follows specific, partly conflicting spatial planning targets and processes. The idea behind the tool was to use simple, GIS-based mechanisms for visualization of alternative land use scenarios to facilitate a stakeholder dialogue about respective pros and cons and optimized land management solutions. The tool

development was achieved iteratively in close collaboration with end users to guarantee best possible uptake. The tool allowed for individual, rule-based analysis of the multiple functions of the landscape and their sensitivity to alternative development scenarios. The depth and complexity of the analysis could thereby be adapted to the respective user needs.

Loibl and Walz (2010) used an Alpine village case for a transdisciplinary study of landscape transition scenarios and respective consequences. The objectives, development, and outcome of the participatory approach were described to derive strategic design criteria for participatory studies. For the case of tourism development, which was the major triggering factor in the Alpine village case, the most challenging item was the identification of the tipping point of development, where environmental and social impacts of growth in the tourism sector become so severe that negative back-loop on the sector is to be expected. This process may be accelerated through global warming, which poses further challenges on the identification of best management strategies. The paper concluded that participatory scenario assessment strategies can support this process.

How did the nine papers contribute to making land use impact assessment operational and useful in the policy context? What were the common and the distinct elements of the impact assessment studies?

One characteristic element of the papers was the spatial scale of analysis. The European scale was approached in four of the papers (Metzger et al. 2010, Helming et al. 2011*a*, *c*, Prins et al. 2011). In those cases, the impacts of European-level policy scenarios were assessed for European and extra-European regions. Tools and methods used were entirely quantitative simulation models with a focus on foresight and scenario information. Except for Metzger et al. (2010), decision makers and other stakeholders were not involved in the analysis. The other papers focused on regional to local scale, thereby addressing regional planning and policy scenarios (F&#252rst et al. 2010, Loibl and Walz 2010, Waldhardt et al. 2010, Helming et al. 2011*c*, Morris et al. 2011). In all those cases, participatory methods were used for scenario design and assessment either solely (Loibl and Walz 2010, Morris et al. 2011) or in combination with quantitative modeling and tool design (F&#252rst et al. 2010, Waldhardt et al. 2010). Stakeholder dialogue, mediation, and solution finding were the major purpose of those studies. In addition, Morris et al. (2011) also discussed the use of the local level participatory impact assessment study for informing policy decision making at a higher governance level. They thereby opened the door for new research avenues and methods that may indeed achieve vertical, cross-scale integration of impact assessment studies that, in the end, may improve legitimacy of decision making across governance levels.

The combination of quantitative modeling with qualitative, participatory methods for impact assessment may considerably improve usefulness and legitimacy of impact assessment tools. Examples for such a combined use are provided by F&#252rst et al. (2010), Waldhardt et al. (2010), and Helming et al. (2011*c*). In those cases, stakeholders were involved in scenario definitions, indicator selections, and in the analysis of the modeling results, thereby providing a valuation of results against the background of normative perceptions and demands. It became clear that the combined use of modeling and participatory methods can take advantage of the assets of both methods while also surmounting their shortcomings. In quantitative modeling, the evidence-based, detailed, reproducible, and neutral character of results is convincing, while its lack of transparency and the implicitness of judgments challenges its legitimacy. Qualitative approaches generate legitimacy through the shared ownership and building upon democratic processes that confront knowledge, values, and perceptions of different stakeholder groups and experts in a transparent way. The challenge remains to also use this combinatory method not only at local case level but also for assessment studies at larger scales and at high policy making levels.

Using the concept of landscape as a comprehensive spatial framework for impact assessment and spatial planning, conservation and development targets can be mutually addressed and integrated (Sandker et al. 2010). The landscape concept was implicitly pervasive in all scenario studies as an integrating entity between socioeconomic and biogeophysical features of a spatial system. This was the basis for analyzing the interactions of land uses with the natural capital of the land and respective consequences for land use functions. In the local and regional studies of F&#252rst et al. (2010), Loibl and Walz (2010), Waldhardt et al. (2010), and

Morris et al. (2011), one particular region was the core of the analysis for which land use options had to be assessed. At this scale, the idea of landscape as a cultural entity perceived by people is most evident (Brandt and Veijre 2003). In the European level studies, the idea of landscape was only used for spatial delineation of assessment outcomes. Socio-cultural aspects of landscapes were not considered at this aggregated level.

The concept of multifunctionality was explicitly employed by four papers (F&#252rst et al. 2010, Helming et al. 2011*a*, Morris et al. 2011, Waldhardt et al. 2010). In all cases it was used to involve stakeholders in the detection and analysis of trade-offs between alternative land use scenarios. The impact of land use on the three pillars of sustainable development could thereby be illustrated and valued in an integrated way. Multifunctionality proved to be a useful concept to operationalize sustainable development for the case of land use because it entails the need to derive trade-offs between social, environmental, and economic development targets.

In conclusion, three major aspects are revealed that may be seen as steps forward in improving the use of land use impact assessment in the policy context: the involvement of decision makers and other stakeholders early on in the design of the impact assessment study; the integration of quantitative analysis with normative, participatory valuation methods; and the robust and transparent design of the analytical methods.

This special feature was one of the outcomes of the International Conference on Impact Assessment of Land Use Changes (IALUC) that took place in Berlin, Germany in April 2008. It was organized by the European funded Integrated Project SENSOR (www.sensor-ip.eu) in cooperation with the European funded Integrated Projects SEAMLESS (www.seamless-ip.org), EFORWOOD (www.eforwood.com), and PLUREL (www.plurel.net). The conference intended to consolidate the emerging research community on impact assessment in the area of land use change and multifunctionality.

Responses to this article can be read online at: http://www.ecologyandsociety.org/vol16/iss1/art50/responses/

Acknowledgments:

We would like to thank all the authors as well as all the anonymous reviewers for their thorough and constructive work in contributing to this issue. The research for this article was executed as part of the SENSOR integrated project funded under the EU 6th Framework Programme for Research, Technological Development and Demonstration, Priority 1.1.6.3. Global Change and Ecosystems (European Commission, DG Research, contract 003874 (GOCE)). The authors would like to thank the European Commission for the financial support received and the SENSOR consortium members for their kind collaboration and for the many fruitful discussions and debates that helped shape the thinking behind the paper.

LITERATURE CITED

Binder, C. R., G. Feola, and J. K. Steinberger. 2010. Considering the normative, systemic and procedural dimensions in indicator-based sustainability assessments in agriculture. *Environmental Impact Assessment Review* 30(2):71-81.

Böhringer, C., and A. Löschel. 2006. Computable general equilibrium models for sustainability impact assessment. *Ecological Economics* 60 (1):49-64.

Brandt, J., and H. Veijre. 2003. *Multifunctional landscapes. Vol II. Monitoring, diversity and management.* WIT Press, Southampton, UK.

Claessens, L., J. M. Schoorl, P. H. Verburg, L. Geraedts, and A. Veldkamp. 2009. Modelling interactions and feedback mechanisms between land use change and landscape processes. *Agriculture, Ecosystems & Environment* 129:157-170.

Commission of the European Communities (CEC). 2009. *Impact assessment guidelines.* SEC (2009) 92. Publications Office of the European Union, Luxembourg.

Council of Europe. 2000. *European Landscape Convention.* Council of Europe, Paris, France.

[online] URL: http://www.coe.int/t/dg4/cultureheritage/heritage/landscape/default_en.asp.

De Smedt, P. 2010. The use of impact assessment tools to support sustainable policy objectives in Europe. *Ecology and Society* 15(4): 30. [online] URL: http://www.ecologyandsociety.org/vol15/iss4/art30.

F&#252rst, C., H. König, K. Pietzsch, H. Ende, and F. Makeschin. 2010. Pimp your landscape - a generic approach for integrating regional stakeholder needs into land use planning. *Ecology and Society* 15(3): 34. [online] URL: http://www.ecologyandsociety.org/vol15/iss3/art34/.

Gabrielsen, P., and P. Bosch. 2003. *Environmental indicators: typology and use in reporting.* Internal working paper. European Environmental Agency, Copenhagen, Denmark.

Hák, T., B. Moldan, and A. L. Dahl, editors. 2007. *Sustainability indicators: a scientific assessment*. SCOPE Series Vol. 67, Island Press, Washington, D.C., USA.

Helming, K., H. Bach, O. Dilly, R. F. H&#252ttl, B. König, T. Kuhlmann, M. Pérez-Soba, S. Sieber, P. Smeets, P. Tabbush, K. Tscherning, K. M&#252ller, D. Wascher, and H. Wiggering. 2008. Ex ante impact assessment of land use changes in European regions – the SENSOR approach. Pages 56-77 *in* K. Helming, M. Pérez-Soba, and P. Tabbush, editors. *Sustainability impact assessment of land use changes*. Springer-Verlag. Berlin, Germany.

Helming, K., I. De la Flor, and K. Diehl. 2011*b*. Integrated approaches for ex-ante impact assessment tools - the example of land use. *In* A. von Raggamby and F. Rubik, editors. *Sustainable development, evaluation and policy-making.* Edward Elgar, Cheltenham, UK, *in press.*

Helming, K., K. Diehl, H. Bach, O. Dilly, B. König, T. Kuhlman, M. Pérez-Soba, S. Sieber, P. Tabbush, K. Tscherning, D. Wascher, and H. Wiggering. 2011*a*. Ex ante impact assessment of policies affecting land use, Part A: analytical framework. *Ecology and Society* 16(1): 27. [online] URL: http://www.ecologyandsociety.org/vol16/iss1/art27/.

Helming, K., K. Diehl, T. Kuhlman, T. Jansson, P. H. Verburg, M. Bakker, M. Pérez-Soba, L. Jones, P. J. Verkerk, P. Tabbush, J. B. Morris, Z. Drillet, J. Farrington, P. Le Mouël, P. Zagame, S. Sieber, T. Stuczynski, G. Siebielec, and H. Wiggering. 2011*c*. Ex ante impact assessment of policies affecting land use, Part B: application of the analytical framework. *Ecology and Society* 16(1): 29. [online] URL: http://www.ecologyandsociety.org/vol16/iss1/art29/.

Helming, K., and H. Wiggering, editors. 2003. *Sustainable development of multifunctional landscapes.* Springer-Verlag, Berlin, Germany.

Jacob, K., A. Volkery, and A. Lenschow. 2008. Instruments for environmental policy integration in 30 OECD countries. Chapter 2 *in* A. J. Jordan and A. Lenschow, editors. *Innovation in environmental policy? Integrating the environment for sustainability.* Edward Elgar, Cheltenham, UK.

Leemans, R., G. Asrar, A. Busalacchi, J. Canadell, J. Ingram, A. Larigauderie, H. Mooney, C. Nobre, A. Patwardhan, M. Rice, F. Schmidt, S. Seitzinger, H. Virji, C. Vörösmarty, and O. Young. 2009. Developing a common strategy for integrative global environmental change research and outreach: the Earth System Science Partnership (ESSP). *Current Opinion in Environmental Sustainability* 1 (1):4-13.

Loibl, W., and A. Walz. 2010. Generic regional development strategies from local stakeholders' scenarios – an Alpine village experience. *Ecology and Society* 15(3): 3. [online] URL: http://www.ecologyandsociety.org/vol15/iss3/art3/.

Lotze-Campen, H. 2008. The role of modelling tools in Integrated Sustainability Assessment (ISA). *International Journal of Innovation and Sustainable Development* 3:70-92.

Mander, &#220., H. Wiggering, and K. Helming, editors. 2007. *Multifunctional land use – meeting future demands for landscape goods and services*. Editorial. Springer, Berlin, Germany.

Metzger, M. J., M. D. A. Rounsevell, H. Van den Heiligenberg, M. Pérez-Soba, and P. Soto Hardiman. 2010. How personal judgment influences scenario development: an example for future rural development in Europe. *Ecology and Society* 15(2): 5. [online] URL: http://www.ecologyandsociety.org/vol15/iss2/art5/.

Millennium Ecosystem Assessment (MA). 2003. *Ecosystems and human well-being: a framework for assessment.* Island Press, Washington, D.C., USA.

Morris, J. B., V. Tassone, R. de Groot, M. Camilleri, and S. Moncada. 2011. A Framework for Participatory Impact Assessment (FoPIA): involving stakeholders in European policy making, a case study of land use change in Malta. *Ecology and Society* 16(1): 12. [online] URL: http://www.ecologyandsociety.org/vol16/iss1/art12/.

Nilsson, M., A. Jordan, J. Turnpenny, J. Hertin, B. Nykvist, and D. Russel. 2008. The use and non-use of policy appraisal tools on public policy making: an analysis of three European countries and the European Union. *Policy Sciences* 41(4):335-355.

Organisation for Economic Co-operation and Development (OECD). 2003. *OECD environmental indicators: development, measurement and use.* Organisation for Economic Co-operation and Development, Paris, France. [online] URL: http://www.oecd.org/dataoecd/7/47/24993546.pdf.

Paracchini, M. L., C. Pacini, M. L. M. Jones, and M. Pérez-Soba. 2009. An aggregation framework to link indicators associated with multifunctional land use to the stakeholder evaluation of policy options. *Ecological Indicators* 11(1):71-80.

Pérez-Soba, M., S. Petit, L. Jones, N. Bertrand, V. Briquel, L. Omodei-Zorini, C. Contini, K. Helming, J. Farrington, M. Tinacci Mossello, D. Wascher, F. Kienast, and R. de Groot. 2008. Land use functions – a multifunctionality approach to assess the impact of land use change on land use sustainability. Pages 375-404 *in* K. Helming, M. Pérez-Soba, and P. Tabbush, editors. *Sustainability impact assessment of land use changes.* Springer-Verlag, Berlin, Germany.

Plummer, M. L. 2009. Assessing benefit transfer for the valuation of ecosystem services. *Frontiers in Ecology and Environment* 7(1):38-45.

Prins, A. G., B. Eickhout, M. Banse, H. Meijl, W. Rienks, and G. Woltjer. 2011. Global impacts of European agricultural and biofuel policies. *Ecology and Society* 16(1): 49. [online] URL: http://www.ecologyandsociety.org/vol16/iss1/art49/.

Sandker, M., B. M. Campbell, M. Ruiz-Pérez, J. A. Sayer, R. Cowling, H. Kassa, and A. T. Knight. 2010. The role of participatory modeling in landscape approaches to reconcile conservation and development. *Ecology and Society* 15(2): 13. [online] URL: http://www.ecologyandsociety.org/vol15/iss2/art13/.

Schaldach, R., and J. A. Priess. 2008. Integrated models of the land system: a review of modelling approaches on the regional to global scale. *Living Reviews in Landscape Research* 2. [online] URL: http://www.livingreviews.org/lrlr-2008-1.

Thiel, A. 2009. The use of ex-ante modelling tools in European impact assessment: what role does land use play? *Journal of Land Use Policy* 26 (4):1138-1148.

Van Herwijnen, M. 2008. The sustainability A-Test. Chapter 3 *in OECD sustainable development studies: conducting sustainability assessments.* Organisation for Economic Co-operation and Development, Paris, France. ISBN Number: 978-92-64-04725-9

Waldhardt, R., M. Bach, R. Borresch, L. Breuer, T. Diekötter, H. Frede, S. Gäth, O. Ginzler, T. Gottschalk, S. Julich, M. Krumpholz, F. Kuhlmann, A. Otte, B. Reger, W. Reiher, K. Schmitz, P. Schmitz, P. Sheridan, D. Simmering, C. Weist, V. Wolters, and D. Zörner. 2010. Evaluating today's landscape multifunctionality and providing an alternative future: a normative scenario approach. *Ecology and Society* 15(3): 30. [online] URL: http://www.ecologyandsociety.org/vol15/iss3/art30/.

Wiggering, H., C. Dalchow, M. Glemnitz, K. Helming, K. M&#252ller, A. Schulz, U. Stachow, and P. Zander. 2006. Indicators for multifunctional land use – linking socio-economic requirements with landscape potentials. *Ecological Indicators* 6: 238-249.

World Commission on Environment and Development (WCED). 1987. *Our common future.* Oxford University Press, New York, New York, USA.