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The contribution of modelling and stakeholder engagement to transdisciplinary landscape research: an exploration of the Landscapes Toolkit

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Abstract: The Landscapes Toolkit, a spatially-explicit integrated modelling framework, was developed in collaboration with stakeholders in the Tully basin, Australia. The aim of the Toolkit is to assist local communities and government as well as natural resource management (NRM) organisations in assessing options for sustainable landscape development. The Landscapes Toolkit analyses and compares the outcome of stakeholder-defined land use and management change scenarios on water quality, biodiversity and economic performance by linking the respective disciplinary models. Experiences from applying the Landscapes Toolkit in the Tully basin, a catchment flowing into the Great Barrier Reef lagoon, suggest that the modelling framework strikes a satisfactory balance between capturing the richness of social-ecological system processes, disciplinary science and the capacity of stakeholders to understand and compare scenario results. Therefore the Landscapes Toolkit offers a promising framework to support local communities, government and NRM organisations in making more informed decisions about sustainable landscape development. In this paper, I explore the potential contribution of the Landscapes Toolkit to the emerging field of transdisciplinary landscape research.

Keywords: collaborative research; decision-support-tool; sustainability learning; sustainable landscape development; problem-oriented research

1. INTRODUCTION

The interest in transdisciplinary research and practice, which refers to overcoming the split between the sciences and humanities, has increased remarkably in the past decade [e.g. Tress et al. 2003; Hirsch Hadorn et al. 2008]. Within the field of landscape planning and management, transdisciplinary researchers aim to bridge the natural sciences, social sciences and humanities, in an effort to find innovative solutions to complex landscape-related issues. In addition, transdisciplinary researchers engage a wide range of stakeholders, including scientists with different disciplinary backgrounds and non-scientists, and capitalise on the experiences of all participants [Tress et al. 2003].

According to Mittelstraß [1992; 1995], a German philosopher, transdisciplinarity is a type of research which is based on real-world problems and aims to identify and solve such problems without relying on any specific discipline. Kinzig [2001] argues that transdisciplinary research fills the gaps existing between disciplines when the problem to be solved transcends the boundaries of scientific disciplines. Hoechtl et al. [2006] add that the problem to be solved not only transgresses the boundaries of scientific disciplines but also science as a whole. This conceptualisation is similar to Funtowicz and Ravetz's [1993] notion of post-normal science. In the post-normal sciences stakeholder participation is relevant, particularly when facts are uncertain, values are in dispute, stakes are high and decisions are urgent [Funtowicz and Ravetz 1994].

In this context, where stakeholders play a crucial role, Funtowicz et al. [1998] suggest that the main science objective may be to enhance the process of the social resolution of the problem. Mutual learning among stakeholders to address the problem through adaptive management might be the outcome, rather than a definitive 'solution' or technological implementation. This is a significant change in the relation between problem identification and the prospects of science-based solutions.

Consequently, in transdisciplinary research new insights and explanatory theories are generated through collaboration between stakeholders as well as through cross-fertilisation of ideas, knowledge and experience from participating stakeholders [Tress et al. 2003; Lawrence 2004]. Thereby, transdisciplinary research enhances systems understanding, achieves more appropriate, and potentially more innovative, solutions and a synergy of new methods.

In this article, primarily addressed to scientists, planners and policy makers involved in the development of sustainable land use and management strategies at the landscape/regional scale, I explore the potential contribution of the Landscapes Toolkit, a spatially-explicit integrated modelling framework, to transdisciplinary landscape research. The intention is not to present the Landscapes Toolkit in detail; that was the aim of a different paper [Bohnet et al in review], but to explore how and why the application of the Landscapes Toolkit may contribute to transdisciplinary landscape research.

2. THE LANDSCAPES TOOLKIT

The Landscapes Toolkit, a spatially-explicit integrated modelling framework, was developed in collaboration with stakeholders in the Tully basin, Australia. The aim of the Toolkit is to assist the regional NRM organisation, council and the local community in exploring options for sustainable landscape development [Bohnet et al in review]. The rationale for developing this decision-support-tool was driven by the need to improve water quality in the basins draining into the Great Barrier Reef (GBR) lagoon [Anon. 2003]. However, while water quality is of major concern in the region to protect the environmental and economic values of the GRB, NRM organisations, councils and local communities are also interested in enhancing biodiversity and maintaining agricultural industries and farmers' incomes in the region. Aiming to achieve multiple landscape goals, the Landscapes Toolkit integrates a common database and disciplinary component models that allow for the comparative-static assessment of stakeholder-defined scenarios (Figure 1). A key difference between the Landscapes Toolkit and multi-criteria analysis tools is that the Landscapes Toolkit is driven by stakeholder-defined spatially-explicit land use and management change scenarios based on their knowledge, assumptions and values (Figure 2). Whereas multi-criteria analysis models are driven by stakeholder rankings of many criteria based on their importance.

In contrast to *projective* and *predictive* approaches, which forecast likely land use and management change scenarios based on past trends and/or aggregate agent behaviour, the *explorative* approach taken in the Landscapes Toolkit allows future scenarios to be developed by stakeholders. The linked disciplinary models allow for analysis of the impacts of changes in land use and management on water quality, biodiversity and economic performance of the landscape as a whole [Bohnet et al. in review]. Stakeholders are central to the Landscapes Toolkit, which has been developed as a participatory planning tool aimed at supporting stakeholders: i) in discussing trade-offs between different future scenarios and ii) in making more informed decisions about sustainable landscape development.
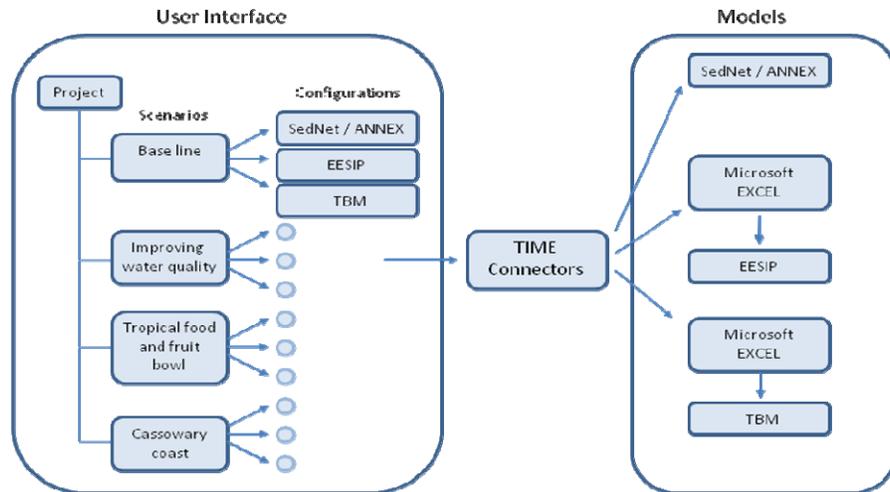
Figure 1. Schematic representation of the Landscapes Toolkit depicting the separation between the user interface and the external models. The Baseline scenario and associated datasets and functionalities form the central part of the Landscapes Toolkit, which support participatory development of future scenarios (e. g. Improving water quality/Tropical food and fruit bowl/Cassowary coast). The water quality (SedNet/ANNEX), economic (EESIP) and biodiversity (TBM) models are the component models linked in the Landscapes Toolkit. TIME based connectors [Rahman et al. 2004] have been created for each component model to act as the glue between the user specified scenario configurations and the models [Source: Bohnet et al. in review].
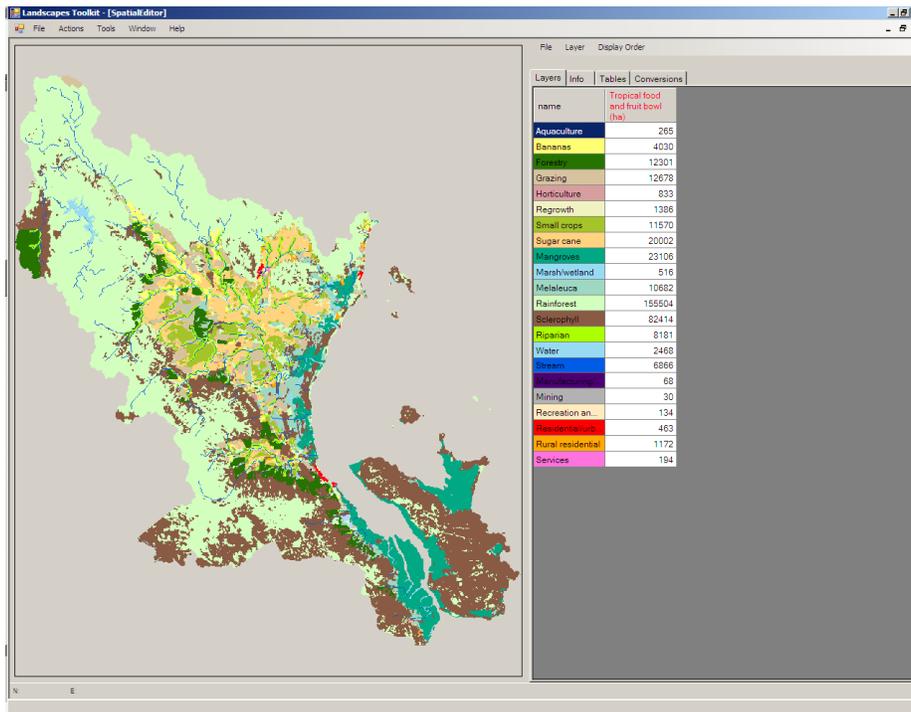

Figure 2. Screenshot from the Landscapes Toolkit software showing the 'Tropical food and fruit bowl' scenario developed by stakeholders based on their knowledge, assumptions and values on the left. On the right a colour-coded legend and areas (in ha) per land use/cover is provided.

3. CHARACTERISTICS OF TRANSDISCIPLINARY LANDSCAPE RESEARCH

The perception of one or more extra-scientific problems, i.e. problems that are a production of everyday life, marks the start of a transdisciplinary project [Jaeger and Scheringer 1998]. In landscape research the increasing pressures and competing demands placed on landscapes call for a transdisciplinary approach to solve landscape-related issues [Tress et al. 2003].

The transdisciplinary problem solving strategy (Figure 3), put forward by Jaeger and Scheringer [1998] is divided into four steps: (1) problem comprehension, (2) problem analysis, (3) treatment of subareas, and (4) integration of subareas in order to achieve overlapping results. Here I use this problem solving strategy to explore how and why the Landscapes Toolkit may contribute to transdisciplinary landscape research.
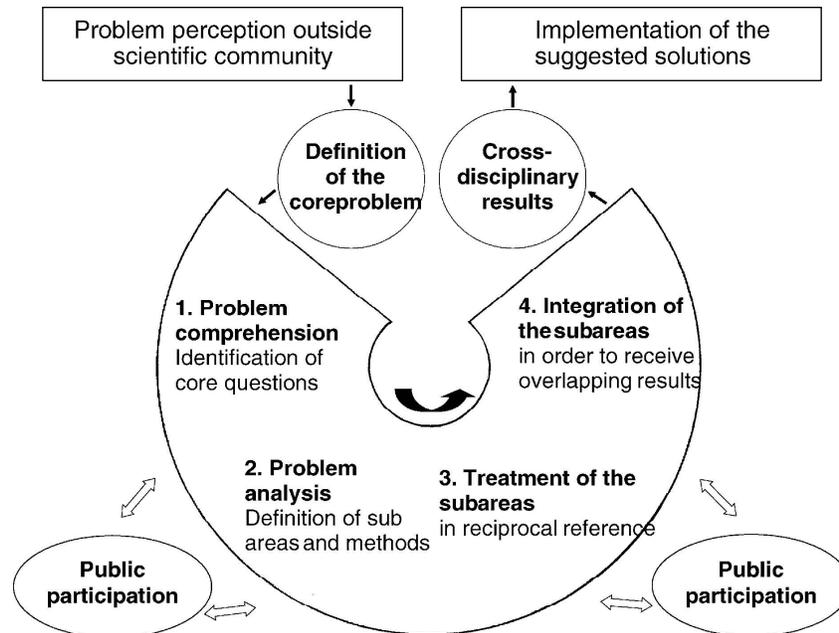

Figure 3. The problem solving strategy in transdisciplinary projects (Source: Based on Jaeger and Scheringer [1998] in Hoechtl et al. [2006])

3.1 Problem comprehension

The Landscapes Toolkit was developed to support stakeholders in exploring options for sustainable landscape development [Roebeling et al. 2005; Bohnet et al. in review]. Stakeholders can define spatially-explicit land use and management change scenarios for the landscape under study that are plausible to them and can assess the likely impacts of the scenarios. Examples of the questions that stakeholders might pose that the Landscapes Toolkit can address include:

1. What are the likely water quality, biodiversity and socio-economic impacts of a particular land use and management change scenario?
2. To what degree do these impacts differ to the current situation (i.e. land use and management practice)?
3. What are the trade-offs between different scenarios and the current situation (i.e. land use and management practice)?
4. Based on the priorities for the future development of the particular landscape under study, e.g. water quality improvement, which scenario seems most promising in achieving the desired outcome?

Questions which this current version of the Landscapes Toolkit can not address include questions related to optimising the landscape for a particular outcome such as:

1. What are the most cost-effective land use and management practice change arrangements that will improve water quality (for details to answer these kinds of questions see Roebeling et al. [2009])?
2. What are the most cost-effective land use and management practice change arrangements that will enhance overall biodiversity?

Since landscape problems are generally complex and involve trade-offs between different values, the Toolkit was developed as an *explorative* tool rather than an *optimisation* tool. However, optimisation models may be added in the Landscapes Toolkit to explore those land use and management change configurations that are tailored to achieve a particular landscape outcome (e.g. water quality improvement).

3.2 Problem analysis

Due to the complex interactions occurring in landscapes, the Landscapes Toolkit was developed for triple-bottom-line assessment of land use and management change scenarios. The Landscapes Toolkit links three disciplinary models: (1) the catchment model SedNet/ANNEX (Sediment River network model/Annual network Nutrient Export) [Prosser et al. 2001; DeRose et al. 2002] to assess the water quality impacts from land use and management change scenarios, (2) the Environmental and Economic Spatial Investment Prioritisation (EESIP) model [Roebeling et al. 2009; Bohnet et al. in review] to assess the regional economic implications of land use and management change scenarios, and (3) the Terrestrial Biodiversity Model (TBM) to assess the biodiversity implications of land use and management change scenarios [Bohnet et al. in review]. The three models are run as separate stand-alone models in the Landscapes Toolkit enabling discrete analysis of water quality, economic performance and biodiversity impacts.

The land use change routines (GIS-allocation rules) built into the Landscapes Toolkit as well as the management change options which are part of the component models allow stakeholders to develop land use and management change scenarios that are plausible to them. Providing a spatially-explicit context also allows stakeholders to use their local knowledge. The scientific results (including their uncertainties) from the stakeholder developed scenarios are readily available for a range of water quality, regional economics and biodiversity indicators. These scientific results provide the starting point for stakeholders to discuss trade-offs between different landscape configurations, policy requirements and values attached to different parts of the landscapes.

3.3 Treatment of subareas

In the Landscapes Toolkit the subareas were defined around core functions and interests of rural (non-urban) landscapes: water, biodiversity, agricultural income and human choice. Models which allow the assessment of water quality, regional income from agricultural production, and biodiversity were integrated in the Landscapes Toolkit to produce results for a wide range of indicators. Indicators for water quality, for example, include sediment, phosphorus and nitrogen. Human choice is incorporated in the Landscapes Toolkit through the ability for stakeholders to develop their own scenarios. Stakeholders have the opportunity to develop and assess a wide range of scenarios using a wide range of indicators or only one scenario for one indicator depending on the particular question, interests and values. This kind of modelling approach is very different from science-driven models which produce predictions or projections for the future, as the Landscapes Toolkit does not provide 'the optimal' solution to a particular question [Bohnet et al. in review].

3.4 Integration of subareas

The summary of the subarea results finally provides answers to the main questions related to the potential impacts of future land use and management change (section 3.1). Since in most landscapes, the answer regarding sustainable landscape development is not clear-cut and depends on the priorities set by policy-makers and the values of the people living in the landscape under study, the Landscapes Toolkit supports stakeholders in making more informed decisions about future developments. Through the operationalisation of scenario development (Figure 2) and evaluation (Figure 4) with stakeholder participation, using disciplinary simulation models for quantitative assessment and comparative analysis, the Landscapes Toolkit expands the use of computer models beyond the usual reach of traditional science-driven integrated models [Bohnet et al. in review].

Figure 4. Example of output from the Landscapes Toolkit showing comparative analysis between four scenarios (x-axis) displayed for, in total, four indicators (listed below x-axis) using multiple scales. Note that regional economic income from agriculture is highest in the 'Tropical food and fruit bowl' scenario, whereas water quality and biodiversity is improved most in the 'Cassowary coast' scenario.

3.5 How and why the Landscapes Toolkit may contribute to transdisciplinary landscape research

Experiences from developing and applying the Landscapes Toolkit in the GBR region [Roebeling et al. 2005; Bohnet et al. in review], suggest that the modelling framework strikes a satisfactory balance between capturing the richness of social-ecological system processes, disciplinary science and the capacity of stakeholders to understand and compare scenario results. Regular stakeholder meetings provided the opportunity for scientists to present their component models linked in the Landscapes Toolkit, how they work and what information they provide. End-users, such as community groups, NRM organisations and local government, had the opportunity to ask questions about the models including certainty of results and to make suggestions and raise concerns. These meetings guided the

development of the Landscapes Toolkit and ensured that the Landscapes Toolkit would be meeting the expectations of potential end-users and researchers.

Based on a holistic landscape concept [e.g. Naveh 2001; Tress and Tress 2001; Swanwick and Land Use Consultants 2002] and the idea that transdisciplinary landscape research is a future orientated, pro-active science that takes on the challenge of looking beyond the boundaries of one's own discipline and familiar ways of thinking [Hoechtl et al. 2006], the Landscapes Toolkit, through its spatially explicit nature, offers a framework for pro-actively exploring stakeholder defined future land use and management change scenarios and assessing their impacts on a range of indicators related to water, biodiversity and economics. Through its design as an explorative tool and the in-built land use and management change functionalities, the Landscapes Toolkit offers great potential to advance the theory and practise of transdisciplinary landscape research.

Stakeholder acceptance of the tool and participation in research projects that use the Landscapes Toolkit with the aim to address and solve real-world problems is critical and a prerequisite to its success. Therefore the contribution of the Landscapes Toolkit to transdisciplinary landscape research will largely depend on how the participatory or action research approach is structured, which stakeholders are invited to participate in the process and how the suggested solutions are linked to other planning processes or policies [e.g. Kirchner-Heßler et al. 2007]. As with any participatory or action research project, managing stakeholder expectations will also be critical for any project that employs the Landscapes Toolkit.

4. CONCLUSIONS

The Landscapes Toolkit offers a promising integrated modelling framework to support local communities and government as well as regional NRM organisations in making more informed decisions regarding broad questions related to future landscape development or more specific questions related to water quality, biodiversity and regional economics related to farming. The experience from developing and applying the Landscapes Toolkit to date underlines the need for strategies directed to local and regional needs. To develop landscape related policies (e.g. for water or protected areas) and actions the concerns of local communities need more attention because the challenges related to real-world problems cannot be resolved by desk studies alone [Hoechtl et al. 2006]. To test the usefulness of the Landscapes Toolkit as a participatory planning and learning tool and the potential contributions it can make to transdisciplinary landscape research will require further applications in different landscape contexts and to different research questions which will in turn necessitate a variety of stakeholder configurations and participatory processes.

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