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Sustainable settlement growth by model-based decision support: Comparison of two MCA-tools for urban regions

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Abstract: Multi-criteria decision support systems (MCA-DSS) have been gaining enormous importance for land use planning and policy making. The number of MCA-DSS is large and their purposes, actors to be involved and spatial context for application are highly diverse. In Germany, the national research programme "REFINA" (Research for the Reduction of Land Consumption and for Sustainable Land Management) funded by the German Ministry of Education and Research (BMBF) produced a number of different DSS for different actors and purposes. But also at the cross-national level, large research initiatives such as European Union's Sixth Framework programme for research, priority »Global change and ecosystems« supported the development of land use related DSS. In our paper, we present two MCA-DSS from both research initiatives and compare them in terms of i) spatial setting and stage of planning, ii) actors, iii) indicators, iv) type of programming, v) type of modelling and vi) effectiveness. Additionally, we introduce a quality check of both tools against the five "guidelines for involving users in development" formulated by McIntosh et al. [2009:41ff.] in order to assess their "usefulness and usability" [McIntosh et al. 2009: 34] within spatial planning. The first tool was developed at the University of Bonn within the project FIN.30 ("Intelligent land use", 2006-2009) focussing on reduced land consumption within settlement development of cities. This multi-criteria assessment tool evaluates greenfield and infill sites concerning their sustainability and resource efficiency. The MCA development (multi-criteria assessment) and its incorporation into a Decision Support System (DSS) were accomplished by utilising a stakeholder-driven approach. The resulting tool can be applied in preparing and revising land-use plans. The second tool, the integrated Impact Analysis Tool (iIAT), was developed within the project PLUREL [2007-2010; www.plurel.net]. The iIAT is an internet-accessible land use impact assessment tool that displays statistical and modelling results in form of spidergrams. They allow for a visualisation of changes in sustainability indicators, as positive or negative trends according to different scenarios. The iIAT so far represents a novel interface between science and policy-making contributing to further knowledge on impacts of future urbanisation in Europe.

***Keywords**:* model-based decision support; multi-criteria assessment; sustainable settlement growth; urban regions

1 INTRODUCTION

Following Voinov & Bousquet [2010: 1268], "stakeholder engagement, collaboration, participation, shared learning and fact-finding have become buzz words in many management-oriented areas of science". But it's not only science where

those fields need to be addressed. Moreover many areas and decision-processes in current urban and environmental planning are bound to these demands. Parker et al. [2002: 210] state that "the need for integrated assessment and modeling (IAM) has heightened as the extent and severity of environmental problems in the 21st century worsens".
But how do these demands can be brought together? How can scientists consider the challenges of sustainable settlement growth, multidimensional planning decisions and increasingly complex actor- and stakeholder involvement in urban planning in such a way that respective MCA-DSS tools are well understood and effectively applied?
The two MCA-DSS presented in this paper are diverging in terms of their technical features, in spatial setting, applied indicators, type of modelling and tool. Thematically, they both refer to sustainable settlement development. Tool FIN.30 is a visual-basic based MCA-DSS tailored towards the demands of multicriteria assessment of housing potentials of land use plans [Kötter et al. 2010, Schetke et al. 2012]. The iIAT-tool is an internet-based platform providing multicriteria analysis covering both the EU-27 and the regional level [Haase et al. 2010, www.plurel.net]. Both tools aim at an integrated assessment of land use change in urban areas. Both tools are characterized by stakeholder involvement during the development process.
Applying a quality-check against the "good practice guidelines for involving users in development" by McIntosh et al. [2009: 41ff. and further developed in 2011] in the second part of the paper, we will leave the arena of tool properties and modelling approaches and instead focus on how and to what extend both groups of scientific developers were able to successfully involve users into the development of both tools. We assume that not the questions matter of how a MCA-DSS was realized technically and on which underlying models it refers to. Of prime importance instead is a successfully "bridging the gap between science and planning practice" [Schetke et al. 2012: 208] and whether the MCA-DSS users understand and apply the tool within their daily planning practise. In our case, this planning practice deals with the rural- urban interface of European regions for the iIAT and the evaluation of land use plans at municipal level in FIN.30.

2 METHODOLOGY

2.1 MCA-DSS FIN.30

The MCA-DSS FIN.30 was developed within the research-project FIN.30 by the Department of Urban Planning and Real Estate Management of the Institute of Geodesy and Geoinformation at the University of Bonn in collaboration with three partner cities of North Rhine-Westphalia, Germany. The project (runtime 2006-2009), funded by the German Ministry of Education and Research (BMBF), was part of the research program REFINA. Target of the program was "the development and testing of innovative concepts for the reduction of land consumption. These concepts should help to achieve a multitude of goals such as the protection of the environment and conservation of nature, economic growth, socially compatible housing, quality of urban building and mobility" (http://www.refina-info.de/en/). The development of the MCA-DSS was one of two targets within the project FIN.30 and aimed at the "assessment and selection of new housing sites according to the principles of sustainability including economic efficiency" [translated acc. to Kötter et al. 2010: 6]. The modules of the MCA-DSS therefore cover an ecological, social and economic dimension of sustainability which can be independently applied. Table 1 provides insight into the technical and model-related features of both MCA-DSS.

2.2 The PLUREL-iIAT

The PLUREL iIAT is an internet-accessible land use impact assessment tool that displays statistical and modelling results in form of spidergrams. They allow for a visualisation of changes in sustainability indicators, as positive or negative trends according to different scenarios are immediately. The iIAT so far represents a novel interface between science and policy-making contributing to further knowledge on environmental, economic and social impacts of future urbanisation in Europe. It was developed within the EU-Integrated Project PLUREL (2007-2010; www.plurel.net). The iIAT has been developed to make comprehensive and complex scientific modelling accessible and understandable for a broad range of end-users, such as European policy-makers, regional and urban planners. The main purpose was to create awareness about sustainability development trajectories at different scales and for different types of regions.
So doing, the iIAT shows how the impacts of urbanisation under future scenario conditions will differ from the current situation. They represent no forecasts, but rather cover a broad range of possible and alternative futures as a method to structure thinking about future uncertainty. The iIAT provides various parameter selection opportunities regarding the spatial scope of analysis. The most basic one distinguishes between the selections of one or more NUTSX (combination of NUTS3 and Corine Land Cover classes) regions. If only one region is selected, indicator values for this specific region are taken into consideration. This is particularly useful to track sustainability impacts for this specific region under different scenario settings for instance. Otherwise, one or the combination of two regional typologies can applied to specify the grouping requirement for a number of regions, e.g. of the same country, spatial planning typology or innovation potential, just to name some. Also the selection of the entire EU27 is possible [Haase et al. 2010, Piorr et al. 2010].

Table 1 Properties of the two MCA-DSS FIN.30 and PLUREL iIAT.

	FIN.30	PLUREL iIAT
I. Spatial setting and stage of planning	Municipal level, preparation and revision of land use plans, ranking of future housing sites [Kötter et al. 2010, Schetke et al. 2012]	EU-27 NUTSX level and regional level [urban regions; Haase et al., 2010; Piorr et al. 2010]
II. Actors	Urban planners, members of the municipal administrative body	EU-level, national, regional and urban planners, policy analysts, experts and scientists
III. Indicators	ecological, social and economic	ecological, social and economic
IV. Type of programming	Visual basic	JAVA® platform (version 1.6) which integrates several open-source software libraries to extend the functionality (GeoTools, Browser-Launcher2, iText and JFreeChart); PostgreSQL server version 8.4
V. Type of modelling and tool	Rule-based modelling [acc. to Klostermann & Pettit 2005], aggregation and standardisation of data Multi criteria analysis	Statistical and rule-based modelling, aggregation and standardisation of data Multi criteria analysis
VI. Process	Participatory Decision Analysis [acc. to Voinov & Busquet 2010]	Participatory Decision Analysis [acc. to Voinov & Busquet 2010]
VII. Effectiveness	Application realized within a Visual Basic- environment and based on official land use data reduces additional data-processing and training of new software.	The tool is easily accessible via internet. No installation is needed but JAVA runtime environment at the computer. Worldwide accessible. Highly effective to be used by inter-disciplinary group discussions with (W)LAN access (project meetings)

3 PROPERTIES OF FIN.30 AND IIAT

In this discussion section, we will introduce a quality check of both tools against the five “guidelines for involving users in development” according to McIntosh et al. [2009: 41ff.]. Aim of this section is to prove to what degree both tools follow the best practise guidelines which were collected by McIntosh et al. [2009] and to assess the tools´ “usefulness and usability” [McIntosh et al. 2009: 34]. The section gives advice on the effectiveness of the models in terms of valuable contribution to urban planning. Table 2 provides a qualitative overview of the degree to which the guidelines could be success-fully fulfilled using the following categories: ++ fulfilled, + partially fulfilled, 0 undecided, — not fulfilled.

Guideline 1: Know the capabilities and limitations

The project team of FIN.30 consciously chose a visual basic interface to “concentrate on the implementation of knowledge-based content rather than” [Matthews et al. 2006: 21] introducing a totally new MCA-DSS within the planning institutions of the partner cities. The programming of the MCA-DSS FIN.30 was welcomed by the communal partners [Kötter et al. 2010] and “could fulfil the planners' demand for an easy-to-understand and easy-to-apply programme” [Schetke et al. 2012: 208]. In terms of the iIAT, another solution was preferred: The tool’s worldwide accessibility was the criterion to be optimised. Therefore, it bases on JAVA runtime environment and a connection to the internet. This way, the tool is highly effective to be used very flexibly in group discussions at policy or project meetings at any time [Haase et al. 2010].

Guideline 2: Focus on process not product

“The indicator set was consensually elaborated and tested during stakeholder workshops with urban planners […]. Its complexity, structure and comprehensibility are adjusted to the demands of communal planners” [Schetke 2010: 13]. During the FIN.30 project three workshops per year “were held with local stakeholders from the Department of Urban Renewal and Land Management [...] and the Department of Urban Planning and Building Regulations [...]“ [Schetke et al. 2012: 199]. Additional workshops with experts from different scientific disciplines guaranteed the profound scientific elaboration of the underlying indicator set of the MCA-DSS [Kötter et al. 2010, Schetke 2010, Schetke et al. 2012]. The iIAT was developed in a stakeholder process during the 4-year EU-project PLUREL. Including thematic sharpening, problem analysis and indicator development, more than 20 meetings and workshops helped to shape the tool [www.plurel.net].

Guideline 3: Understand roles, responsibilities and requirements

In the final project year of FIN.30, different types of test applications were run together with communal end-users. Firstly, an introduction into the MCA-DSS was given to end-users within on-the-fly-workshops. Here, end-users could test the MCA-DSS in a guided environment with scientists as direct consultants. And second, the test-applications where executed at the communal offices with the respective responsible technical employee in collaboration with the scientific developers. Target of these workshops were the fine tuning of the final indicator-set and the derivation of expert-weights [Kötter et al. 2010]. The collaborative character of the MCA-DSS-development FIN.30 could bring together science and practice to a large extend but could not abandon all restrictions. Following Schetke et al. [2012: 207] “these restrictions result from administrative and personal constraints, as well as the prevailing mode of interaction between science and planning practice in the field of land-use planning.”
For the PLUREL iIAT, a final testing of the tool by both experts and stakeholders was placed at the final project conference in 2010 and at national workshops in the

6 European case studies. Due to time and organisational limitations it has to be doubted whether all roles, responsibilities and requirements related to the tool (development process) are fully understood. The developers present and introduce the tool at current – in the post project phase – to projects, teams, etc. to improve what is required in guideline 3.

Guideline 4: Work collaboratively

The collaborative character of the MCA-DSS-development of both tools FIN.30 and PLUREL iIAT was concisely described in the above-standing paragraphs. Additional moderators to manage workshop situations [as described in McIntosh et al. 2009] where not applied in FIN.30 but in PLUREL (in the national stakeholder workshops). The frequency of the workshops in addition to frequent face-to-face meetings also with selected stakeholders was sufficient for a successful collaboration between science and practice.

Guideline 5: Build and maintain trust and credibility

Extending FIN.30 findings from guideline 4 a "close connection between municipal staff and university researchers" [McIntosh et al. 2009: 43 referring to Monticino et al. 2006] could be achieved. This credibility is underpinned by ongoing collaborations between selected project partners beyond the project FIN.30. Beside that a slight retarded external perception of the MCA-DSS in the planning-community can be stated as still other municipalities next to the project partners are asking for information on the tool for possible applications. For the PLUREL iIAT the phase of making it public is still ongoing. The use of EU-wide public available data clearly contributes to trust building and user routine. The limited number of scenarios provided by the tool and the limited access to the underlying database – which is actually stored in an open-source database format but not at a public server – make credibility more difficult.

Table 2 Quality check of the two MCA-DSS FIN.30 and PLUREL iIAT

Quality check-guidelines [according to MCINTOSH ET AL. 2009: 41ff.]	FIN.30	PLUREL iIAT
Know the capabilities and limitations of DIST technologies	+	+
Focus on process not on product	++	++
Understand roles, responsibilities, requirements	0	0
Work collaboratively	++	+
Build and maintain trust and credibility	++	0

++ fulfilled, + partially fulfilled, 0 undecided, — not fulfilled

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