International Congress on Environmental Modelling and Software

3rd International Congress on Environmental Modelling and Software - Burlington, Vermont, USA - July 2006

Jul 1st, 12:00 AM

Combining participatory approaches and modelling: lessons from two practical cases of policy support

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Combining participatory approaches and modelling: lessons from two practical cases of policy support

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Abstract: In this paper two different policy exercises carried out with the METRONAMICA land use modelling framework are discussed. The first aims at finding suitable locations for the expansion of residential and business activities in Utrecht Province, the Netherlands. It takes into consideration future economic and demographic developments as well as all other land use claims in the province. The second was carried out as part of the EEA-PRELUDE project and aimed at exploring the impacts of different scenarios on land use developments and the state of the environment in Europe. Both exercises are similar in combining a participatory approach with modelling in interactive stakeholder sessions. Both aim at integrating the opinions, visions and data from different actors and sectors to present an integrated view of the future. However, they differ in the type of scenarios dealt with. The first is very much an exercise in practical planning exploring the impacts of possible zoning regulations under conditions of varying socio-economic growth. The second allows for the creation of very different scenarios by a diverse group of stakeholders featuring more extreme events. For both exercises the model represents the current processes causing land use change and combines them with future trends captured in the scenarios with a view to present potential future developments in the use of land as well as the social, economic, and ecological qualities of the spatial system. The paper concludes with lessons learned relative to the use of METRONAMICA in support of policy-making: the appropriateness of the framework for combining participatory approaches and modelling, the difficulties encountered and benefits experienced in combining both, and, recommendations for future work.

Keywords: Policy support; Spatial modelling; Cellular Automata; Story And Simulation; Participatory approaches.

1. THE METRONAMICA FRAMEWORK FOR INTEGRATED LAND USE MODELLING

A number of powerful land use models has become available in recent years (Clarke *et al.*, 1997, Verburg *et al*., 2002). Some of these are claimed to be usefully applicable to support policy-making. However, most are developed in a research context and have thus far not been used beyond it. In recent applications and publications it has been shown that METRONAMICA land use models are among the most versatile currently available (Pontius *et al.*, in press) used for practical policy making (Engelen *et al.*, 2005).

METRONAMICA is a modelling framework supporting the development and application of spatially-dynamic land use models enabling the exploration of spatial developments in cities, regions or countries caused by autonomous developments, external factors, and policy measures using structured 'what-if analysis' (RIKS, 2005). The consequences of trends, shocks and policy interventions are visualised by means of dynamic 'year-by-year' land use maps as well as spatially explicit economic, ecologic and socio-psychological indicators represented at high spatial resolution. It thus stimulates and facilitates awareness building, learning, and discussion prior to decision-making.

METRONAMICA features a layered model structure representing processes operating at three embedded geographical levels: the *global* (**1** administrative or physical entity), the *regional* (***n*** administrative or physical entities within the *global* level) and the *local* (***N*** cellular units within each *regional* entity) (see Figure 1).

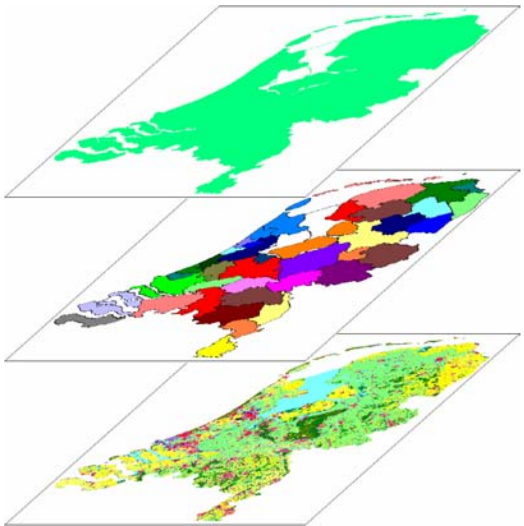

Figure 1: The Dutch application of the METRONAMICA modelling framework, the Environment Explorer, working at 3 spatial levels.

At the *global* level growth figures for the overall population, the activity per economic sector, and the expansion of particular natural land uses are entered in the model as global trend lines.

At the *regional* level a dynamic spatial interaction based model (see for example: White, 1977, 1978) caters for the fact that the national growth will not evenly spread over the modelled area, rather that regional inequalities will influence the location and relocation of new residents and new economic activity and thus drive regional development. The regional model allocates national growth as well as the interregional migration of activities and residents based on the relative attractiveness of each region.

Subsequently, at the *local* level, the regional demands are allocated on the land use map by means of a cellular automata based land use model evolving on a grid varying between ¼ha and $4km^2$ (Couclelis, 1985; White and Engelen, 1993, 1997; Engelen et al., 1995). Changes in land use at the *local* level are driven by four important factors:

1. The physical *suitability*, represented by one map per land use function modelled. The term suitability is used here to describe the degree to which a cell is fit to support a particular land use function and the associated economic or residential activity for a particular activity.
2. The *zoning* or institutional suitability, represented by one map per land use function modelled. For different planning periods the map specifies which cells can and cannot be taken in by the particular land use.
3. The *accessibility*, represented by one map per land use function modelled. Accessibility is an expression of the ease with which an activity can fulfil its needs for transportation and mobility in a particular cell based on the transportation system
4. *Dynamic impact of land uses in the area immediately surrounding a location*. For each land use function, a set of spatial interaction rules determines the degree to which it is attracted to, or repelled by, the other functions present in its surroundings; a 196 cell neighbourhood. If the attractiveness is high enough, the function will try to occupy the location, if not, it will look for more attractive places. New activities and land uses invading a neighbourhood over time will thus change its attractiveness for activities already present and others searching for space. This process constitutes the highly non-linear character of this model.

2. PRACTICAL CASE: SUPPORT FOR A PROVINCIAL MASTER PLAN

2.1 Context

Utrecht Province in the Netherlands has a high economic and demographic growth because of its specific qualities and central location in the Netherlands. This causes problems such as housing shortage and congestion of the road network. Finding suitable new locations for housing, industry, and offices is an important issue in the development of the new master plan. Because the amount of space in the Province is limited and there are numerous actors with different goals it is important that new locations are sought using an integrated approach. With a view to investigate to what extent an integrated land use model could provide support in this process, the Dutch application of METRONAMICA, known as Environment Explorer[1], was deployed for a policy exercise involving strategic policy practitioners, GIS specialists and other technicians; all staff members of Utrecht Province and engaged in the development of the new master plan. The model was used to structure and support the policy-making process by combining the inputs and ideas from the sectoral fields and presenting an integrated view of the different alternatives and their consequences.

[1] Environment Explorer is developed for and with the Netherlands Environmental Assessment Agency (www.mnp.nl).

2.2 Process

The exercise was set-up and coordinated by a project team consisting of a policy maker and a GIS specialist from Utrecht Province and two modellers[2]. It started with interviewing policy makers from each sector in the Province participating in the development of the new master plan. Individually they were asked to list important spatial problems for which they would like to be supported by Environment Explorer. This resulted in the focus of the exercise: '*searching locations for new residential, industrial and office development*' in an integrated context.

Next, the policy-makers from the different sectors were given a few weeks to prepare –assisted by their technicians– a stack of thematic preference maps representing their sectoral views on locations for development of houses, industry and offices. For these maps the Province was overlayed with a 25ha grid (the same resolution as Environment Explorer), and each grid cell was given a value between 0 (locations not preferred) and 10 (locations very much preferred). The thematic preference maps were developed using a combination of maps from the GIS of Utrecht Province and expert knowledge. Per sector more or less thematic maps were selected but in total the following themes were withheld: environmental hygiene, social cohesion, economics, cultural history, landscape, traffic & transportation, ecology & environment, water resources & soil characteristics.

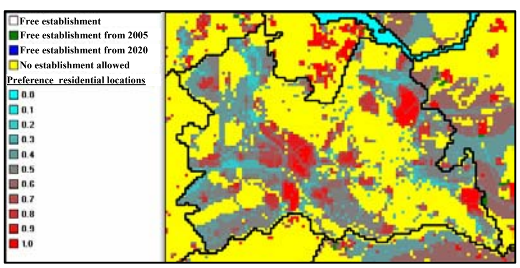

Figure 2: The search space consisting of the available locations and the preference of residential, industrial and commercial functions to occupy these locations.

In a first workshop, gathering policy-makers and technicians from the different sectors, the thematic preference maps and their underlying criteria were presented. The maps were weighted according to their importance and combined in an integral map. To facilitate the latter, participants representing the sectors could distribute a given number of points among the thematic maps to express their relative importance. Preferences and weights differed for the different possibilities for expansion, hence different integral preference maps resulted for new residential, industrial and office locations.

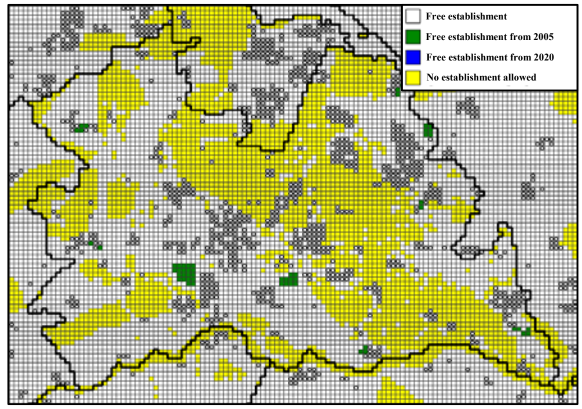

Figure 3: Alternative 2 for new locations of residential functions after 2003 (in green).

In order to restrain development within the legal boundaries set by zoning regulations, zoning maps were created for the residential, industrial and commercial land use functions. By combining the preference maps with the zoning maps the so-called 'search space' for new developments in each sector was found (see Figure 2). These maps not only show where development is allowed, but also how preferential the available locations are based on the integrated assessment. Using these maps the policy makers were asked to create two different alternatives for urban expansion in the coming planning period (2005-2015) given a fixed amount of expected growth. Figure 3 shows one of the alternatives for new housing locations in the associated zoning map. In contrast to the two strictly planned alternatives there was a third one to verify what autonomous developments would take place in the absence of new zoning initiatives.

During a second workshop the consequences of the alternatives on the future land use were calculated with Environment Explorer for different demographic and economic scenarios (see Figure 4). Outputs were compared and a general discussion took place about the sense of reality of the results and the usability of Environment Explorer for policy preparation and strategic planning at the provincial level.

The results obtained were interesting in that in the third alternative the model concentrates new growth as much as possible in the already packed urban centres. In contrast, the newly zoned areas in both planned alternatives open new land for urban development outside the existing centres. All new locations are discovered and taken in by the model rather early in the simulation period,

[2] The modellers are the authors

hence develop successfully. More peripheral locations take somewhat longer to grow. The model shows also interesting non-linear growth differences between newly zoned areas in that some become nuclei attracting additional urban expansion, while others do not. The latter has of course major ramifications for policy-making and planning.

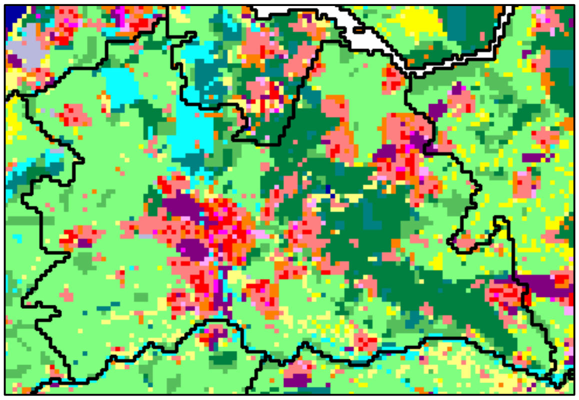

Figure 4: Simulated land use of 2030, developed under conditions as provided by alternative 2.

2.3 Discussion

The combination of practitioners from different backgrounds, i.e. policy-makers, GIS specialists and modellers, was very instrumental for the kind of integrated approach. Not in the least this enabled exchange of information relative to the usage, possibilities and limitations of Environment Explorer at any stage during the exercise and the preparation of the GIS-intensive input for the policy exercises.

This exercise demonstrated that policy relevant problems at the regional level, and in particular that of Utrecht Province, can be formulated into inputs for the model, and that its outputs can be translated back into useful information for strategic policy makers. It also raises questions requiring a more in depth analysis of the precise growth paths and morphogenesis associated with each alternative.

3. PRACTICAL CASE: SUPPORT FOR STORYLINES AND SCENARIOS

3.1 Context

To answer the question how people will live and work in Europe, how the landscape will evolve and what the environmental consequences of the occupation patterns will be in some 35 years from now, the PRELUDE project of the European Environment Agency developed five different land use scenarios for Europe (EEA, 2005). The project was carried out according to a Story And Simulation approach (SAS) in which scenarios and storylines developed in participatory sessions are underpinned by state-of-the-art land use models in an iterative approach. This section focuses on one aspect of PRELUDE: the regional interpretation and simulation modelling of the five European storylines and scenarios developed, and vice versa, the input from the regional modelling into the storylines.

3.2 Process

The project was set-up and coordinated by the European Environment Agency. It engaged some 25 stakeholders representing a broad range of European and international agricultural, industrial, governmental and environmental organisations, alongside with expert 'support teams' for the facilitation of the stakeholder process, the European, and the regional quantification and modelling[3].

The process involved a total of three workshops. In the first workshop the stakeholders developed five possible futures for land use change in Europe. After the workshop experts translated the resulting qualitative scenarios to quantitative information and land use modelling at the EU-level. This information was provided to the stakeholders in the second workshop with a view to strengthen their scenarios.

After the second workshop the regional modelling was introduced to assess the consequences of the EU scenarios in a regional context. The main results of this were the land use dynamics over a period of 35 years associated with the five scenarios as well as their environmental impacts as captured by five dynamic spatial indicators. The methodology applied is particularly suited for quantifying the qualitative information typical of storylines and scenarios. It essentially involves the following four iterative steps and shows great similarity with the work presented in White et al, 2004:

A. Setting the boundaries: In this step the regions are selected and investigated, data is collected, decisions on the modelling resolution are made and applications of METRONAMICA for each region are set-up and calibrated. Northern Italy, The Netherlands and Estonia were selected for the regional modelling based on their distinctive geographical locations,

[3] The support teams consisted of: (University of Kassel, University of Louvain-la-Neuve, Prospex, and RIKS)

physical characteristics, economic and demographic development potentials. Land use and indicators are essentially calculated and presented at the 25ha resolution on a year-by-year basis.

B. Regional interpretation of European scenarios: Narrative storylines at the European level are downscaled to the selected regions based on regional, cultural, political, economic and physical characteristics. For each of the five scenarios this step resulted in three consistent, country-specific interpretations.

C. Quantification of narrative storylines and scenarios: From the literal text of the storylines 'clues' are extracted. These are meaningful text fragments in the narratives that provide information on states, state changes and processes. Subsequently each clue is linked to (a) parameter(s) in the METRONAMICA model fit for its representation. For example the clue '*climate change caused droughts*' is linked to a suitability map for agriculture featuring declining values over time as a consequence of drought. The clue '*people move from the cities to the countryside*' is linked to the cellular automata interaction rules of the model representing the push and pull effects between land use functions, in particular a stronger pull of rural on residential land uses. The next step is to quantify the parameters. In PRELUDE, values were found using a combination of information from the storylines, actual data and the modelling work carried out at the EU-level.

D. Model runs and analysis of results: For each scenario and each country selected, the land use changes and the associated environmental indicators were simulated. Scenarios were compared and so were differences between countries within a scenario. Outputs were presented in graphs, maps and animated maps showing the yearly changes in the land use for the scenario period (See for example Figures 5 and 6).

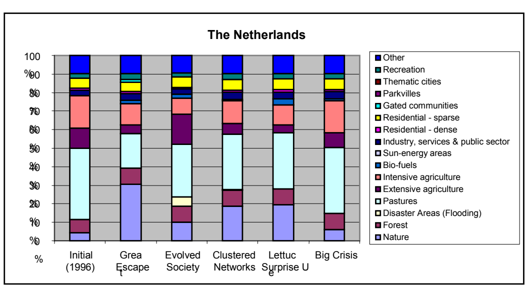

Figure 5: Summary of land use change in the initial situation and the different scenarios (2035).

In a third and final workshop the modelling results were presented to, and discussed with, the stakeholders to verify the extent to which the storylines had been faithfully interpreted and to assess how the storylines could be further improved based on the modelling results. In this workshop the stakeholders where directly confronted with the modelling results. Information on the model, its underlying assumptions, behaviour or parameters was only provided if requested. At the end of the workshop both the storylines and some model parameters had undergone slight modifications resulting in more consistent scenarios.

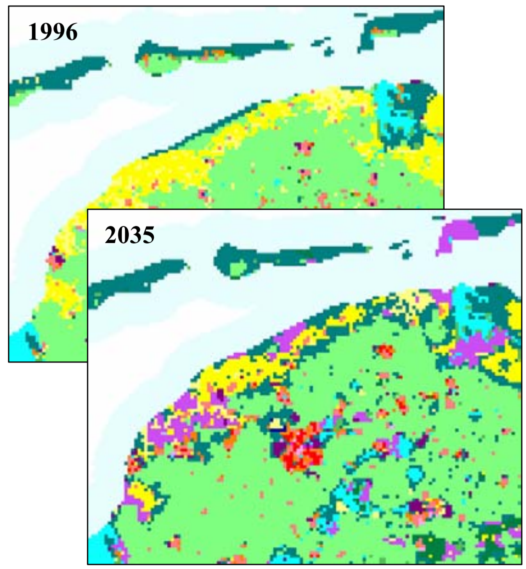

Figure 6: Initial land use (1996) and simulated land use for the Northern part of the Netherlands for 2035 under conditions of one of the scenarios, in which bio-fuels (purple) occupy a large part of the current arable areas (yellow).

3.3 Discussion

The Story And Simulation method described above combines the advantages of two very different approaches: the creativity and flexibility of participatory storyline development and the consistent, coherent integration and visualisation power of spatial modelling. In PRELUDE the interaction between the stakeholders and modellers lead to a vivid and open discussion. This improved both the storylines and the modelling work and resulted in creative, consistent scenarios. In effect the translation from qualitative to quantitative and the incorporation of creative elements from the storylines in the land use model were the main challenges in the project. METRONAMICA proved to be very flexible in this respect as it enabled the inclusion of new land use functions like '*gated communities*', '*parkvilles*', and '*thematic cities*' as well as the development of user-defined indicators making the connections between the model output and the important elements in the storylines. The link between the qualitative storylines and the quantitative parameter values was made by the modellers. However, future projects of the kind should devote more time to discuss this quantification with the stakeholders, even though it would require a deeper understanding of the model on their behalf.

4. COMPARING BOTH CASES

Although both exercises focus on land use changes they do this in quite distinct ways. The planning exercise with Utrecht Province focuses on what is likely to happen: it is essentially based on business as usual scenarios featuring minor adaptations, accounting for policy interference or external drivers like economic and/or demographic growth. For this type of exercise it is important to dispose of a fully calibrated and validated model with good predictive capabilities, since differences between alternatives may be minor and the exercise is aimed at supporting the planning process in detail.

The PRELUDE exercise on the contrary stimulates creative thinking and the incorporation of surprising events; it focuses on what is plausible rather than what is likely to happen. The modelling in this type of exercise is aimed at realistically capturing the processes embodied in the storylines and to show where lacking information and/or inconsistency show up. For this type of exercise the supporting model needs to be as flexible as possible for it to include as wide as possible a range of elements from the storylines. Because often the scenarios are extreme and results are used in a relative sense, a detailed calibration is less important.

Regarding the process both exercises try to adhere to current practice as much as possible, but do this in a very different manner. The planning exercise takes small steps to fill the model with necessary data and parameters collected by the end-users and builds-up to results. In the scenario exercise storylines are developed without knowledge of the model; the translation from storylines to model parameters is done by modellers and results (land use changes) are presented to stakeholders without giving them prior detailed information on the model. Based on the latter however, the discussion on scenarios, parameters and model structure is initiated. The interactive nature and graphical user interface of METRONAMICA facilitated this process greatly. Effects of choices made could be demonstrated instantaneously and in a very transparent manner. This was probably one of the main reasons stakeholders expressed very little doubts about the quantification and its results.

5. COMBINING PARTICIPATORY APPROACHES AND MODELS: CONCLUSIONS AND RECOMMENDATIONS

By integrating modelling in participatory processes, visions about the future and ideas about the underlying processes of change can be underpinned with modelling results. This makes the exercise repeatable and the discussion explicit. Clearly, as any such exercise explores futures that diverge more or less from know trends and states, models are required featuring a representation of the processes of change in a system and not a simple state description of that system. In developing integrated visions for the future, integrated models have an added value because they provide:

- an improved understanding of the interactions between the different functions and processes shaping the system and/or region;
- elucidation of the effects of policy interventions on the discipline of the policy maker and that of others: the 'side-effects';
- a deeper insight in the dynamic cause-effect relations of the alternatives: more than just a cartographic description;
- the possibility of quickly calculating the consequences of alternatives, also those that are not obvious at first sight;
- objective measurement and evaluation of more alternatives than would otherwise be possible;
- an improved communication between different sectors and disciplines by concentrating the visions and discussions around one instrument.

Because of their highly technical level and complexity, models are often only used by technicians. They provide policy makers with results on demand, but their worlds remain essentially separated. By incorporating modelling in a participatory process, the gap between the world of the stakeholders and that of the modellers becomes very small due to the high level of interaction required to provide the desired information and support. Thus, the modelling work can also benefit from the participatory approach.

METRONAMICA contributed to both exercises thanks to its high level of completeness, flexibility and interactivity. Thus 'clues' from storylines could be quantified to a very large extent, and the stakeholders considered the modelling work as an essential contribution to the scenario development. However, setting up and calibrating models for new regions for which no application like Environment Explorer was readily available, took considerable effort. This should be accounted for in any new exercise in the future.

With regards to the planning exercise in Utrecht Province METRONAMICA's raster representation and the interactive manipulation of the inputs that it enabled was greatly appreciated. However, it was questioned whether the model provided the information required at a sufficient level of detail and accuracy. Technically speaking the level of detail can be easily raised since the model can be applied at higher spatial resolutions. However, raising the level of accuracy is more difficult and is hampered by the predictive capabilities of current land use models. This should be communicated carefully to stakeholders, planners and policy-makers involved in any modelling project.

This paper mainly focused on the extent to which a land use model like METRONAMICA can provide support to participatory approaches. A very relevant question that is not answered here is to what extent the participatory approaches and scenario analyses described contribute to the current process of policy making.

6. ACKNOWLEDGEMENTS

The authors wish to thank the Utrecht Province and in particular J. van Vught and C. van Strien as well as the European Environment Agency and in particular Y. Hoogeveen and T. Henrichs. Their input has been very instrumental for the success of the exercises described.

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