SPATIAL ANALYSIS IN SUPPORT OF PHYSICAL PLANNING

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Cover illustration: high density office development on former sports fields at the ‘Zuidas’ area opposite the Vrije Universiteit Amsterdam in 2003 (Eric Koomen).

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Spatial analysis in support of physical planning

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door

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geboren te Haarlem

promotoren: prof.dr. H.J. Scholten
prof.dr. P. Rietveld

Dedication

Dedicated to my parents for
putting their faith in me

Contents

Preface

Delivering a doctoral dissertation or thesis effectively means proving that you are able to do research independently. While I indeed carried out most of the research myself, spent many evenings alone in the attic drafting the included papers and am, of course, fully to blame for any incorrectness, I could not have completed this work without the help of many, many others. Therefore, I would like to express my thanks here to all persons and organisations that contributed to this thesis.

First of all I would like to thank Alfred Wagtendonk for luring me back to the *Vrije Universiteit Amsterdam* and Henk Scholten for enthusiastically stimulating me to do this research and providing the freedom to let me find my own niche in it. I am, furthermore, indebted to my other promoter, Piet Rietveld, who patiently initiated me in the world of econometrics and scientific writing.

This thesis is a compilation of the spatial analyses I performed in various studies related to physical planning that were commissioned and supported by many different organisations and research programs. For their initial support I want to thank the former *Rijksplanologische dienst*, now *Ruimtelijk Planbureau*, soon to become *Planbureau voor de leefomgeving*. I regret not being able to show Jan Groen the final result of the work he initiated. I thoroughly enjoyed the cooperation with the part of the RIVM that became *Milieu- en Natuurplanbureau* and soon will also be *Planbureau voor de leefomgeving*. Especially the support of Judith Borsboom-van Beurden and Arno Bouwman was essential in doing the land-use simulations presented in the last chapters. The cooperation with their former colleagues Marianne Kuijpers-Linde and Willem Loonen was equally pleasant and I am very excited that we now start the new Geodan Next adventure together.

Furthermore, I would like to thank the Netherlands Ministry of Housing, Spatial Planning and the Environment (VROM) and H&S consultants for their kind cooperation in the research on rural vitality. For the work related to water management I am grateful for the opportunities provided by the former *Rijksinstituut voor Integraal Zoetwaterbeheer en Afvalwater-behandeling*, the German Federal Ministry of Education and Research (BMBF) and the *Technischen Universität Berlin*. The 'Environment, Surroundings and Nature' (GAMON) programme of the Netherlands Organisation for Scientific Research (NWO) funded the work related to the valuation and preservation of open space in the Netherlands. The substantial support from the Dutch National research programme 'Climate changes Spatial Planning' provided the opportunity for the further development and application of the land-use modelling framework and the dissemination of the subsequent results.

Almost all of this thesis' chapters are, or soon will be, published as journal or book contributions. As such they have gone through lengthy review procedures and I am thankful to the many anonymous reviewers whose comments greatly helped to enhance the scientific value of the original papers. The first steps towards a coherent thesis were made during a three-month stay late 2005 at the SIGTE-group of the *Universitat de Girona* in Catalonia. My family and I enjoyed this break very much; *moltes gràcies per l' hospitalitat!* The constructive comments on the initial version of this manuscript provided by the members of the thesis committee (Adri van den Brink, Helen Couclelis, John Stillwell, Peter Nijkamp and Tom Veldkamp) furthermore helped to improve its quality. Additional thanks go to John for making the joint editing of the 'Modelling land-use change' book such an instructive and rewarding experience. I am also grateful to Eva Jane Stam and Patricia Ellman for their linguistic help with several chapters.

Many of the studies included in this thesis were carried out in close cooperation with colleagues of different research groups in the Netherlands and abroad. I would like to acknowledge the following persons in particular for their much-appreciated contributions to the included analyses: Evelien van Rij, Fernando Bação, Hanneke van der Klis, Jan Ritsema van Eck, Jeroen Aerts, Maarten Hilferink, Maria Teresa Borzachiello, Noor van der Hoeven, Richard Kaufholz, Rosan van Wilgenburg, Terry van Dijk and Tom Kuhlman. Jasper Dekkers deserves special thanks for the fact that he endured cooperation in four chapters of this thesis. In addition, I also want to express thanks to the many colleagues of the SPINlab and the department of Spatial Economics of the *Vrije Universiteit Amsterdam* for providing the pleasant working environment and distractions that were essential for carrying on with this research in the past seven years. And Eduardo, I hope to keep seeing you around!

As usual the last acknowledgements are reserved for the ones that will always come first. Paloma, Wilco and Robin I am very grateful for all the moral support you provided while I worked on this thesis, and I am extremely happy that we can now celebrate its finalisation together.

Eric Koomen
Amsterdam, March 2008

PART I: INTRODUCTION

Chapter 1

SPATIAL ANALYSIS IN SUPPORT OF PHYSICAL PLANNING[1]

Introduction

Abstract: Spatial analysis is key to the formulation and evaluation of physical planning initiatives. The current thesis combines various forms of spatial analysis and many newly available and highly detailed spatial data sets in a series of studies related to different spatial-planning issues. Open-space preservation is the most common objective of the studied policy interventions, but concern for other spatial developments, such as changes in countryside vitality, water availability and flood risk, also receive attention. This chapter introduces the research topic; the most commonly applied spatial analysis methods and the outline of the thesis.

Key words: Spatial analysis; spatial data; research issues; physical planning; thesis outline.

1. SETTING THE SCENE

A safe, attractive and healthy living environment with adequate services and employment within reach is the average resident's desire. Spatial developments that threaten these preferred conditions for living, recreation and employment are thus likely to receive extensive public and political interest. Such attention is certainly paid to the issues that directly threaten safety, as is the case with, for example, the increased flood risk associated with climate change. In fact, the spatial adaptations that may be needed to face climatic changes are a major new theme in current research related to physical planning (Kabat *et al.*, 2005). The concern for the deterioration of the physical environment caused by ongoing urbanisation processes is a theme that has been on the physical planning agenda for a much longer

[1] Section 3 is a translated and abridged version of a chapter previously published in: Van Herwijnen, M., Koomen, E. and Beinat, E. (2002) *Methoden en systemen voor het afwegingskader Ruimtelijke Effecten*; *Een inventarisatie naar de methodologische aspecten van afwegingsmethoden en DSS toepassingen geschikt voor het Afwegingskader Ruimtelijke Effecten (AKRE)*, IvM-rapport nummer E02-14, Vrije Universiteit Amsterdam.

period. Fear for this 'urban sprawl' phenomenon has given rise to various policy interventions in the United States and many other western countries (Maruani and Amit-Cohen, 2007). In general such attempts aim to steer urbanisation processes through the enforcement of restrictions in sensitive areas and the promotion of urban development in other areas. The concern for regionally deteriorating socioeconomic conditions has also given rise to numerous spatial interventions that include the development of new infrastructure and business estates and the implementation of spatial and financial policies to stimulate specific regions or economic sectors.

Policy interventions aimed at organising the distribution of activities in space have a long history and are known under various names. Urban or town planning concerns the layout and location of cities and was already practised by the Romans. Another interesting historic example of urban planning is offered by the new towns (*villes neuves*) that were established in the 12th and 13th century in France and the Netherlands following economic and military-strategic objectives (Rutte, 2002). Regional or, more generally, physical or spatial planning typically deals with larger areas than individual cities and aims to ensure that spatial goals are achieved in the future (Van den Brink *et al.*, 2007). Land-use planning, obviously, deals with the organisation of land use and is, as such, more or less equivalent to the other forms of planning mentioned above. In fact, the above-terms are used interchangeably (Evans, 2004).

This thesis alternately uses the terms physical and spatial planning for those policy interventions that aim to steer spatial developments in such a way that societal and environmental conditions are improving, whilst also meeting other objectives related to, for example, economic development, water management and biodiversity conservation. Reconciling these often conflicting objectives is an extremely demanding task that calls for: clear undisputed information on current developments; insight in possible future trends; the preparation of alternative policy measures and an understanding of their impact. Spatial analysis can provide the required information on past, current and projected spatial developments as well as indicate the impact of existing and proposed policy measures as is demonstrated in this thesis. The research presented here combines various forms of spatial analysis with newly available and highly detailed spatial data sets in a set of studies related to different spatial planning issues. Open-space preservation is the most common objective of the studied policy interventions, but concern for other spatial developments related to, for example, countryside vitality, water availability and flood risk also receives attention. The following sections describe the research questions; some commonly applied spatial data analysis methods; and the spatial analysis process in relation to physical planning. The last section introduces the thesis outline.

2. RESEARCH QUESTIONS

The current thesis presents a number of studies that aim to contribute to the formulation and evaluation of physical planning policies geared towards steering spatial developments. These studies relate to both urban and rural areas and they focus on actual physical planning policies as well as some of the policy concepts and general notions that underlie these policies. Besides having a spatial planning focus the presented research also addresses several methodological issues related to data applicability, integration of analysis methods and simulation of land-use changes. The studies forming this thesis centre around three main research themes:

A. how can spatial developments be quantitatively characterized?;
B. to what extent do specific spatial policies impact spatial developments?;
C. how can simulations of future land use support policy makers?

The studies related to quantifying spatial developments (theme A) aim at providing insight in ongoing processes mostly linked to urbanisation as a solid base for policy formulation. These studies have a strong methodological focus as they include many new and highly detailed spatial data sets and various advanced analysis techniques including hedonic pricing, self-organizing maps and complex regression analyses. More specifically the following sub questions are dealt with:

1. how can the value of open space be quantified from a city dwellers' perspective (Chapter 3)?;
2. how can current urban intensification processes be described (Chapter 4)?;
3. how can urban concentration and land-use diversity be characterised in maps of future land use (Chapter 9)?

All these issues are considered relevant for policy makers as they provide objective information on the very starting points of their interventions. A proper assessment of the value of open space (Chapter 3) may provide objective input to policy measures that aim to preserve open space with different financial instruments. Whereas methodologies that are able to capture ongoing urban intensification (Chapter 4) and concentration processes (Chapter 9) are valuable in assessing the current state of these aspects and, furthermore, are essential in monitoring the success of intensification and concentration policies.

The studies related to the impact of spatial policies on spatial developments (theme B) focus on predominantly rural areas and aim to answer an additional three sub questions:

4. how can the effectiveness of current open space preservation policies be assessed at the national level (Chapter 5)?;
5. how can this effectiveness be explained at the local level (Chapter 6)?;

6. to what extent are rural areas suffering from a loss of socioeconomic vitality (Chapter 7)?

The relevance of the studies on the effectiveness of spatial policies related to open-space preservation (Chapters 5 and 6) for policy makers is self evident; a quantitative evaluation of the impact of such policies is essential when their abolishment, prolongation or adjustment is considered. The supposed lack of countryside vitality that is attributed to the current Dutch restrictive open space preservation policies is one of the motivations for the current shift towards less restrictive policies in rural areas. The quantitative definition of the rural vitality concept and the critical assessment of its current state (Chapter 7) provide important ingredients for the ongoing debate on the appropriateness of the shift in policies that would create more economic development potential in rural areas.

The studies related to the simulation of future land use (theme C) clearly combine a methodological focus related to the potential merits of current land-use models with an outlook on the policy implications of their results. As an introduction to the rather specific topic of land-use modelling, Chapter 2 introduces the approaches that are common in this field and, furthermore, discusses their position in the various phases of the spatial planning process. More specifically the included land-use modelling studies address the following sub questions:

7. what future lies ahead for agricultural land in the Netherlands (Chapter 8)?;
8. to which extent do future land-use patterns meet the current planning objectives of urban concentration and land-use diversity (Chapter 9)?;
9. how can land-use simulations be used to assess possible water shortages in the future (Chapter 10)?;
10. how can the impact of spatial safety strategies on future flood risk be assessed (Chapter 11)?

The simulation of the future of agricultural land use (Chapter 8) presents a reference point to policy makers in their discussions on possible and unwanted spatial developments in rural areas. Likewise, the assessment of simulated future land-use patterns in terms of urban concentration and land-use diversity (Chapter 9) provides planners with the possibly divergent outcomes of different spatial planning scenarios. The assessment of the likely impacts of land-use change on the hydrological system (Chapter 10) is specifically interesting for water managers who are interested in limiting the possible risk of damage to, for example crops, caused by moisture shortages. The integration of land-use modelling and flood-risk assessment into a discussion support system (Chapter 11) allows for an inspection of the possible impacts of various safety strategies.

Almost all of the chapters that together form this thesis have appeared or are expected to appear in peer-reviewed scientific journals or edited books. The details are described in Table 1-1. A more extensive discussion of the outline of this thesis is provided in a following section. First, however, it is considered appropriate to discuss briefly some of the basic principles of spatial data analysis, as all presented studies have in common that they rely heavily on the use of spatial analysis techniques in combination with large amounts of highly detailed spatial data.

Table 1-1. Overview of the publications related to the chapters of this thesis

Chapter	Related publication(s)
1	Van Herwijnen, M., Koomen, E. and Beinat, E. (2002) *Methoden en systemen voor het afwegingskader Ruimtelijke Effecten; Een inventarisatie naar de methodologische aspecten van afwegingsmethoden en DSS toepassingen geschikt voor het Afwegingskader Ruimtelijke Effecten (AKRE)*, IvM-rapport nummer E02-14, Vrije Universiteit Amsterdam.
2	Koomen, E. and Stillwell, J. (2007) Modelling land-use change. Chapter 1 in: Koomen, E., Stillwell, J., Bakema, A. and Scholten, H.J. (eds.) *Modelling land-use change; progress and applications, Springer*, Dordrecht, pp. 1-21. Koomen, E., Rietveld P. and De Nijs, T. (2008) Modelling land-use change for policy support; editorial, *Annals of Regional Science* 42 (1): 1-10.
3	Dekkers, J. and Koomen, E. Valuation of open space; hedonic house price analyses in the Dutch Randstad region, *Ecological Economics* (submitted).
4	Koomen, E., Rietveld, P. and Bação, F. The third dimension in urban geography; the urban volume approach, *Environment and Planning B* (submitted).
5	Koomen, E., Dekkers, J. and Van Dijk, T. (2008) Open-space preservation in the Netherlands: planning, practice and prospects, *Land Use Policy* 25 (3): 361-377.
6	Van Rij, E., Dekkers, J. and Koomen, E. (2008) Analysing the success of open space preservation in the Netherlands: the Midden-Delfland case, *Tijdschrift voor Economische en Sociale Geografie* 99 (1): 115-124.
7	Koomen, E. and Van Wilgenburg, R. (2006) Platteland en kleine kernen verrassend vitaal; kwantitatieve analyse van de sociaal-economische veranderingen van ruraal Nederland. In: Schrijnen, P.M. (ed.), *Nieuwe economie nieuwe ruimte, nieuwe ruimte nieuwe economie*; bijdragen aan de PlanDag 2006, pp. 85-94.
8	Koomen, E., Kuhlman, T., Groen, J. and Bouwman, A. (2005) Simulating the future of agricultural land use in the Netherlands, *Tijdschrift voor Economische en Sociale Geografie* 96 (2): 218-224.
9	Ritsema van Eck, J. and Koomen, E. (2008) Characterising urban concentration and land-use diversity in simulations of future land use, *Annals of Regional Science* 42 (1): 123-140.
10	Dekkers, J. and Koomen, E. (2007) Land-use simulation for water management. Chapter 20 in: Koomen, E., Stillwell, J., Bakema, A. and Scholten, H.J. (eds.) *Modelling land-use change; progress and applications*, Springer, Dordrecht, pp. 355-373.
11	Van der Hoeven, N., Aerts, J., Van der Klis, H. and Koomen, E. (2008) An Integrated Discussion Support System for New Dutch Flood Risk Management Strategies. Chapter 8 in: Geertman, S. and Stillwell, J. (eds.) *Planning Support Systems: Best Practices and New Methods*, Springer, Berlin (forthcoming).

3. SPATIAL DATA ANALYSIS METHODS

Since the introduction of the Geographical Information System (GIS) in the 1960s (Scholten and Buurman, 2000) it has become possible to store, retrieve and display spatial data in a structured way with computers (Rogerson and Fotheringham, 1994). Proper analysis of spatial data, however, only started in the mid 1990s, as is reflected in the host of literature on this topic published around that time (see, for example, Fotheringham and Rogerson, 1994; Birkin *et al.*, 1996; Fischer *et al.*, 1996a). In fact, spatial analysis and GIS were long considered to be complementary, but separate fields (Anselin and Getis, 1992; Nijkamp and Scholten, 1993; O'Kelly, 1994; Fischer *et al.*, 1996b).

This distinction has now become blurred by the strongly increased analytical capabilities of GIS, the explosive growth in spatial data availability and the continuing integration of GIS in other sorts of information systems. These trends have, amongst others, resulted in a growing family of integrated spatial decision support systems (SDSS) or planning support systems (PSS) that receive a lot of research attention (e.g. Geertman and Stillwell, 2002; Van Herwijnen, 1999; Uran, 2002 and Janssen *et al.*, 2002). This introduction refrains from introducing the general history, basics and applicability of GIS as this is done extensively elsewhere (e.g. Longley *et al.*, 2005; Scholten *et al.*, 2008). Instead, a number of basic methods to visualise and analyse spatial data are described here to properly position the studies included in this thesis.

The distinction and description of spatial data analysis methods combines elements of previous methodological reviews presented by Birkin *et al.* (1996) and Van Herwijnen (1999). For an in-depth description of these methods and the more specific related analysis techniques the reader is referred to textbooks dedicated to this subject (e.g. De Smith *et al.*, 2007).

3.1 Transformation

Transformation methods form the basis of data visualisation and essentially change a certain form of data representation into another to enhance specific features. Many conventions exist in cartography that help creating clear and commonly understood representations of spatial data. A clear description of this is provided by, amongst many others, Monmonier (1996) and Kraak and Ormeling (1996). Two commonly applied transformation methods are: *classification* and *filtering*.

Classification is used to diminish the variability in data values and can emphasize a certain portion of a spatial data set. By adjusting the classification in a visual representation of a data set specific phenomena can be enhanced or obscured, indicating that the selection of the appropriate class boundaries is crucial. *Filtering* changes the value at each location in a data set based on the original values at that location and its surroundings. This approach is common in raster files and commonly uses a 5- or 9-cell neighbourhood. Different mathematical operators (average, median, minimum et cetera) can be used to obtain a new value for the central cell in the neighbourhood. Distance related weighing is often used here when the selected neighbourhoods are large. Chapter 4 describes the use of a number of different filtering techniques to distil meaningful information from highly detailed spatial data sets.

3.2 Aggregation

Spatial aggregation methods reduce the individual values of a data set to a single value for a specified region or the whole study area. The latter aggregation reduced the number of spatial dimension of the data set from 2 to 0, creating a non-spatial indicator or index value. This loss of spatial information is compensated by the delivery of a clear, unequivocal summary of the original content. Aggregation can also be performed at a regional level, producing a new much coarser representation of the original data.

Spatial aggregation methods either deliver spatial or non-spatial indicator values depending on the use of the spatial character of the original data. Aggregations based on general averages or total values are non-spatial as these are independent of the original spatial configuration of the data. The average size of certain types of interconnected areas (average size of all urban areas) is considered a spatial indicator value as this depends on how the urban areas are connected. Chapters 4, 7 and 9 apply a number of different aggregation techniques.

3.3 Combination

Combination of different spatial data layers is one of the key functions of GIS and it offers a powerful tool to provide an overview on many different data sets in one new integrated representation. By overlaying different data layers it is also possible to create a new data layer instead of merely visualising a result. The overlay operation is thus a typical spatial analysis operation available in any proper GIS. A classic example of this type of analysis is to define the area of overlap of two or more separate data layers indicating, for example, the area where new developments are not permitted following a large set of zoning regulations. Overlays are well suited to compare several data layers in a structured manner. Basically three different comparison options can be distinguished (Muehrcke, 1973):

1. a data set with another data set that represents the truth as is common in, for example, validation exercises;
2. a data set with another data set, for example, to compare the development over time of a specific phenomenon or to study spatial patterns of related spatial phenomena;
3. a data set with a theoretical data set, to test assumed relations.

Map-to-map comparisons are described in the Chapters 5 and 6 where the land-use conversions over time are analysed by means of cross-classification and the construction of transition matrices. Chapter 9 shows the potential of difference maps that indicate where, according to model simulations, new developments take place. Such difference maps are less adequate when more than two data sets are compared. In that case maps can be produced that locally aggregate results to describe, for example, the number of times that a certain location is supposed to be urbanised according to a set of future simulations.

3.4 Valuation

Valuation is an appropriate tool to help interpret the results of spatial analysis operations. By applying a normative and consequently subjective classification operation to analysis outcomes their value is better understood. In essence, this is not a spatial analysis method since it, generally, only applies to non-spatial valuation functions. The main aim of valuation is to make the content of related data sets comparable. It is a common tool in environmental impact assessments and decision support systems that aim to provide clear, easily interpreted outcomes to policy makers and stakeholders. Simple valuation exercises result in a limited number of categories distinguishing, for example, positive, negative or neutral outcomes in relation to a reference value. Monetary valuation that is common in, for example, cost benefit analyses is an example of a more elaborate valuation method. All valuation methods have in common that they allow for subsequent ranking of alternative outcomes and the application of multi-criteria analysis (see, for example, Van Herwijnen, 1999). A straightforward valuation of analysis outcomes is presented in Chapter 7 that distinguishes between positive, negative and neutral developments. A more elaborate valuation of flood risk simulation results in terms of economic damage and potential casualties is described in Chapter 11.

3.5 Proximity analysis

A classic type of GIS-assisted analysis deals with the assessment of distance, normally expressed as proximity. Buffer analyses that create zones of influence (e.g. noise contours around roads) surrounding different types of shapes are typical examples of proximity analysis. Plain distance maps that describe the Euclidian or other type of distance to a specified object (e.g. railroad, city centre) offer useful input to various forms of spatial statistical analysis that, for example, aim to explain specific spatial phenomena. Chapter 3 and 4 provide examples of the use of these distance maps. More complex spatial studies related to proximity are network analyses that are common in infrastructure and transport research (Borzacchiello *et al.*, 2008).

3.6 Simulation

By describing the relevant relations of a system it is possible to simulate its future state. A common form of simulation (or modelling) is applied in impact assessments that describe the possible consequences of a specific event or policy. Such assessments follow predefined cause-effect relations that are made operational by one or more of the spatial data analysis methods described before. More complex examples of simulation are offered by the models that simulate, for example, the groundwater or land-use system. As the latter part of this thesis explicitly deals with models of land-use change, a more extensive introduction to this topic is provided in the next chapter. That chapter also discusses the optimisation approach that is often distinguished as a separate analysis method (e.g. Birkin *et al.*, 1996). This approach, aimed at finding optimal spatial configurations rather than simulating probable patterns, is, however, not applied in the studies that form this thesis.

3.7 Application of the spatial data analysis methods

All of the analysis methods described in this section are to some extent applied in the studies included in this thesis. Table 1-2 lists the discussed analysis methods and indicates in which chapters they are applied. The overview makes it clear that combination methods are the most frequently applied techniques in this thesis. This is probably also true for many other GIS-assisted studies. The studies in this thesis, furthermore, make much use of aggregation and simulation methods. Aggregation is applied to both raster cells (Chapters 4, 9 and 11) and vector data (Chapter 7) to generalise the outcomes of analyses on highly detailed data sets to a level at which they are more easily visualised and interpreted. The valuation of outcomes has been applied in Chapters 7 and 11. The transformation of data through various filtering techniques is only prominent in Chapter 4. Pure cartographic transformations were applied in the creation of the maps for all different chapters, but these have been left out of the overview below, as they are not considered to be part of the actual analysis of the data.

The combination of the described analysis methods opens possibilities for more advanced forms of spatial analysis, such as the modelling and simulation of spatial processes that are relevant for physical planning. This is the topic of the next introductory chapter and the Chapters 8-11.

Table 1-2. Application of spatial data analysis methods in the chapters of this thesis

Chapter	Transformation	Aggregation	Combination	Valuation	Proximity analysis	Simulation
2						X
3			X		X	
4	X	X	X		X	
5			X			
6			X			
7		X	X	X		
8						X
9		X	X			X
10						X
11		X	X	X		X

4. SPATIAL ANALYSIS AND PHYSICAL PLANNING

The ultimate goal of spatial analysis is to transform spatial data into meaningful information. In the context of physical planning this means the provision of information that helps policy makers in preparing, developing and evaluating policy alternatives. The concluding section of Chapter 2 describes these different phases in the planning cycle and discusses the possible application of land-use models per phase. First, however, this section introduces the general process that transforms spatial data into relevant information. Subsequently, several spatial analysis issues are briefly shortly introduced that are particularly relevant for the physical planning related studies included in this thesis.

4.1 The spatial analysis process

Initial reviews of the main objectives of spatial data analysis distinguish between exploratory and explanatory (or confirmatory) spatial data analysis (e.g. Anselin and Getis, 1992). Within spatial analysis and the related field of spatial modelling the main objectives are forecasting or scenario generation, (policy) impact analysis and policy generation or design (Fischer *et al.*, 1996b). Considering that: 1) the fields of spatial data analysis and spatial modelling are becoming more integrated, as was discussed in the previous section; and 2) these different objectives are sequential in the conventional modelling process (Batty and Xie, 1994) the following division of the spatial analysis process is proposed (Figure 1-1). The process is characterised here by a number of subsequent analysis phases that differ in the degree of understanding that is involved. Since the final evaluation or monitoring phase may provide information that is useful for the preceding phases the whole process is considered to be iterative. The text below shortly describes the different analysis phases and indicates how the chapters of this thesis can be linked to them. Table 1-3 presents these relations in a more concise form.

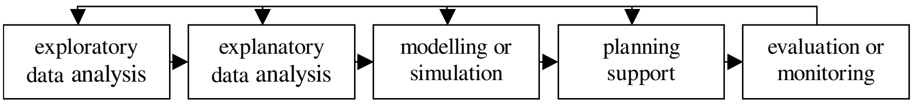

Figure 1-1. The iterative spatial analysis process.

Exploratory data analysis is usually a first step when new causal relations are sought. The inductive process of displaying spatial data to reveal patterns and anomalies and to suggest related processes was first developed by Tukey (1977) and is by many considered to be the main function of GIS or spatial analysis (Anselin and Getis, 1992; Douven and Scholten, 1995; Goodchild and Janelle, 2004). An example in a spatial planning context is the analysis of land-use change maps to discover ongoing spatial processes. Chapter 4 in this thesis applies various forms of exploratory data analysis, such as the self-organizing map approach, to assess the potential of the newly constructed urban volume data layer.

Explanatory data analysis goes a step further and introduces a notion of causality. This type of analysis is also known as confirmatory analysis as it seeks to confirm hypotheses related to observed spatial processes. Normally, it aims to explain such processes by applying statistical regression analysis. This is demonstrated in Chapter 4 where the possible relations suggested by different forms of visualisation and the self-organizing map approach are tested in a more formal combination of different regression analysis techniques. Chapter 3 also uses regression analysis to explain spatially differentiated house prices from a large set of (spatial) explanatory variables.

Once formal causal relations are established *modelling or simulation* can be used to assess the possible state of a system given certain initial conditions and expected events or (policy) interventions. The term modelling is usually applied to any quantitatively structured representation of an actual process, whereas the term simulation is often associated with the mimicking of complex, generally social, processes to produce outlooks on possible future states. This terminology issue is evaded here and both terms are used interchangeably in this thesis. A relatively straightforward type of modelling consists of impact assessment analyses that describe the possible consequences of a specific event. This 'what if' approach calls for a quantitative description of cause-effect relations. More complex models simulate the development of complete physical or socioeconomic systems. The last four chapters of this thesis deal with such a type of model to simulate land-use patterns.

When specific policy objectives are known it becomes possible to provide *planning support*. The outcomes of the modelling process are then used to propose or evaluate alternative policy options. This support can be given in the form of result presentations dedicated to specific policy themes or, more elaborately, through the development of specific decision or planning support systems. Most studies in this thesis relate to planning support, but only Chapter 11 deals explicitly with the development of an integrated system to support discussions on a specific policy theme.

Evaluation or monitoring is an important step after decisions are taken or planning strategies are implemented. Its goal is to analyse whether the actual impact matches the anticipated results. This final step in the planning process is often overlooked, causing possibly adverse impacts to remain unnoticed. Proper *ex-post* evaluation or monitoring can help adjust unsuccessful plans and will, furthermore, improve the planning knowledge base. Thus, ideally, the outcomes of this phase should feed back into previous stages of the spatial analysis process. This thesis includes three different *ex-post* evaluation studies (Chapter 5, 6 and 7). Chapter 9 and 11 include an *ex-ante* evaluation that assesses the likely impacts of proposed spatial strategies on specific policy issues. This type of evaluation confronts assumptions, related to the possible consequences of envisaged policy interventions, with specific impact assessments.

Table 1-3. The spatial analysis phases and related chapters of this thesis

Chapter	Exploratory data analysis	Explanatory data analysis	Modelling or simulation	Planning support	Evaluation or monitoring
2			X		
3		X			
4	X	X			
5				X	X
6				X	X
7				X	X
8			X	X	
9			X	X	X
10			X	X	
11			X	X	X

4.2 Spatial analysis issues

While applying spatial analysis for physical planning a number of research issues is particularly important. These issues are common to the application of spatial analysis in general, but they have specific implications for the physical planning context and the studies included in this thesis. The selected spatial analysis issues relate to *scale*, the treatment of *spatial effects* and, more general, the difficulty of obtaining *causal relations* from spatial analysis.

Scale, or spatial resolution, is one of the fundamental issues in spatial analysis. This is embedded in Tobler's much-quoted first law of geography that states: "everything is related to everything else, but near things are more related than distant things" (Tobler, 1970: 236). Scale is directly linked to this law as it refers to the distance between the objects of study. For spatial analysis, Tobler's law, amongst others, implies the obvious fact that studies at the national, regional or local level can produce very different results.

Another issue related to spatial scale is the fact that different processes may be dominant at different scales. These different scale levels may, furthermore, be linked. This becomes apparent from, for example, global-level processes of increased economic interaction and growth that, depending on the comparative advantages at the national level, are likely to increase the demand for certain economic sectors and decrease it for others. Depending on the local conditions of, for example, infrastructure and the available workforce these national processes may lead to the development of new business estates at one location and the closing down of another type of business at another. Therefore, it is important to address the multi-scale characteristics of socioeconomic systems by encompassing the scale dependencies of the interrelated socioeconomic and biophysical processes at various levels (Verburg *et al.*, 2004). The study on rural vitality (Chapter 7) shows that local socioeconomic developments may, indeed, strongly deviate from national averages. The applications of the *Land Use Scanner* model (Chapters 8-11) differentiate between different scale levels in the sense that they define the suitability for specific land-use functions according to local conditions and specify their demand at the national or regional level according to national trends and regional differences.

Studies related to physical planning normally belong to the branch of socioeconomic research and, as such, often rely on statistical data collected at the rather arbitrary level of socioeconomic or, worse, administrative levels. The seminal work of Openshaw on the modifiable area unit problem (e.g. Openshaw and Taylor, 1979; Openshaw 1984) has proven that the demarcation of these zones and, essentially, scale in general, significantly influences the outcomes of subsequent studies. Some, therefore, argue that in socioeconomic science the actual geographic world is best approached as a continuous surface at the micro level (Goodchild and Janelle, 2004; Burger *et al.,* 2007). This approach is already common in spatial analysis of the physical world, implying that social scientists may be able to benefit from the experiences of scientists in the fields of, for example, physical geography and remote sensing.

To test the benefits of using continuous, micro-level data in the spatial analysis of socioeconomic phenomena, the studies in this thesis incorporate as much of these data as is currently feasible. This novel approach is particularly prominent in Chapter 4 that discusses the use of highly detailed topographical and height data sets to analyse urban patterns. Detailed continuous data sets are also important in the studies related to evaluation of the impact of spatial policies (Chapter 5 and 6).

The issue of temporal scale is closely related to spatial scale as events happening shortly after each other tend to be more closely related than events that are further apart in time. It follows then that some of the observations made above also apply to the issue of time or the combination of space and time (Peuquet, 2002). Time is important in physical planning studies as these typically focus on the exploration and explanation of past events or the modelling of possible future events. This implies that the careful selection of the appropriate temporal resolution is extremely important in a study. Unfortunately, this is often hampered by the limited availability of reliable and methodologically consistent time-series data. The studies in this thesis, therefore, usually have to make do with relatively short time spans that possibly limit the robustness of their outcomes.

Spatial effects refer to two types of characteristics that make spatial data special: dependence and heterogeneity (Anselin, 1990). The former effect is also known as spatial autocorrelation and corresponds to Tobler’s law: near things are more related than distant things. Spatial heterogeneity, on the other hand, indicates that the dependence structure is inconsistent across space. In economics and econometrics these spatial effects are often considered to: “complicate any straightforward understanding of spatial data” (Anselin and Getis, 1992: 23). As such they are viewed upon as possible sources of error that should be controlled (Klotz, 1999; Bell and Bockstael, 2000).

In geography, on the other hand, the spatial effects are generally considered to contain valuable sources of information. This is especially true for the concept of spatial dependence that is often used in an explanatory spatial data analysis to describe spatial relations and help formulate a related hypothesis to explain them. The concept of neighbourhood dependence, in fact, forms the basis for the cellular automata type of spatially explicit land-use models (e.g. Batty, 1997; Couclelis, 1997; White and Engelen, 2000), more extensively discussed in Chapter 2. A rarer application of spatial dependence in land-use modelling is found in the autologistic regression models that simulate land-use patterns from statistically observed neighbourhood relations (McMillen, 2001; Dendoncker *et al.*, 2007).

The different treatment of spatial effects in economics and geography is described well by Bateman *et al.* (2000: 222) who point out the: "fundamental differences in the way that geographers and spatial econometricians view the concept of space". Irwin and Geoghegan (2001) refer in this respect to the 'correct' and 'creative' use of space. In their opinion the former applies to the econometric and the latter to the geographic treatment of spatial effects. Since the studies in this thesis are performed by a geographer disguised as an economist both approaches are followed. An exploratory analysis relying on an assessment of spatial dependence is included in the urban volume study (Chapter 4), whereas a thorough treatment of spatial autocorrelation is offered in Chapter 3.

Another fundamental research issue relates to the possibility of obtaining *causal relations* from spatial data analysis. Some argue that this type of analysis is best suited to explore rather than explain spatial processes (Goodchild and Janelle, 2004). In their opinion statistical analyses performed on spatial data only describe these processes. Similar arguments are made by others, who argue that a notion of causality should be added to statistical models describing land-use change processes (Veldkamp and Lambin, 2001; Parker *et al.*, 2003). Looking back at 40 years of spatial analysis, Berry (2004) concludes that many of the initial technical constraints to spatial analysis (e.g. lack of computer power, limited data availability) have disappeared. In his opinion, the tremendous improvements in, for example, computer power and data availability now call for new rounds of fully spatio-temporal and multidisciplinary spatial theory to steer spatial analysis. The studies in this thesis do not claim to present such integrated new theories, but many offer a multidisciplinary approach combining elements of geographical information science, geography, economics and other sciences. The studies, furthermore, incorporate notions of causality in their treatment of spatial processes as is exemplified by the inclusion of stakeholder opinions in the assessment of the success of open-space preservation (Chapter 6) and the evaluation of regional rural vitality (Chapter 7).

5. THESIS OUTLINE

The general outline of the thesis is provided in Figure 1-2. The chapter directly following this introduction discusses some of the basic theoretical ideas, concepts and methodologies that underpin the modelling of land-use change. It represents an overview of the types of approaches that have been adopted by researchers hitherto and links these to a recent compilation of advances in land-use modelling. By way of conclusion, a short overview on typical policy related applications of land-use change models is offered. The subsequent five chapters relate to the *analysis of past and current spatial developments*. The next four chapters then describe the *simulation of future spatial developments*.

Chapters 3 and 4, more specifically, focus on urban areas that are less influenced by spatial policies. Chapter 3 aims to analyse the value of open space for citizens by applying a hedonic pricing model of residential property values. The analysis is supported by extensive sets of detailed spatial data. Three local Dutch housing market case studies in the Randstad region are presented in which open space is distinguished on three different scale levels, ranging from a view of a small local open space to the proximity of a large regional open space for recreational purposes. The presented quantitative valuation of this asset can help policy makers improve their decisions in weighing up the pros and cons of diverse planning alternatives.

Chapter 4 presents a new methodology that measures density in urban systems. By combining highly detailed height measurements with, amongst others, topographical data we are able to quantify urban volume. This new approach is tested in two separate case studies that respectively relate to the temporal and spatial dimension of the urban environment. In the first study the growth of the city of Amsterdam over the past century is examined. The urban volume indicator is used to visualise and quantify the urban extension and intensification process. To critically analyse the spatio-temporal development of Amsterdam the self-organizing map approach is applied. Special attention is given to highlighting any signs of recent polynuclear development. The second case study compares the building height frequency and spatial distribution of high-density zones in the four major Dutch cities. Additionally, the presence of built-up areas and the actual urban volume values are simultaneously explained with a Heckman selection model.

Chapter 5, 6 and 7 focus on rural areas that are subject to a stronger impact of spatial policies. Chapter 5 analyses the contribution of Dutch spatial policies to open-space preservation by comparing actual land-use developments within different restrictive planning regimes. The presented analysis differs from comparable efforts that usually rely on census statistics through use of local-level geographical data and related spatial analysis techniques. The approach has the advantage of being able to analyse the impact of spatially explicit regional zoning regulations. In addition to comparing regions with strict and less strict regimes, this chapter also assesses the importance of another open-space characterisation. The latter refers to a distinction in agriculturally shaped and exploited landscapes and natural areas. The chapter concludes with a discussion on possible spatial planning implications.

I Introduction

1 Spatial analysis in support of physical planning; introduction	2 Modelling land-use change; theories and methods

II Analysis of past and current spatial developments

Quantifying spatial developments	*Impact of spatial policies on rural areas*
3 Valuation of open space; three hedonic house price analyses in the Dutch Randstad region	5 Open-space preservation in the Netherlands; planning, practice and prospects
	6 Analysing the success of open-space preservation in the Netherlands; the Midden-Delfland case
4 The third dimension in urban geography; the urban volume approach	7 Indicators of rural vitality; A GIS-based analysis of socio-economic development

III Simulation of future spatial developments

8 Simulating the future of agricultural land use in the Netherlands	9 Characterising urban concentration and land-use diversity in simulations of future land use	10 Land-use simulation for water management; application of the Land Use Scanner in two large-scale scenario studies	11 An integrated discussion support system for new Dutch flood risk management strategies

IV Conclusion

12 Conclusion and discussion

Figure 1-2. Thesis outline.

The subsequent chapter analyses the success of open-space preservation at the local level for Midden-Delfland, an open area in the metropolitan western part of the country. A specific combination of policy instruments and government regulation has made the preservation of open space in this area very successful even compared to other buffer zones. A quantitative analysis of the land-use changes and a more qualitative review of the applied policy instruments are presented here in attempt to explain this success. The analysis can help planners in finding ways to effectively protect contested open areas.

The last of the chapters dealing with the analysis of spatial developments in rural areas proposes a methodology to quantify the policy concept of rural vitality following a strict socioeconomic interpretation. The use of highly detailed spatial data is crucial in this approach that allows the assessment of the structural characteristics and performance of countryside vitality in the Netherlands. The study shows that developments as regards population, employment and facilities in small settlements in the generally well-accessible Netherlands do not differ greatly from the national trends. The results thus question the basis for the specific rural development objectives of the new National Spatial Strategy.

The following four chapters describe simulations of future spatial developments carried out with the *Land Use Scanner* model. Chapter 8 looks into the future of agricultural land in the Netherlands where the agricultural sector has lost much of its importance over the last 50 years in terms of the number of people involved and its relative contribution to the economy – even though production is still increasing. Yet, the area under agricultural use has changed relatively little: farmland still dominates the country. The question for the future is how expected further changes in agriculture will affect agricultural land use: how much land will be taken out of production and to what use it will be put. This is especially relevant now that the Dutch government has decided to loosen its grip on spatial planning. Two opposing socioeconomic scenarios are therefore drafted that offer a coherent view on agricultural change, external pressures and government intervention. Implementing these in a land-use simulation model provides an initial answer to the possible future of agricultural land in the country.

Chapter 9 presents two sets of functional indicators that were implemented and tested for the assessment of spatial aspects of future land-use configurations as simulated by a land-use model. This is potentially useful for the ex-ante evaluation of spatial planning policies. The indicators were applied in a Dutch case study and relate to two important themes in Dutch spatial planning: compact urbanisation and mixing of land uses. After a short introduction of these themes, the sets of indicators are presented which are used for their evaluation. These indicators are applied to simulations based on two scenarios for land-use development in the Netherlands up to 2030. After a discussion of the results we conclude that the combined application of land-use models and indicators produces new and potentially useful information for policy makers, although both the model and the associated indicators are still in a state of development.

The impact of land-use change on local hydrological characteristics and, more specifically, water shortage is discussed in Chapter 10. Future land use is an important component in studies that focus on the upcoming challenges for water management. This chapter describes two applications of the *Land Use Scanner* model on a national or larger scale, in which the scenario method is used to simulate future land-use patterns in view of climate change.

Climate change is also an important component in Chapter 11 that describes the development of a discussion support system to facilitate the debate on flood risk management strategies. It aims to provide insight into the impact of various strategies in terms of flood probability and flood risk expressed as potential economic damage and number of casualties.

The final chapter summarises the results of this thesis and discusses the extent to which the initial research questions have been answered. This discussion will focus on the policy implications of the findings as well as the methodological lessons learned.

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Chapter 2

MODELLING LAND-USE CHANGE[1]

Theories and methods

Abstract: This chapter explains some of the basic theoretical ideas, concepts and methodologies that underpin the modelling of land-use change. It represents an overview of the types of approaches that have been adopted by researchers hitherto and links these to a recent compilation of advances in land-use modelling. By way of conclusion, a short overview on typical policy related applications of land-use change models is provided.

Key words: Land-use change modelling; theory; methodology.

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Section 4 is published as part of: Koomen, E., Rietveld P. and De Nijs, T. (2008) Modelling land-use change for policy support; editorial, *Annals of Regional Science* 42 (1): 1-10.

PART II: ANALYSIS OF PAST AND CURRENT SPATIAL DEVELOPMENTS

Chapter 3

VALUATION OF OPEN SPACE[1]

Hedonic house price analyses in the Dutch Randstad region

Abstract: In this paper, we aim to reveal the monetary value of open space by using a hedonic pricing model of residential property values. The analysis is supported by the use of Geographic Information Systems (GIS). We present three local Dutch housing market case studies in the Randstad region. In all studies we distinguish open space on three different scale levels, ranging from a view of a small local open space to the proximity of large regional open space for recreational purposes. We find that a view of open space, *ceteris paribus*, increases house prices 4 to 8 percent. We also observe that the availability of local open space within 25 metres of residences has a substantial positive impact on house prices. In two of the three selected housing market areas this positive impact is even found up to 50 metres. The contribution of larger areas of regional open space to house prices cannot be established unequivocally, as its impact ranges from positive to negative depending on the studied area.

Key words: Land use; open space; valuation; hedonic price theory; GIS.

[1] This chapter is submitted as: Dekkers, J. and Koomen, E., Economic valuation of metropolitan open space; three hedonic house price analyses in the Randstad region, the Netherlands, *Ecological Economics.*

Chapter 4

THE THIRD DIMENSION IN URBAN GEOGRAPHY[1]

The urban volume approach

Abstract: A new methodology is presented that measures density in urban systems. By combining highly detailed height measurements with, amongst others, topographical data we are able to quantify urban volume. This new approach is tested in two separate case studies that respectively relate to the temporal and spatial dimension of the urban environment. In the first study the growth of the city of Amsterdam over the past century is studied. The urban volume indicator is used to visualise and quantify the urban extension and intensification process. To critically analyse the spatio-temporal development of Amsterdam the self-organizing map approach is applied. Special attention is given to highlighting any signs of recent polynuclear development. The second case study compares the building height frequency and spatial distribution of high-density zones in the four major Dutch cities. Additionally, the presence of built-up areas and the actual urban volume values are simultaneously explained with a Heckman selection model.

Key words: Urban morphology; urban volume; density; indicator; self-organizing maps.

[1] This paper is submitted as: Koomen, E., Rietveld, P. and Bação, F. The third dimension in urban geography; the urban volume approach, *Environment and Planning B*.

Chapter 5

OPEN-SPACE PRESERVATION IN THE NETHERLANDS[1]

Planning, practice and prospects

Abstract: Open-space preservation is a planner's issue that is constantly debated, in particular on the success of the implemented instruments. Assessments of policy-effectiveness face many methodological problems that are briefly discussed here. We choose to analyse the contribution of Dutch policies to open-space preservation by comparing actual land-use developments within different restrictive planning regimes. The presented analysis differs from comparable efforts that usually rely on census statistics through its use of local-level geographical data and spatial analysis techniques. Our approach has the advantage of being able to analyse the impact of spatially explicit regional zoning regulations. In addition to comparing regions with strict and less strict regimes, this paper also assesses the importance of another open-space characterisation. The latter refers to a distinction in agriculturally shaped and exploited landscapes and natural areas. We conclude the analysis with a discussion on possible spatial planning implications.

Key words: Open-space preservation; policy evaluation; spatial planning; land-use change; the Netherlands.

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Chapter 6

ANALYSING THE SUCCESS OF OPEN-SPACE PRESERVATION IN THE NETHERLANDS[1]

The Midden-Delfland case

Abstract: Open-space preservation is an important aim of spatial planning. In the Netherlands, the recreational, ecological and historic values of open spaces between cities, the Buffer zones, are recognised and thus receive ample attention of policy makers. This paper focuses on Midden-Delfland, an open area in the metropolitan western part of the country. A specific combination of policy instruments and government regulation has made the preservation of open space in this area very successful even compared to other Buffer zones. A quantitative analysis of the land-use changes and a more qualitative review of the applied policy instruments are presented here in attempt to explain this success. The analysis can help planners in finding ways to effectively protect contested open areas.

Key words: Open-space preservation; spatial planning; policy evaluation; the Netherlands.

1. INTRODUCTION

Planners in many countries have been looking for strategies to preserve metropolitan open spaces, commonly referred to as green belt policies (see for example Carmona *et al.*, 2003; Gailing, 2005; Ravesteyn *et al.*, 2005 and Swaffield and Primdahl, 2006). The preservation of metropolitan open space coincides with the public wish to preserve nature in a broad sense (Groote *et al.*, 2006). However, projects and policy strategies to preserve these green open areas in between cities often do not succeed. See, for example, for the Dutch case: Rekenkamer (2006), Farjon *et al.* (2004) and VROM-Raad (2004) and internationally: Alterman (1997), Bannon and Cassidy (2000)

[1] This chapter is reproduced with kind permission of Blackwell Publishing and is published as: Van Rij, E., Dekkers, J. and Koomen, E. (2008) Analysing the success of open space preservation in the Netherlands: the Midden-Delfland case, *Tijdschrift voor Economische en Sociale Geografie* 99 (1): 115-124.

and Romero (2003). Within the international context, the Dutch institutional framework for the protection of green areas is seen as one of the most successful frameworks in the world (Alterman, 1997). The distinction between urban areas and open space is a basic principles in the Dutch spatial planning doctrine (Faludi and Van der Valk, 1994) and the new Memorandum on Spatial planning follows this tradition as the protection of open space continues to be a major principle of spatial organisation (VROM *et al.*, 2004; Priemus, 2004). "One of the basic principles is that Buffer zones – green corridors of no less than four kilometres wide – must be left open between major agglomerations" (Faludi and Van der Valk, 1994: 106).

Since 1958, eight Buffer zones have been designated in the urban constellation of the Randstad in the western Netherlands (RNP, 1958). To keep these areas open the need was felt to improve their recreational, natural and agricultural potential. In addition to the special zoning status, land consolidation and, from 1964 onwards, also land acquisition were seen as appropriate instruments (Bervaes *et al.*, 2001). It is, furthermore, important to note that that the Buffer zone policy has been drafted together with the specific plans (growth centres and growth towns) to steer urbanisation towards the outer edges of the Randstad (Faludi and Van der Valk, 1994). The restrictions on urbanisation inside the Randstad were thus compensated with urbanisation incentives outside. The fact that during the debate in parliament on the new Memorandum on Spatial planning, amendments (TK 2004-2005) were handed in to continue the national Buffer zone policy is a clear sign of the enduring importance of the concept.

With the acceptance of the Midden-Delfland Reconstruction Act (Reconstructie wet) in 1977, the Buffer zone policy in this area was supplemented, with a special statute that governed its land reallocation. In addition to the zoning system that is in force for all Buffer zones, institutions as compulsory purchase, land consolidation and development of nature and recreational areas have been applied. In his thesis, Kreukels (1980) analyzes the first stages of the planning process in Midden-Delfland. Preceding the anticipated, general evaluation of the Buffer zone policy in 2015 (VROM *et al.*, 2004), this paper examines the reconstruction project in Midden-Delfland, its goals, process and results in terms of land-use change, and compares this with the general trend in other Buffer zones and the Netherlands as a whole. It also assesses which major factors contributed to the success of the project, now that it comes to a close. The research relies on both quantitative and qualitative methods, in the form of a land-use change analysis (see also Koomen *et al.*, 2008) and in-depth interviews, document analysis and study area visits (see Van Rij, 2006).

2. OPEN-SPACE PRESERVATION IN MIDDEN-DELFLAND

Midden-Delfland is an open area between the agglomerations of Rotterdam, Delft, The Hague and the extensive Westland greenhouse complex (Figures 6-1 and 6-2). The traditional peaty meadows, cows and windmills are seen as unique selling points of Midden-Delfland. Originally, the full 6,600 hectares of the area were used for dairy farming. Nowadays dairy farmers are active in the 4,000 hectares situated in the heart of the area. Other land-use types present are recreation, nature and greenhouse horticulture. In response to the continuous expansion of the cities of Delft and Rotterdam that seemed to lead to their coalescence, a specific statute for this area, the so-called reconstructiewet Midden-Delfland was established. The three main objectives of this statute were: 1) preserving open space, 2) developing recreational areas and 3) improving farming conditions. These objectives correspond to the general policy goals of the Buffer zones. According to the most recent Dutch Memorandum on Spatial planning (VROM *et al.*, 2004) and amendments to it (TK 2004-2005) the main goal of the Buffer zones is still the safeguarding of open spaces between cities. Strengthening the recreational, agricultural and natural values of these areas remain important pathways to preserve open space.

To achieve the three objectives in Midden-Delfland, a land consolidation project including land reallocation was carried out. Besides that, the statute marked out the project area and the zones where compulsory purchase for development of the recreational area would be allowed. To prevent the cities from spreading out, these areas were positioned adjoining the cities. Except for some broad outlines, the statute did not include detailed zoning provisions. As in the entire country, municipalities have the right to make detailed binding zoning plans. The special statute did not introduce a complete new toolbox of new instruments or sanctions. In fact, it was much like other land consolidation acts, describing the various stages of a land consolidation project, implementation tools and the rights of owners and other parties concerned. An important role was attributed to the Reconstruction Committee, which was in charge of the entire project and was formed by representatives of the municipalities, the province, the Farmers Union, the Midden-Delfland Countryside Union, the district water board and the Dutch Association for travel and recreation (ANWB). Besides project coordination, an important task of this Committee was to decide which individual building initiatives would be permitted. These institutions were in place during the whole project (1977-present). The long duration of the statutory land consolidation prohibited policy changes.

Central government provided most of the budget and the civil servants needed for this project. To take care of the maintenance of the recreational zones, central and local government provided funding and a recreational board was established, formed by representatives of these governmental bodies. Even after the reconstruction project, this board will remain active. At this moment the Nature Conservation Union, farmers, the State Forestry Organisation are the most important landowners while the recreational board, golf course operators and farmers are holding land on a long lease. The land consolidation has now taken place and the project is expected to be finished in 2008, meaning that the Reconstruction Committee will be abolished and that no more reallocation and development of land will take place.

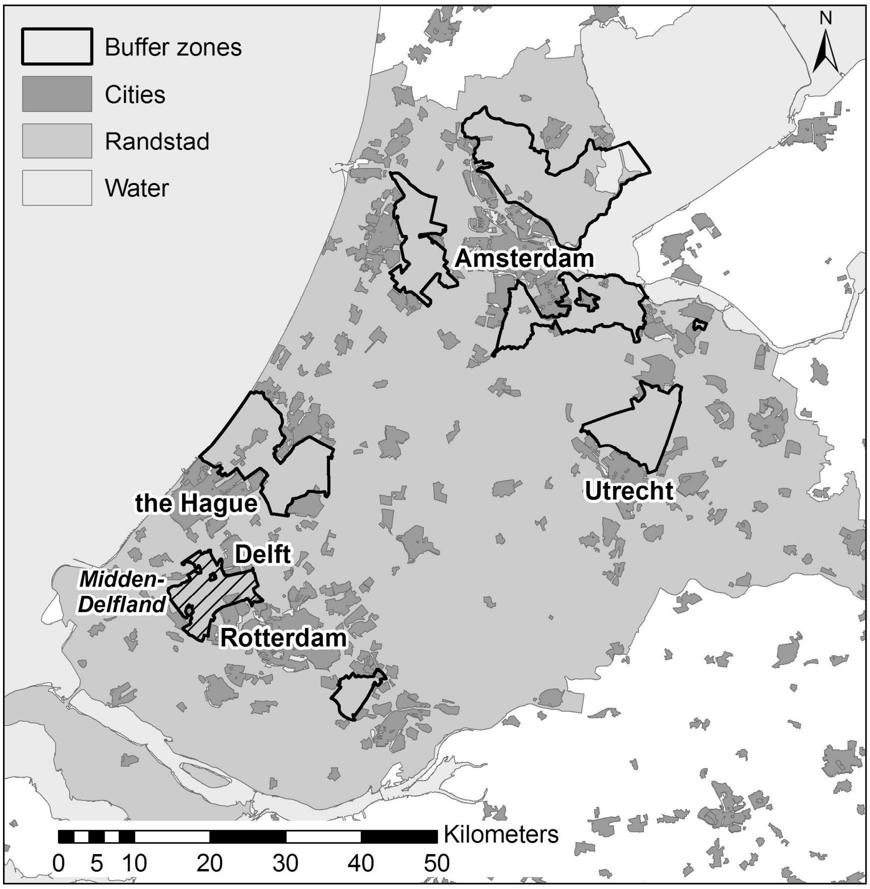

Figure 6-1. Midden-Delfland and other Buffer zones in the western part of the Netherlands.

3. ANALYSING LAND-USE CHANGE IN MIDDEN-DELFLAND: SUCCESSFUL OPEN-SPACE PRESERVATION

Evaluation in planning seems to be simple; one can check whether the outcome of planned action is in conformity with the plan. This basic approach has, however, been criticized (e.g. Scriven, 1972). Faludi (2000) stated that the question should be whether the plan performs well in the subsequent communicative process and this requires looking in detail at the decisions and actions of the people to whom the plan addresses its message and to establish whether and to what extent they have taken the message on board. Setting goals in advance for both process criteria, like Scriven and Faludi argue, as well as content criteria, leads to a more valuable evaluation (De Bruijn and Van der Voort, 2000). For the analysis of the Midden-Delfland reconstruction such a combined method has been chosen. First a Geographical Information Systems (GIS) is used to analyze to what extent spatial developments in Midden-Delfland, compared to the rest of the Netherlands and the other Buffer zones, conform to the three planning goals of the Buffer zone policy. In addition to this quantitative GIS-analysis, in-depth interviews and a policy analysis have been added to the evaluation, following the ideas of Guba and Lincoln (1989) on using perceptions of participants in evaluations. This qualitative part of the research is discussed in the next section.

GIS is used to compare the spatial developments in Midden-Delfland with the averaged national changes in land use and the developments in the other Buffer zones. We rely on remotely sensed, rasterised data sets, as these are available for different time steps and thus allow for the easy construction of transition matrices (Verburg *et al.*, 2004; Lambin *et al.*, 2003; Sonis *et al.*, 2007) based on a pixel-by-pixel comparison of subsequent, methodologically consistent land cover data sets. In this analysis we compare the two recent versions of the Dutch land-use database (LGN3 from 1995, and LGN5 from 2004) at a 25-metre resolution. Previous versions of this land-use database could, unfortunately, not be used as these were methodologically inconsistent (Thunnissen and De Wit, 2000; De Wit, 2004). So, we had to make do with this relatively short period that, luckily, signals a substantial amount of land-use change and thus allows for a critical comparison of the quantity of change within and outside the restrictive policy zones.

Studies on land-use change use a multitude of different classification systems that, depending on their objective and available data, typically highlight either the urban, natural or agricultural types of land cover or land use (see, for example, Pontius *et al.*, 2008). For this analysis we selected a hybrid typology of seven land-use types that, specifically, offers a consistent, integrated view on the conversion of open spaces: 1) built-up areas; 2) urban green; 3) greenhouse horticulture; 4) other agriculture; 5) infrastructure; 6) nature; and 7) water. These types refer to rather straightforward main groups of land use; the seemingly contradictory urban green category contains sparse vegetation (bare soil or grassland) in or nearby urban areas. It contains land with a predominantly green appearance and a functional relation to the neighbouring urban area, including, for example, sports-fields, parks and land set aside for construction. The selected approach allows for an efficient and straightforward analysis of the most important land-use changes. Our analysis does not consider minor developments relating to, for example, land-use modifications or changes in land–use intensity as we deliberately focus on the principle planning objective of preventing the conversion of open space into urban uses.

Between 1995 and 2004 the use of about 110,000 hectares or over 3% of the total surface area, in the Netherlands has changed (Table 6-1). The dominant processes at the national scale were: 1) nature development following the Dutch National Government's plans for a new ecological main structure (LNV, 1990); 2) the conversion of mainly agriculture land into urban green that can be seen as potential urbanisation; and 3) actual urbanisation. It is interesting to note that most of the actual urbanisation takes place in urban green areas. Apart from the obvious conversion of construction sites into urban areas this process also includes the conversion of sports-fields, allotment gardens and other less intensively used green areas in the urban sphere. The seven Buffer zones other than the Midden-Delfland area show the same trends with a comparable magnitude. The major difference is that, in line with the policy objectives for the Buffer zones, less actual urbanisation and more nature development occurs here.

Midden-Delfland, by comparison, shows the largest land-use change; over 12% of the total area changed its function in the ten-year period studied. But only a very small amount of change (0.04%) refers to the construction of new built-up land, hinting at the success of the open space preservation policies. This is a striking result even compared to the other Buffer zones were 0.30% of the land was changed into built-up area. Compared to the rest of the Netherlands and other Buffer zones, the spectacular increases in the area for nature (5.46%), infrastructure (0.21%) and greenhouse horticulture (3.50%) are also eye-catching. And finally, urban green also increases more (1.72%) in Midden-Delfland than in other Dutch areas (see also Figure 6-2A).

Table 6-1. The most important land-use transitions for the Netherlands, the Buffer zones except Midden-Delfland and the Midden-Delfland area between 1995 and 2004 in hectares (ha) and percentages of their respective total areas

Land-use change		The Netherlands		Buffer Zones ex. Midden-Delfland		Midden-Delfland	
From	To	(ha)	(%)	(ha)	(%)	(ha)	(%)
(1) Actual urbanisation		19,572	0.56	208	0.30	3	0.04
agriculture	built-up	8,690	0.25	115	0.17	0	0.00
nature	built-up	1,298	0.04	16	0.02	1	0.01
urban green	built-up	9,584	0.27	77	0.11	2	0.03
(2) Infrastructure development		1,487	0.04	72	0.10	14	0.21
agriculture	infrastructure	1,487	0.04	72	0.10	14	0.21
(3) Greenhouse horticulture dev.		3,523	0.10	62	0.09	235	3.50
agriculture	greenh. hort.	3,523	0.10	62	0.09	235	3.50
(4) Potential urbanisation		33,969	0.97	620	0.91	115	1.72
agriculture	urban green	32,518	0.93	603	0.88	115	1.72
nature	urban green	1,451	0.04	16	0.02	0	0.00
(5) Nature development		38,244	1.10	957	1.40	366	5.46
urban green	nature	1,309	0.04	44	0.06	32	0.48
agriculture	nature	33,436	0.96	875	1.28	334	4.98
water	nature	3,499	0.10	38	0.05	0	0.00
(6) Minor green transitions		14,766	0.42	243	0.36	73	1.08
agriculture	water	3,866	0.11	63	0.09	24	0.36
nature	water	3,410	0.10	4	0.01	0	0.00
nature	agriculture	1,430	0.04	41	0.06	0	0.00
other changes		6,062	0.17	134	0.20	48	0.72
Total change		111,561	3.20	2,161	3.16	805	12.01
Total surface area		3,488,823		68,350		6,705	

The majority of the land-use changes in the area is indicative of the strong government intervention in the area following the Reconstruction Act. This is especially true for the extensive nature development and the conversion of agricultural land into urban green. Areas adjoining the cities were converted to a substantial new nature area and additional recreational areas. The new urban green areas that in other parts of the country are a forerunner of actual urbanisation have a different function here. A field inspection learned that the observed urban green areas consist of an already existing and a proposed golf course (both labelled with '1' in Figure 6-2A). The new nature areas mainly refer to new woodlands that have a strong recreational function (labelled with '2'). Site visits furthermore learned that the relatively strong increase in infrastructure partly consists of roads for cyclists, hikers and farmers. So this development also follows from the reconstruction's intention to develop recreational and agricultural facilities. An additional infrastructure development is the construction of a new stretch of the long-awaited highway (A4) extension west of Delft. The development of greenhouses (labelled with '3' in Figure 6-2A) does not contribute to the attractive appearance of the area, but it has been the result of a thorough decision-making and was part of the reconstruction plan. The development leads to a further spatial clustering of greenhouses that is intended to solve planning problems in nearby villages and to clear out scattered greenhouses.

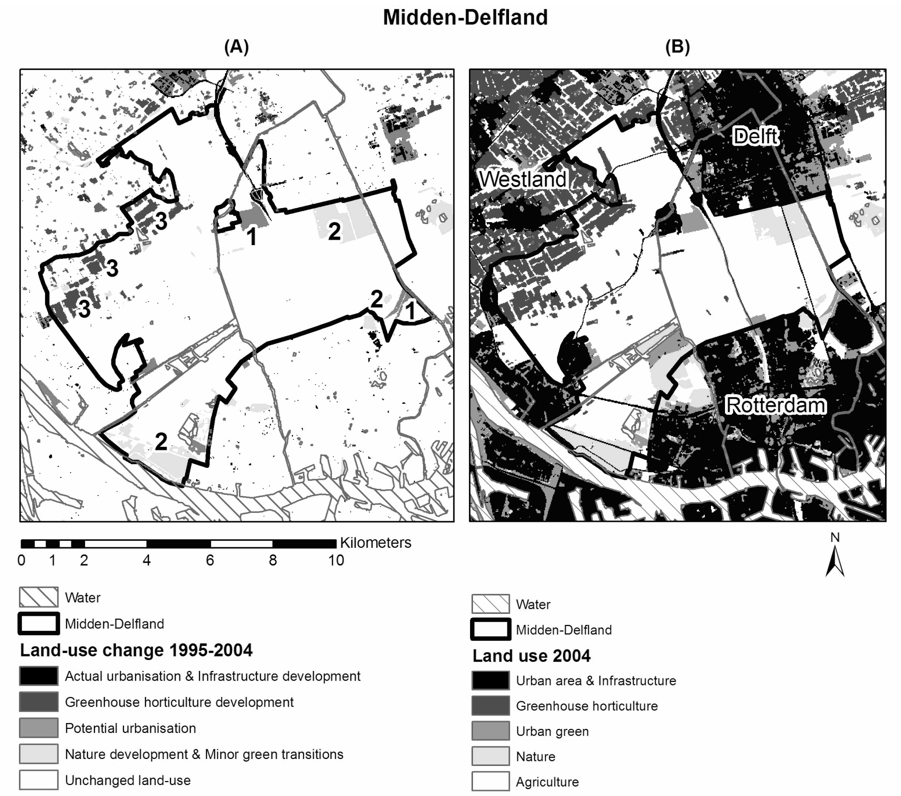

Figure 6-2. Depiction of the land-use changes in Midden-Delfland between 1995 and 2004 mentioned in Table 6-1 (A) and the 2004 land use (B). The numbers are referred to in the text.

From the GIS-analysis we conclude that the policies to preserve open space and to develop recreational areas in Midden-Delfland have been successful, because of the almost absent increase in built-up areas, and the strong increase in nature and recreation areas. With respect to the third aim of the reconstruction project, the improvement of farming conditions for the dairy farming typical of the area, the situation is less positive. Although the land consolidation took place as planned and farming conditions have improved, the conditions for farming are still considered to be poor (Van Rij, 2006). The latter problem can, however, be attributed to general changes in the market for farm products, the land market and agricultural policy

(Bervaes *et al.*, 2001; Ellenkamp, 2002; Koomen *et al.*, 2005). The causes and solutions for these problems can thus only be found at a higher, (inter)national level than the policies studied here apply to.

4. EXPLAINING THE SUCCESS

Considering the apparent success of the Midden-Delfland statute according to the quantitative analysis described before, the question arises whether this conclusion is confirmed by the qualitative research and, more importantly, how the success can be explained from the later research. During the 21 in-depth, semi-structured interviews conducted with local residents and participants in the reconstruction process (members of the Reconstruction Committee, agrarian landowners, civil servants and politicians) different opinions on the project were collected. Central questions were: what were the strengths and weaknesses?; which parties, what decisions and policy-programmes contributed to the results of the project?; what did the stakeholders like and dislike?; what was the effect of the project? The answers help to put the quantitative results of the land-use change analysis into perspective. When asked about the successes and failures of the reconstruction, the interviewed people stated that, despite critique on certain aspects of the reconstruction, the major achievement of the Reconstruction Act was that, unlike other areas in the region, Midden-Delfland has been preserved as an open area (Van Rij, 2006). These interviews and the policy documents analyzed also show how the reconstruction has achieved these results. Corresponding with ideas on successful network management (De Bruijn and Ten Heuvelhof, 2000) this has to do with the content of the plans as well as the process. The content of the plan is discussed below. Then we elaborate on the institutions and funding that facilitate the planning and implementation process. After that the characteristics of the process are discussed.

An important element in the content of the plans was the development of recreational areas on the edges of the cities. The tactical importance of these areas to combat the ongoing urban sprawl was already explicitly considered during the preparation of the Midden-Delfland statute (Ritsema, 1987). In the less threatened areas in the heart of the area farmers could still look after open space. The secretary of the Reconstruction Committee explained the tactical idea behind the content of the plan: to protect open space in Midden-Delfland on the long term, changing the municipal binding zoning plans would not have been enough. In addition, spatial quality needed to be improved and the ownership situation had to be changed. The development of the recreational areas was meant to increase spatial quality (see for example Healey, 1999) and by doing so strengthen the public support for Midden-Delfland as a valuable landscape. The acquisition of the recreational areas served a second goal that fitted in with the idea of changing the ownership situation. The fact that these areas adjoining cities became state property was meant to prevent the area from becoming built-up (Ritsema, 1987). In the Netherlands farmers in urban areas are often willing to sell their land for high prices to property developers or municipalities. Unlike property developers and municipalities, the State Forestry Organization that owns the recreational areas, does not have any intentions to build on these recreational areas and therefore is seen as a preferable landowner in the light of open-space preservation. The realisation of the recreational areas in order to increase the public support for the area and to change the ownership situation was considered such a strong concept that these concepts continue to be an important part of the buffer-zone policy (Bervaes *et al.*, 2001). Although these concepts, that formed the core of the plan, have been strong, they cannot solely explain the success of the reconstruction in Midden-Delfland. In other Buffer zones this concept has been copied, but the preservation of open space has not been as successful (see also Snellen *et al.*, 2006 and Table 6-1). The general trend in the other Buffer zones has been a stronger urbanisation and a lower increase in nature areas. The more limited development of urban green also indicates that less recreational area has been developed in the other Buffer zones, but to which extent recreational areas have actually been developed is impossible to say without additional field surveys. Furthermore, other studies point out that in most other Buffer zones less land has been acquired and developed until now (Bervaes *et al.*, 2001). This raises the question whether the policy applied in Midden-Delfland differed from the approach in other Buffer zones. It is important to note here that for the development of public goods as green area, appropriate institutions and sufficient funds play an important role (VROM-Raad, 2004 and Pestman *et al.*, 2000).

With respect to institutions and funding, Midden-Delfland took a special position compared to the other Buffer zones. The project started before the times of major cutbacks in public expenditure. Being the first project of its kind, total duration and project costs were underestimated. Now, the total costs of the project are estimated at a total of about 200 million euros; 100 million euros for land acquisition, 18 million euros for civil servants and 82 million euros for the implementation of works (Van Rij, 2006). Central Government paid for these costs and, in addition, also finances 40% (roughly one million euros) of the maintenance costs for the recreational area (Groenservice Zuid-Holland, 2005). In line with the retrenchment policy, Central Government recently tried to lower this payment to the Reaction Board, but refrained from doing so in order to avoid paying high compensation. The considerable input of financial and human resources is often mentioned as the reason why the entire approach, although being fairly successful, has not been fully applied elsewhere. Besides this difference in funding, the Midden-Delfland Reconstruction Act also differed with respect to three specific institutions: it offered the possibility of compulsory purchase, it introduced a special procedure in front of the Reconstruction Committee and it had an important communicative effect. Civil servants that executed the Midden-Delfland project often mentioned the statute's possibility for compulsory purchase when explaining the project's success during interviews (Van Rij, 2006). In other Dutch metropolitan green areas this possibility did not exist in this extensive form and it was normally not mapped out at the start. The compulsory purchase option made it much easier to acquire land in Midden-Delfland and to develop this land in compliance with the plan. Apart from this, the Midden-Delfland statute introduced a building approval procedure controlled by the Reconstruction Committee in line with regular Land consolidation Acts. This Committee had no financial interest in property development, unlike the Dutch municipalities that govern normal zoning plans (Korthals Altes, 1995). The procedure thus formed an important additional barrier to building development, in particular in the minds of the people involved. In this way the Reconstruction Committee also played a presumably unintended but important role in strengthening the restrictive zoning ordinances. The Act did not only have formally intended consequences. In interviews the communicative effect of the specific Midden-Delfland statute was often mentioned. This corresponds with the idea that laws often have an important communicative effect (Van der Burg, 2001). The statute very clearly demarcated the zones where building was not allowed.

With respect to process, the fact that the Midden-Delfland project was a pilot project also mattered. In particular during the first stages, it received much political and governmental attention. Its pilot status also secured substantial, hitherto unsurpassed funding as was discussed before. Besides that, in the light of ideas on network management (De Bruijn and Ten Heuvelhof, 2000) the influence of local representatives in the formulation of the basic ideas for the statute and their participation in the plan-making process contributed to the success. The cooperation between all parties involved in the Reconstruction Committee was often mentioned during the interviews as a key factor for the success.

5. CONCLUSION

Preservation of open space in metropolitan regions is a challenge for planners. An examination of the successful approach in Midden-Delfland offers the opportunity to get insight in this complex issue. A quantitative GIS-analysis that compared land-use changes in Midden-Delfland with changes in other buffers zones and in the rest of the Netherlands has shown that two aims of the reconstruction process, the preservation of open space and the development of recreational areas, have been achieved. The activities set out to accomplish the third aim of improving dairy farming condition have had less impact. Because the problems and solutions for this specific agricultural sector stretch beyond the scope of the reconstruction project, we conclude that the reconstruction project, in general, has been a success.

A subsequent, qualitative analysis in the form of in-depth interviews and a policy analysis offered several clues to explain the success. The respondents marked the tactical idea of developing recreational areas at the urban edges to stop sprawl and the availability of sufficient funds and appropriate institutions as reasons for the successful open-space preservation in Midden-Delfland. Institutions that contributed to this success were the possibility for compulsory purchase and a special building approval procedure in front of the Reconstruction Committee. Other important, albeit initially unforeseen, factors of success were considered to be the use, *avant la lettre*, of network management concepts and the communicative aspects of the specific statute.

Looking at the specific local circumstances of the open-space preservation policies in Midden-Delfland it becomes clear that the local success is no guarantee for comparable results elsewhere. The uncertainty about the budgets for the other Buffer zones and the unpopularity of land purchase in recent policy, poses a serious threat to the effectiveness of similar policies at other locations. The continuously weakening economic position of farmers in metropolitan areas is a further threat to open-space preservation, that, without proper (inter)national countermeasures, can eventually undermine their current local success.

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Chapter 7

INDICATORS OF RURAL VITALITY[1]

A GIS-based analysis of socioeconomic development

Abstract: Concern for the socioeconomic vitality of rural areas has stimulated various development programmes. This paper proposes a methodology to quantify the policy concept of rural vitality following a strict socioeconomic interpretation. The use of a Geographical Information System (GIS) and highly detailed spatial data are crucial in this approach that allows the assessment of the structural characteristics and performance of countryside vitality in the Netherlands. The study shows that developments as regards population, employment and facilities in small settlements in the generally well-accessible Netherlands do not differ greatly from the national trends. The results thus question the basis for the specific rural development objectives of the new National Spatial Strategy.

Key words: Rural vitality; socioeconomic development; small settlement; indicator; geographical information system; the Netherlands.

1. INTRODUCTION

Many people consider that the vitality or socioeconomic potential of rural areas is at risk. In particular, the continuously decreasing importance of the agricultural sector in many western countries (see, for example, Van der Ploeg, 2006) has led to serious concern about the socioeconomic prospects of predominantly rural areas. Especially the rural areas in the more remote parts of the EU "are still being depleted of population and economic activity through cumulative self-perpetuating cycles of decline" (Copus *et al.*, 2006). This decline, by the way, has many more causes than a decreasing importance of agriculture alone. The concern about rural vitality has

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motivated the initiation and continuation of various rural development programmes including the EU's reformed Common Agricultural Policy (CAP) and LEADER initiative. The new Dutch National Spatial Strategy also has the specific objective of improving rural vitality that is believed to be at stake in various areas in the country (VROM *et al.*, 2004). In fact, improving countryside vitality is considered such an important issue that a related policy agenda and execution program have been drafted (LNV, 2004; LNV *et al.* 2007). The current analysis aims to capture the essence of the concept of 'rural vitality' and, furthermore, describe its current state and development over time in The Netherlands. The analysis was commissioned by the Netherlands Ministry of Housing, Spatial Planning and the Environment as part of the evaluation of their National Spatial Strategy. It is interesting to note that this important policy document neither exactly defines the concept of rural vitality nor explicitly specifies where vitality problems occur. The assumed decline in vitality is specifically associated with a decreasing local importance of agriculture that, amongst others, causes agricultural buildings to become vacant (VROM *et al.*, 2004). The Spatial Strategy and related agenda and program, furthermore, lack a clear description of the proper instruments to improve rural vitality, but the policy documents stress the importance of providing rural communities with ample opportunities for residential and economic development. These policy guidelines do not distinguish between peripheral and more central rural areas and aim to improve conditions in all rural areas. Seeing the uncertainties mentioned above this paper centres around three research questions: 1) Can the concept of rural vitality be quantitatively describes? 2) What is the current state of this vitality? And 3) How did this develop in the period preceding the implementation of the new Spatial Strategy, when more severe spatial restrictions were supposedly hampering the rural development potential?

The presence of specific rural development policies indicates that the long-lasting academic debate questioning the actual existence of rural areas (e.g. Friedland, 1982; Mormont, 1990) has bypassed policy makers. The current paper does not participate in this debate, but rather follows the point of view of Léon (2005) and "describe the rural world as a geographical reality characterized by low population density and where the relative abundance of land and natural resources leads to a specific combination of built areas and open spaces". This is very much in line with the functional concept of rurality described by Cloke (2006) that is characterized by the presence of extensive land uses and small lower-order settlements. More specifically, the current analysis of rural areas is limited to small settlements with less then 2000 residences and their surrounding open (non-built-up) areas. This definition is comparable to the one favoured by the US Census

Bureau that classifies places with fewer than 2500 residents and open territory as rural areas (USDA, 2007).

The current paper first introduces the methodology of the research in Section 2, which describes, in turn, this interpretation of the concept of rural vitality, the selected set of indicators, and the spatial definition of the small settlements that constitute the spatial units of the analysis. Section 3 then presents and analyses the results for the rural Netherlands in comparison with the average national trends. Finally, Section 4 draws a general conclusion and discusses the policy implications of the outcomes of the study and how they compare with similar (inter)national studies. A more comprehensive description of this research, which also contains an analysis of regional policy and an in-depth discussion of five local case study areas, can be found in Smaal *et al.* (2005a; 2005b).

2. METHODOLOGY

'Rural vitality' is a rather broad concept that hints at the potential of rural areas to overcome possible problems, such as the diminishing importance of agricultural production, and to function as relatively independent entities that survive without substantial external support. It is related to equally vague and popular terms like 'sustainability' and 'liveability'. This study gives a socioeconomic interpretation of the concept of vitality that allows for a relatively straightforward, quantitative temporal analysis. It thus refrains from including issues such as social cohesion and community identity that are more difficult to quantify and therefore lack the availability of temporal series of detailed (spatial) data.

In this socioeconomic interpretation three main attributes are distinguished: 1) population/ demography; 2) economic activity; and 3) available facilities. These attributes are measured in terms of structure (actual state) and performance (development over time), providing an interrelated 3 x 2 matrix, comparable to the analysis of socioeconomic sustainability offered by Copus and Crabtree (1996). For each of the six cells in the matrix, one or more related indicators are selected that quantify the distinguished socioeconomic attributes (Table 1). More specifically these are:

Number of residences: indicating the size of the settlement and, by approximation, its number of households. In accordance with spatial policy this is an especially meaningful indicator because it relates to the intention of the National Spatial Strategy to provide ample room for natural population growth in rural areas and thus maintain rural vitality. These data are obtained from the dwelling stock statistics of Statistics Netherlands (CBS, 2007) and are coupled to the centre points of six-digit postal code zones that correspond to (part of) a street with, on average, 16 residences.

Employment: described here as the total number of jobs per settlement and thus directly related to the strength of local economic activity. The derived performance indicator characterising local employment growth is particularly interesting since it is closely linked to the policy objective of job creation (Terluin, 2001). The data for this indicator originate from the yearly national inventory of workplaces and are also available at the level of six-digit postal code zones. This data set lists the type of activity, number of employees and place of business of individual companies, institutions and self-employed workers (LISA, 2002). To describe total employment in a settlement the numbers of employees from all types of activities are added up.

Age distribution: related to the issue of vitality through the share of young people (0-15 years) that offer promise for the future, and the share of elderly (65+ years) people that supposedly characterize less vital communities. These demographic data are taken from the key figures of districts neighbourhoods collected by Statistics Netherlands that have been combined with a geographical data set delineating these areas (Geodan, 2003). The spatial level of these data is coarser than that of the other data sets that are available at the six-digit postal code level. Neighbourhoods are roughly equivalent to small settlements, but they can also be larger or smaller.

Available facilities: characterized by the number of basic facilities (retail outlets, schools, catering establishments, basic medical services and bank/post offices), the presence of which indicates the liveliness and attractivity of settlements. The data on available facilities is also taken from the yearly national inventory of workplaces. In this case, the number of individual companies, institutions or self-employed workers belonging to each of the distinguished types of facilities are counted irrespective of their size.

Table 7-1. Overview of the attributes of rural vitality and their structural and performance dimensions in which they are studied

Attributes	Structure	Performance
Population/demography	Number of residences	Rate of change [%]
	Age distribution	Rate of change [%]
Economic activity	Employment	Rate of change [%]
Available facilities	Number of basic facilities (retail outlets, schools, catering establishments, basic medical services, bank/post offices)	Rate of change [%]

By comparing the socioeconomic structure in different years (1996 and 2000) it is possible to provide an overview of the rural vitality performance since the time of the much-criticized restrictive spatial policy of the Fourth Physical Planning Report (VROM, 1989). The supposed loss of rural vitality is often linked to the many spatial restrictions in rural areas and has given rise to the change in spatial policy laid down in the current National Spatial Strategy that aims to give the countryside more scope for development.

The current analysis relies on the use of a Geographical Information System (GIS) and highly detailed spatial data that enable individual small settlements to be distinguished. These are defined here as: continuous built-up areas with a minimum of 5 hectares and containing 11-2000 residences. The starting point in this definition of small settlements is a geographical data set that describes built-up areas, which is derived from the spatial land-use database of the Central Bureau for Statistics (CBS). This data set considers as built-up areas: primary urban areas of every kind (residential areas, retail, business and industrial areas) and the functions related to the urban area (various facilities, dumping sites, parks, cemeteries, recreational areas, et cetera) as far as these are enclosed within the primary urban area. Furthermore, built-up areas have to cover at least 5 hectares. An extensive description of the way the basic built-up area file is established can be found in Odijk *et al.* (2004). In addition, this data set considers as open (non-built-up) areas: water, agricultural zones, nature reserves, airports, building sites and sites with recreational accommodation areas.

Built-up areas that are quite close together (within 500 metres) and, as such, can be supposed to be a coherent village area have been combined in this study by means of a buffer operation in a standard desk-top GIS. The (combined) built-up areas that have a minimum size of 5 hectares are then selected and used to aggregate the various fine-level socioeconomic attribute data sets relating to, for example, number of residences and jobs. The aggregation is a straightforward procedure for the data that are available at the level of the centre points of the six-digit postal code zones. In order to correctly assign the coarser neighbourhood-level demographic data to the settlements the age distribution statistics are first assigned to the individual six-digit postal code zone centre-points located in a neighbourhood. Subsequently, these values are averaged per individual settlement. This approach has the limitation that it ignores possible differences in the number of inhabitants per postal code zone needed to correctly weigh the importance of each of these zones. The demographic statistics are, furthermore, assumed to have a homogenous spatial distribution within a neighbourhood. Without more detailed data, however, the current approach provides the most accurate results possible. By way of example, Figure 7-1 illustrates the different spatial levels of the available data sets. All available data sets refer to 1996 and 2000, apart from the demographic data for which the best possible alternative years were selected (1995 and 2001 respectively).

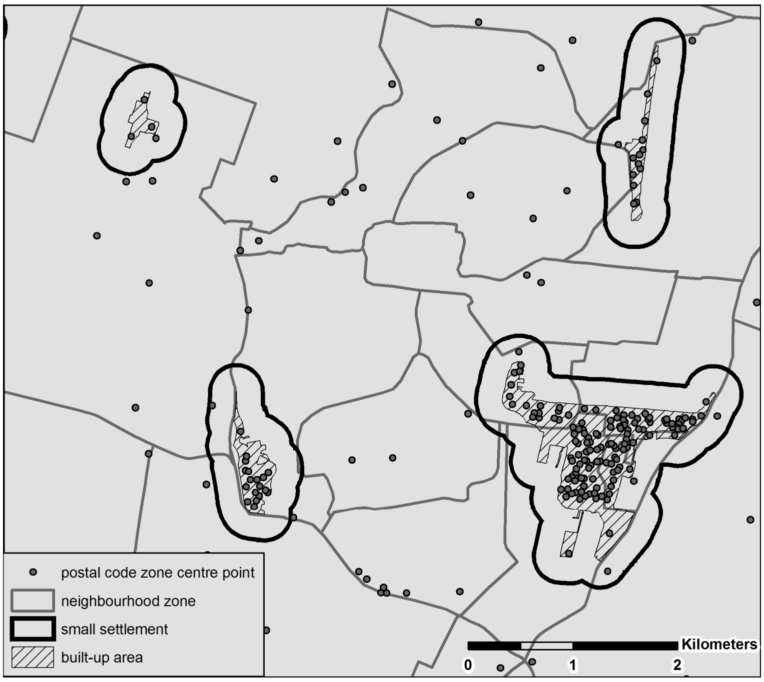

Figure 7-1. Different levels of spatial detail in the included data sets.

Small rural settlements are then considered to be those built-up areas with 11-2000 residences in the year 2000, excluding residences meant specifically for recreation (holiday homes) or group accommodation (student housing complexes, et cetera). Small settlements that have a predominant employment function have also been left out of this analysis. These concern fairly extensive business and industrial areas with relatively few residences, in this case those that have a jobs-to-residences ratio of 20:1 or more, which cannot really be considered small (village) settlements. By deliberately constructing a spatial reference data set of small settlements according to a meaningful definition, it becomes possible to analyse rural vitality at the level where it matters. This approach has the advantage of not having to perform the analysis at the level of existing administrative units that are generally considered to be rather arbitrary (Cloke, 2006). The relevance of the local, settlement level is questionable for phenomena such as employment and service level, as most inhabitants in possession of a car will be able to travel the nearest (larger) settlement that provides the needed employment or wanted services. Nevertheless, the settlement level is chosen as vitality problems are supposed to occur at this level (VROM *et al.*, 2004). The selection of services is, furthermore, restricted to the basic services that are considered vital for local communities.

To reflect the diversity within the small settlements a subdivision is made, based on the number of residences per settlement. A distinction into five size groups is established, each group having roughly the same number of settlements. In order to place the analysis of the settlements in a broader perspective, the results have also been included for the average over all small settlements (11-2,000 residences) and, by way of reference categories, the medium-sized settlements with 2,001 to 8,000 residences, and the Netherlands as a whole are included. The picture of the countryside is completed by the (total) figures for the open area outside the settlements. This area also contains built-up areas smaller than 5 hectares and larger ones with less than 10 residences (small hamlets). Although the open areas are part of the rural Netherlands, they are of less interest for this study, as the supposed lack of vitality is mainly expected to manifest itself in the small settlements.

3. RESULTS

3.1 Population/demography

Table 7-2 shows the structural and performance dimensions of the population indicator. On average, the number of residences in the Netherlands has increased by 5 percent and in the small settlements by 10 percent in the survey period (1996-2000). In the smaller settlements (101-500 residences) the average increase is largest. In other words: villages are growing faster than the rest of the country. In the open area the number of residences has only increased by 2 per cent. The vigorous building in the countryside seems to be in contradiction with the pursuit of the long-standing policy to preserve open space (RNP, 1958; V&B 1960) and compact urbanisation (V&RO, 1977; VROM, 1989) and the general feeling that building is close to impossible in the countryside.

Earlier studies, however, also point in the same direction as this study. The Balance spatial quality 2000 (VROM, 2000) describes an even stronger increase of residential addresses in the open, rural areas in the period 1990-1999. This increase is stronger because of differences in the used base data and the applied definition of open areas, but nonetheless confirms the observation that significant building activities are occurring in the Dutch countryside. A similar conclusion is drawn in another recent study that uses more detailed spatial data (MNP, 2004). What is particularly interesting is that this study points out that the percentage increase of addresses is higher in the small settlements than in the villages and small towns. The increase is by far the smallest (about 3 per cent) in the open areas outside the built-up area, which is in accordance with the general spatial planning philosophy that such areas should be protected. Specific studies on the impact of the restrictive zoning policies that concern substantial parts of the rural areas in the contested western part of the country point out that building activities are less widespread here, but not fully absent (Bervaes *et al.*, 2001; Gies *et al.*, 2005; Koomen *et al.*, 2008). So restrictive policy in the form of clear zoning regulations does work, but only moderately. The relatively strong increase in residences in the small settlements observed in this analysis is thus expected to occur especially in those vast parts of the countryside that are not part of specific restrictive zoning regulations.

Table 7-2. Number of residences by settlement size group (average per settlement), the open area, and the Netherlands as a whole (absolute figures) and their performance (percentage change 1996-2000)

Settlement size	N	Nr of residences 1996	Nr of residences 2000	Change [%]
11-100	175	50	56	13
101-250	332	159	180	13
251-500	396	309	363	17
501-1000	291	647	704	9
1001-2000	215	1363	1448	6
11-2000	*1409*	*472*	*518*	*10*
2001-8000	231	3757	3978	6
open area		306,027	312,524	2
the Netherlands		6,276,066	6,589,699	5

Source: Statistics Netherlands (CBS, 2007).
Note that the column headed 'N' indicates the total number of settlements per size group.

Figure 7-2 shows that the structural dimension of the age distribution of the population in small settlements is nearly equal to the national average. Small settlements and especially the open area contain relatively more persons in the 0 to 14 year age bracket and fewer persons aged over 65 years. This contradicts the current expectation that the rural area has aged more considerably than the rest of the Netherlands.

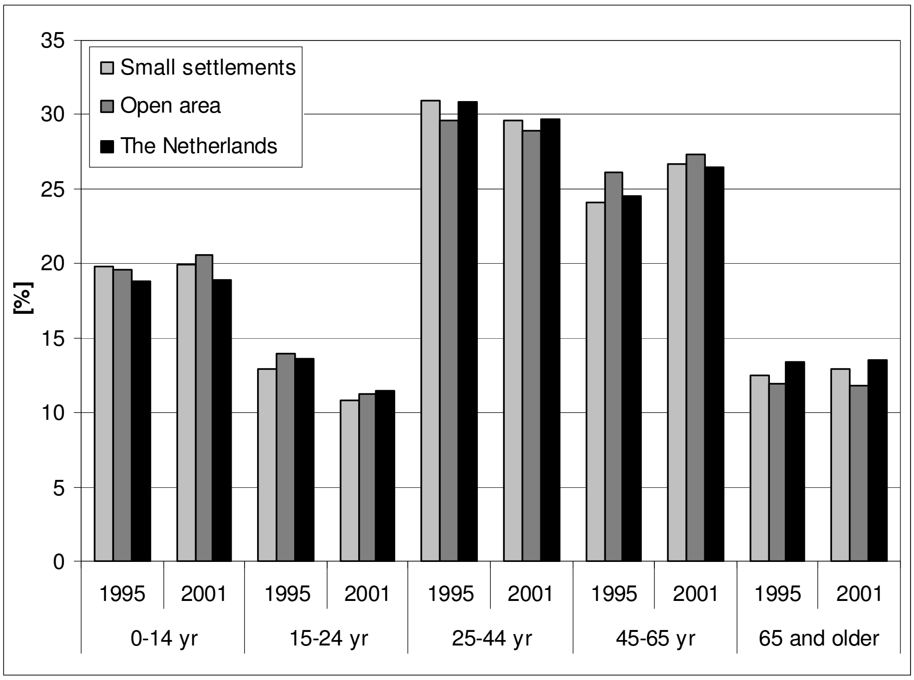

Figure 7-2. Structural dimension of age distribution in small settlements, the open area, and the Netherlands as a whole for the years 1995 and 2001. Source Statistics Netherlands/ Geodan (2003). The figures on the y-axis indicate percentage of total population.

An analysis of the demographic performance in the period 1995-2001 (Table 7-3) shows that the percentage of persons aged 45-65 (the baby-boom generation) and older than 65 has increased faster in the small settlements than in the rest of the Netherlands. So, in fact, the proportion of aged, although still lower than the national average, is increasing relatively. Possibly the increase of the ageing population will materialize here more strongly in the future. The proportion of the age bracket 15-24 years is decreasing throughout the Netherlands, but more strongly in the open area than in the small settlements and the Netherlands as a whole. So it is not true that this age group is decreasing faster in the small settlements than in the whole of the Netherlands, even though that is often supposed to be the case. Incidentally, these developments are very significant for housing policy: especially for aged people more specific housing will have to be provided. A more extensive analysis of the demography and further intricacies of the applied methodology are discussed in Smaal *et al.* (2005b).

Table 7-3. Age distribution performance in 1995-2000 by settlement size group, open area, and the Netherlands as a whole (percentage difference)

Settlement size	0-14 years	15-24 years	25-44 years	45-64 years	65 and over
11-100	0.2	-2.4	-1.1	2.8	-0.3
101-250	0.4	-2.4	-1.1	2.6	0.2
251-500	0.0	-1.9	-1.4	2.8	0.3
501-1000	0.2	-2.0	-1.5	2.7	0.5
1001-2000	0.1	-2.1	-1.6	2.4	1.2
11-2000	0.1	-2.1	-1.4	2.6	0.5
2001-8000	-0.1	-2.2	-1.5	2.2	1.3
open area	0.2	-2.1	-1.1	1.9	0.1
the Netherlands	1.0	-2.7	-0.6	1.3	-0.1

Source: Statistics Netherlands/ Geodan (2003).

3.2 Economic activity

The structural dimension of economic activity in small settlements differs considerably from the country as a whole. Small settlements both absolutely, as well as relatively, offer less employment than the rest of the Netherlands (Table 7-4). The lesser settlements (101-1000 residences) have roughly 1 job for every 2 residences, while for the medium-sized settlements (2001-8000 residences) and the whole of the Netherlands the ratio is about 1:1. The reason that the smallest settlements (11-100 residences) have relatively more jobs is mainly because they contain some relatively large industrial or business areas.

It is particularly remarkable that the employment performance in various-sized settlements, as well as in the Netherlands and the open area, is nearly the same. There is no reason then to suppose that the development of employment in the small settlements is less favourable than the national average. It will not do, however, to overestimate the importance of local employment. Many employees are willing to commute to their work and settlements with more than 2000 residences are a short distance away from almost any smaller settlement in the country.

In the above-mentioned analysis, employment in the agricultural sector has not been considered, as there are no reliable data available at this level of detail. National statistics show that, within the period 1996-2000, the number of jobs in the agricultural sector has decreased by about 10,000. This decrease will have mainly taken place in the open area, but is relatively low compared with the total increase in other employment of over 40,000 jobs in that same area.

Table 7-4. Employment by settlement size group (average per settlement), the open area, and the Netherlands as a whole (absolute figures) and their performance (percentage difference 1996-2000)

Settlement size	Number of jobs 1996	Number of jobs 2000	Change [%]
11-100	79	88	12
101-250	82	94	15
251-500	180	206	15
501-1000	334	377	13
1001-2000	853	956	12
11-2000	279	315	13
2001-8000	3082	3505	14
open area	271,327	313,398	16
the Netherlands	5,995,670	6,830,006	14

Source: LISA (2002).

3.3 Facilities

The availability of basic facilities is considered an important indicator of the quality of life in rural areas, and thereby their potential to sustain their population level and possibly attract new residents. The relevant services selected were: retail outlets (shops), schools, catering establishments (cafes, restaurants, hotels), basic medical services (general practitioner's practice), banks or post offices. The structural dimension of the facility level is, as was expected, directly related to the size of the settlements (see Table 7-5). Only when a settlement has more than 1,000 residences is it, on average, likely to have at least one basic medical service. Most of the settlements with less than 500 residences lack banking or postal facilities. The smallest settlements with less than 100 residences, on average, also have no schools. But other facilities (retail outlets and catering establishments) are available in most cases.

Regarding the development of the countryside's vitality, it is especially interesting to see its performance in facility level (Table 7-6). It is important to note that the indicated performance is generally related to very small absolute differences in the level of facilities. Within the smallest settlements (11-100 residences) often only two or less individual facilities disappear or appear in the period 1996-2000. These specific cases have been put between brackets and are not taken into account.

On average, the development of the level of facilities in the small settlements is keeping pace with the trends applying for the Netherlands as a whole: the number of retail outlets (shops), schools and banks/post offices is slightly decreasing, while the number of catering establishments and basic medical services is increasing a little. The smaller settlements (101–500 residences) usually develop less favourably than the greater small settlements (1001-2000 residences). This survey suggests that the small settlements are, on average, subject to the same general socioeconomic factors (such as increase in the scale of retail businesses and schools, reduction of the bank networks) as the rest of the Netherlands and do not have their own, more negative, dynamics.

Table 7-5. Level of facilities by settlement size group (average per settlement), the open area, and the Netherlands as a whole (absolute figures) in 1996 and 2000

Settlement size	Retail outlets		Schools		Catering establishments		Basic medical services		Bank or post offices	
	1996	2000	1996	2000	1996	2000	1996	2000	1996	2000
11-100	0.5	0.6	0.2	0.2	0.5	0.6	0.0	0.0	0.0	0.0
101-250	1.6	1.5	0.9	0.8	1.3	1.3	0.1	0.1	0.2	0.2
251-500	4.1	3.9	1.2	1.2	2.6	2.7	0.3	0.3	0.7	0.6
501-1000	9.9	9.5	1.7	1.7	4.7	4.9	0.8	0.8	1.2	1.1
1001-2000	22.5	22.3	2.7	2.7	7.8	8.2	1.4	1.4	1.8	1.7
11-2000	*7.1*	*6.9*	*1.3*	*1.3*	*3.2*	*3.4*	*0.5*	*0.5*	*0.8*	*0.7*
2001-8000	70.4	70.4	8.3	8.0	20.4	21.0	3.0	3.2	4.1	3.7
open area	2650	2876	457	456	2344	2492	57	56	53	47
the Netherlands	105009	103494	13560	13220	36676	37782	4522	4705	5005	4488

Source: LISA (2002).

Table 7-6. Facility level performance in 1996-2000 by settlement size group, the open area, and the Netherlands as a whole (percentage difference)

Settlement size	Retail outlets	Schools	Catering establishments	Basic medical services	Bank or post offices
11-100	5	(3)	(1)	(0)	(-25)
101-250	-8	-5	(1)	(11)	-30
251-500	-6	-2	2	3	-17
501-1000	-4	1	4	3	-10
1001-2000	-1	-2	6	1	-7
11-2000	*-3*	*-2*	*4*	*2*	*-12*
2001-8000	0	-4	6	7	-9
open area	9	(0)	6	-2	-11
the Netherlands	-1	-3	3	4	-10

Source: LISA (2002).

Nevertheless, the national data considered here tend to obscure the local impact that the described developments can have. A reduction in the number of schools by 5 per cent, as can be seen for the settlements with 101-250 residences, may seem negligible, but it does mean the disappearance of three schools in four year’s time. It is likely that three small settlements will have been wholly deprived of schools in this period. These incidental occurrences are of great importance for the local perception of rural vitality. When such occurrences are reported in the media, they feed the image of a dwindling countryside.

Concerning the figures discussed here, it should also be mentioned that the number of residences per small settlement has increased by 10 percent on average. So this implies that the number of schools and shops per house has decreased faster (except in the open area).

3.4 Regional variability

Socioeconomic development in rural areas and small settlements can generally be linked to the proximity of larger urban areas; the more accessible rural areas tend to perform better in various socioeconomic phenomena than the more remote rural areas (UK Cabinet Office, 2000; USDA 2005; 2006; Copus, 2006). To test this situation for the Dutch situation five different rural regions in different parts of the country are compared to the average development (Figure 7-3).

The regions are defined at the spatial level of intermunicipal cooperation regions following the Intermunicipal Statutory Regulations Act (WGR: Wet Gemeenschappelijke Regelingen). Municipalities in these regions have formally agreed to cooperate on various issues that may differ per region. The regions range in size from 306 to 837 km2 and have about 150,000 to 220,000 inhabitants. Three regions (Oost-Groningen, Oosterschelde and Kop van Noord-Holland) were selected because of their location at the periphery of the country. Their population densities lie well below the national average of 473 inhabitants per km^2. By way of comparison, two regions are included with a more central location, either in the vicinity of the second biggest city in the country (Midden-Holland) or near a series of smaller cities (Rivierenland). These regions have a higher population density. All regions have at least one central settlement with more than 8000 residences. To facilitate an easy comparison between the regions, the percentage differences of each vitality attribute in the survey period are classified with respect to the averaged national change. This straightforward approach only indicates whether the local developments are more favourable (i.e. a stronger increase in, for example residences and jobs or a decrease in the share of elderly people) or less favourable than the average. Differences of less than one 1% are indicated with a '0'. The applied method does not state the degree of deviation from the average.

The socioeconomic performance described by this set of indicators differs strongly between the selected regions (Table 7-7). Within the regions we, furthermore, find marked differences between the small settlements and surrounding open areas. This points, foremost, at the fact that the observed developments are related to an accumulation of coincidental events. The relocation or closure of one local firm, or the development of a small new neighbourhood has a significant impact on the regional statistics that rely on relatively few settlements. On the whole, the Oosterschelde, Oost-Groningen and Rivierenland regions seem to perform better than the national average, whereas Midden-Holland and Kop van Noord-Holland show less favourable developments.

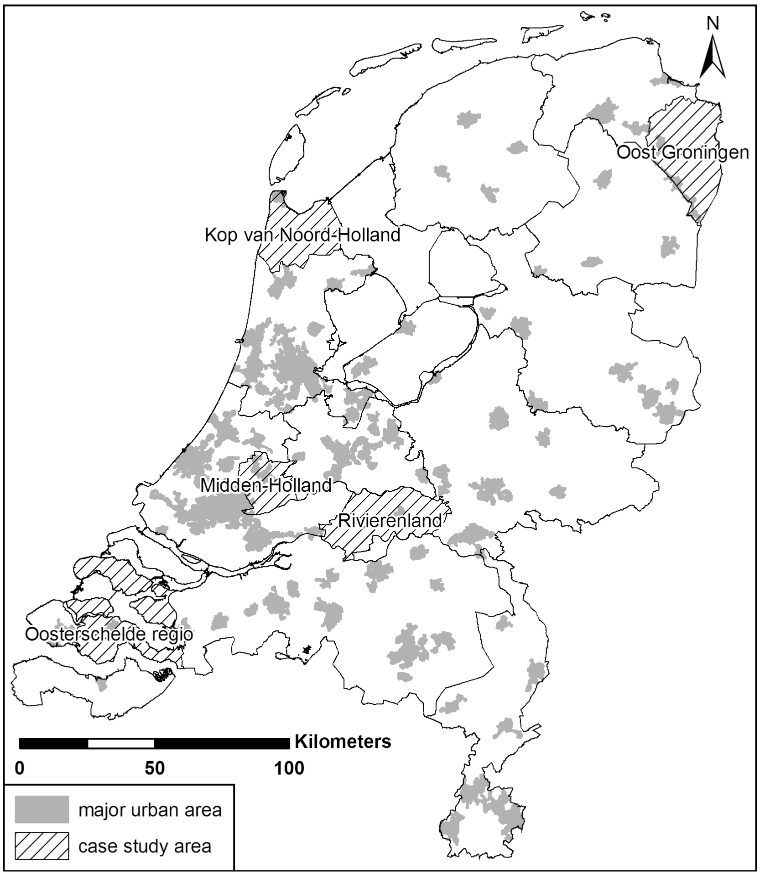

Figure 7-3. The five case study regions and major urban areas in the Netherlands.

In the interviews that were conducted by Smaal *et al.* (2005b) as part of this rural vitality study the relevant regional stakeholders put the general image that the vitality in their regions is at stake into similar perspective. In fact, the regional and local administrators in the relatively peripheral regions of Oosterschelde, Oost-Groningen and Kop van Noord-Holland state that their rural areas are not facing vitality problems. Stakeholders in the more centrally located Rivierenland and Midden-Holland regions, on the other hand, fear a shortage of residences and a decline in service provision. Interestingly, the results of quantitative analysis based on the set socioeconomic indicators and the more qualitative interviews do not match completely. This may be due to the fact that perception of vitality varies per person and indicates the general difficulty in making the rather general concept of rural vitality concrete. The selected case studies do, however, not indicate that socioeconomic vitality develops less favourably in more remote areas. It should be noted here that peripheral areas in the Netherlands can be considered well accessible compared to many other, less densely populated countries.

Table 7-7. Performance (percentage change 1996-2000) in five rural regions compared to the national average

Region	Population density [inh./km^2]	Spatial level	N	Percentage difference (1996-2000)						
				residences	jobs	0-14 yr.	65+	shops	catering establ.	total
Midden-Holland	718	small settlements	12	-	0	0	-	-	+	--
		open area		-	-	0	-	-	+	---
Rivierenland	328	small settlements	61	+	+	0	0	-	0	+
		open area		-	+	0	0	-	+	0
Oosterschelde	186	small settlements	58	+	-	0	0	-	-	---
		open area		-	-	+	+	+	+	++
Oost-Groningen	184	small settlements	31	+	-	0	0	-	+	0
		open area		-	+	0	+	-	+	+
Kop Noord-Holland	262	small settlements	24	0	-	0	0	-	-	---
		open area		-	-	0	0	+	-	--
The Netherlands	473	average [%]		5	14	0.2	0.1	-1	3	0

Sources: CBS (2007), Geodan (2003), LISA (2002).
The differences are classified as being positive (+), negative (-) or smaller than 1% (0).

4. CONCLUSION AND DISCUSSION

The methodology presented in this analysis allows for a quantitative assessment of the socioeconomic vitality of the small settlements and surrounding open areas in the Netherlands. Following this socioeconomic interpretation, it is possible to actually measure this broad policy concept, quantitatively assess its actual state in relation to various reference categories, and analyse its development over time. If the themes of housing, employment, demography and level of facilities are considered important conditions for vitality, it can be concluded that their structural characteristics and performance development are no different in the rural Netherlands than in the rest of the country. Or to put it even more strongly: on the basis of the indicators submitted here it cannot be concluded that the general vitality of the countryside is deteriorating within the period considered. This is in contradiction with the National Spatial Strategy (VROM *et al.*, 2004) that introduces this policy concept and states that the quality of life and vitality of various, more rural areas, are deteriorating, as a consequence of the continuous decrease in the number of agricultural businesses. This analysis questions which form of vitality is meant in the National Spatial Strategy and on what developments the recorded deterioration is based. Furthermore, the suggested link with the decreasing agricultural activity is weak. The remaining local employment has shown an appreciably greater increase, within the studied period, than the actual decrease in agricultural employment. In fact, the general spatially non-explicit policies hinted at in the policy agenda and execution program related to the National Spatial Strategy seem to lack a foundation in the observed rural developments. At specific locations and for certain socioeconomic groups the vitality of their rural surroundings may indeed be at stake, but in order to formulate sensible spatial policies a more precise definition of the problems at hand is needed.

The use of GIS proved to be essential in this analysis. Its spatial analytical capabilities allowed the detailed reconstruction of the small settlements that are at the heart of this approach. The availability of several highly detailed socioeconomic data sets for different time steps made it possible to build a time series of vitality indicators. With the power of contemporary personal computers, it becomes possible to integrate and process the large amounts of spatial and tabular data for the whole country

Obviously, some critical comments in interpreting the results in figures are called for. First, the submitted figures only represent the average development for all small settlements in the Netherlands. It is important to consider the fact here that situations can greatly differ regionally and especially locally: a facility will appear in one settlement, while it will disappear in another. The national trends only represent the net balance of all local developments. They do, however, indicate which changes are structural and, as such, are relevant to policy. A good insight into the local situation is essential, however, for actually formulating a workable policy. A second comment relates to the fact that, in this research, the indicators are a simplified rendering of the socioeconomic phenomena behind them. For example, jobs represent employment and the number of facilities represents the availability of basic facilities. The size and quality of the facilities concerned, however, are being ignored. As regards schools, either a small primary school or an extensive institution for secondary education could be involved. Likewise, a local shop has the same importance in these analyses as a large supermarket. Simply adding up these facilities and setting the figures side by side for different years then comes close to comparing apples and oranges. Again, it implies that the observed trends only give a rough indication of the possible national developments. Thirdly, the time sequence in this research (1996-2000) is rather short. When more recent data become available, the applied set of indicators can be better utilized to trace the development of the small settlements over the course of time.

However, notwithstanding the drawbacks mentioned above, the conclusions in this analysis correspond to a recent, comparable investigation in the Netherlands (Van der Reijden *et al.*, 2002). That study on developments in small settlements for the period 1990-2000 used a different definition of small settlements (as locations with 500 to 5000 inhabitants), but reaches similar conclusions as regards the increase in residences and businesses, the decrease in shops and schools, and the relatively low share of elderly people. These findings that development in the rural zone does not differ greatly from that of the Netherlands as a whole are also consistent with the findings of other research into the economy of the Dutch countryside (Bauwens and Douw, 1986; Terluin *et al.*, 2005). The latter study concludes that the socioeconomic differences between the urban and rural groups of administrative regions in the country are limited; their indicators, at the moment, do not give cause for great anxiety about the socioeconomic development in rural regions.

The relatively favourable development of rural areas described here for the comparatively urbanized country of the Netherlands is, interestingly enough, comparable to the situation in similar rural areas in other, developed countries. The United States Department for Agriculture states that: “The U.S. economic environment is quite favorable for rural areas” (USDA, 2005). Rural population growth is, on average, below that of metropolitan areas, but shows strong regional differences: the rural counties adjacent to metropolitan ones grew considerably, whereas the more remote counties showed a population decline (USDA, 2006). The relatively highly urbanised UK also experiences population and employment growth in its more accessible rural areas (Ward, 2000; UK Cabinet Office, 2000). Even its most remote corners show little evidence of any relationship between remoteness and levels of economic activity (Copus and Crabtree, 1996). This may, in their opinion, be partly attributed to the regional policies funded by the national Government and European structural funds. The overall favourable development in these regions may, however, obscure the fact that problematic situations may exist for specific locations and especially for certain low-income, less mobile cohorts of the community (Higgs and White, 1997; White *et al.*, 1997). In fact, numerous inventories of rural development in Europe indicate a growing dichotomy between the more accessible regions that perform rather well in terms of population growth and economic development and the more peripheral regions that lag behind (Terluin and Post, 1999; Copus at al, 2006). The rural areas in the relatively well accessible Netherlands clearly belong to the former group that performs rather well.

A recent, extensive survey analysed several quality of life aspects in 28 European countries indicators and sheds an interesting light on the local perceptions of rurality. This study focused on the urban-rural differences (Shucksmith *et al.*, 2006) and reveals that the perceived rurality and the degree of urbanisation according to the official statistics may deviate strongly. In most countries people perceive their environment as being more rural than follows from the statistics. This points to an interesting discrepancy between the formal description of rural areas and the way these are perceived by a local people (as described in Shucksmith *et al.*, 2006). A comparable discrepancy is found between our socioeconomic analysis of rural vitality and the national policy makers' perception of this issue. These significantly differing viewpoints give rise to potentially heated, but unproductive debates that can only be prevented by agreeing upon common definitions of the relevant concepts. The conceptualization of the rural vitality theme presented here can hopefully provide a starting-point for a more fruitful discussion on the future of our rural areas.

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PART III: SIMULATION OF FUTURE SPATIAL DEVELOPMENTS

Chapter 8

SIMULATING THE FUTURE OF AGRICULTURAL LAND USE IN THE NETHERLANDS[1]

Abstract: The agricultural sector in the Netherlands has lost much of its importance over the last 50 years in terms of the number of people involved and its relative contribution to the economy – even though production is still increasing. Yet, the area under agricultural use has changed relatively little: farmland still dominates the country. The question for the future is how expected further changes in agriculture will affect agricultural land use: how much land will be taken out of production and to what use it will be put. This is especially relevant now that the Dutch government has decided to loosen its grip on spatial planning. Two opposing socioeconomic scenarios are therefore drafted that offer a coherent view on agricultural change, external pressures and government intervention. Implementing these in a land-use simulation model provides an initial answer to the possible future of agricultural land in the country.

Key words: Agriculture; the Netherlands; land-use modelling; scenario analysis; spatial planning.

1. THE PROBLEM

Space is scarce in the Netherlands. Not only is it one of the most densely populated countries in the world, but economic growth has led to an ever-increasing demand for space for residence, business, recreation and infrastructure. In recent years the goal of establishing a system of interconnected nature areas has added to these demands. Yet a further addition is the need to allocate space for buffering water following new integrated water management policies.

[1] This chapter is reproduced with kind permission of Blackwell Publishing and is published as Koomen, E., Kuhlman, T., Groen, J. and Bouwman, A. (2005) Simulating the future of agricultural land use in the Netherlands, *Tijdschrift voor Economische en Sociale Geografie* 96 (2): 218-224.

In spite of these pressures, two thirds of the land area is still in agricultural use. The Netherlands with its small area is one of the world's largest exporters of agricultural products by value, and in those fields in which it has specialized (such as flowers, vegetables, dairy, pigs, poultry and potatoes) few countries can match the productivity of Dutch farmers.

However, recent developments and prospects for the future are less rosy. Farm incomes have remained behind those in other sectors, and at the same time the sector has come under increasing pressure from society to reduce its negative impact on the environment - through eutrophication of the water, ammonia in the air, use of energy in greenhouses, soil subsidence, and making the landscape more monotonous. Moreover, the protective regime under which farming in the EU has been for so long is under pressure to reform. Such pressures may well lead to a decline of agricultural claims on land.

The question is what such a change will mean for the character of the Dutch countryside. In order to answer that question, we shall evaluate 1) the dynamics of the agricultural sector; 2) the demand for agricultural land from outside the farming sector; and 3) the role of government policies, both economic and spatial. Based on this assessment two socioeconomic scenarios representing opposing views on the future are constructed. These scenarios are then fed into the land-use simulation model *Land Use Scanner* to create maps of possible future land use. Based on these simulations we discuss the prospects for the rural regions in the Netherlands: how much space will be left for agriculture and what new land-use configurations will arise?

2. TRENDS AND DEVELOPMENTS IN AGRICULTURE

The Dutch agricultural sector has changed tremendously in the past decades. Recent inventories (Van Bruchem, 2001; Berkhout *et al.*, 2002) have pointed out several important agricultural trends. The nature of these trends and their implications for the future of agriculture are summarized below:

1. Increase in farm size. The number of farms is in rapid decline, from 410,000 in 1950 to 90,000 in 2002. As the total area under cultivation has decreased by only 16% over the same period (Figure 8-1), we can infer that the average farm is much larger today. Most farmland coming onto the market has been bought by other farms for expansion. The decline in the number of farms is expected to continue as it is still difficult for

farmers to find successors due to socio-demographic and economic conditions (Luijt *et al.*, 2003).

2. Intensification. Higher inputs of both capital and consumables per hectare, in combination with technical progress lead to ever-increasing yields. These inputs are now six times as high as in 1950. Although the growth of productivity has slowed in recent years, there is still scope for further gains: remotely controlled machines, increased application of electronic sensors in various biological processes, introduction of genetic technology, etc. Although such innovations strengthen the position of the sector in competing for space (the value of land will rise with the production that can be obtained from it), they will not necessarily lead to a higher demand for agricultural land because more production can be realised on less space.
3. Reduced national importance. While agriculture remains an important export earner, its share in employment and in GDP has declined dramatically in recent decades. With it the political influence of farmers and their organizations is reduced, thus loosening their traditional grip on rural land.
4. Diversification. An increasing number of farmers provides a wide range of services: tourism, conservation of nature and historical landscapes, water buffering, sale of regional products, health care (recuperation at the farm), and wind-generated electricity. Not all of this diversification is new, of course, but it is receiving increased attention as possible compensation for a further reduction in agricultural incomes (Van der Ploeg, 2003).

Summarizing the above trends we can conclude that Dutch agriculture has been able to adapt to changing socioeconomic conditions. It has changed its focus from a labour-intensive mass-food producing sector to a large scale, intensive and specialised sector. The importance of the production factors land and labour has decreased in favour of capital and technology. The relatively new diversification trend may well indicate another possibility to adapt to changing economic conditions and public preferences. It is thus unlikely that agricultural land will become available on a large scale, causing the desertion of rural areas as can be seen in some marginal agricultural regions in other European countries. The most likely causes for agricultural land to be taken out of production will probably remain the claims from other sectors, as will be discussed below.

3. EXTERNAL PRESSURES ON AGRICULTURAL LAND

Most of the land required for business, housing, infrastructure and recreation is obtained by converting farm land, partly because this category occupies the largest part of the country, but also because farmland is usually cheaper. The largest claim comes from residential land: although population growth is slow, the demand for space per person is rising, due to a reduction in the number of persons per household, growing prosperity and the demand for rural, low-density types of dwellings (VROM, 2001).

Commercial land use (industrial areas, offices) is expected to grow anywhere between 14 and 34% in the coming 20 years (Gordijn *et al.*, 2003). The increase in mobility means an additional demand of space for infrastructure, although the area required will probably be modest. Recreational space is in increasing demand due to changing economic, demographic and cultural conditions (Kroon and Kuhlman, 2004).

Other demands for additional land come from the creation of nature reserves, which received a major impulse by the Dutch plans for a large system of interconnected nature areas - the so-called Ecological Main Structure. Finally, new concepts in water policies (so-called integrated water management) point to reserving space for water buffering - a reversion of the age-old trend of reclaiming land from the water. These will mean either taking land out of production or restricting the use of land to extensive types of agriculture (Van Rooy and Sterrenberg, 2000).

4. GOVERNMENT INTERVENTION

Some of the claims on agricultural land detailed in the preceding section originate from the government, both at the national and local level. However, the government also influences agriculture directly through its economic policies (partly determined by the EU) and indirectly through its spatial policies. The opening up of the intra-European market for agricultural products and the protection of that market against global competition exercise an enormous influence on the vicissitudes of the sector. The national government has stimulated productivity by land consolidation and by subsidizing some subsectors – notably arable farming and dairying in the past, while facilitating the expansion of zero-grazing and promoting agricultural research. In recent decades, environmental policies have become increasingly important, as well as the promotion of animal welfare. Undoubtedly we are on the threshold of further major changes, with the proposed Fischler reforms in the Common Agricultural Policy of the EU, the expansion of the EU, and the increasing demands from parties outside the EU for liberalization of trade.

Besides these economic policies, national and regional spatial policies have a strong influence on the future of agriculture. The relatively strict compact-city policy, together with related restrictions on developing green areas, have reduced the possibilities for the conversion of agricultural land in recent decades, although such conversions were far from absent (VROM, 2000). With the publication of its latest Spatial Policy Report (VROM/LNV/V&W/EZ, 2004), the government offers more freedom to local municipalities in zoning their rural areas. This decentralization and privatization may lead to more opportunities for developing residential and commercial areas in regions where this was formerly discouraged.

5. TWO SCENARIOS FOR FUTURE LAND USE

As discussed before, agricultural change is clearly linked to National government and EU intervention, and general socioeconomic conditions. To provide a coherent framework for studying the various changes, we have selected two scenarios for spatial transformation, which were formulated for the second National Nature Outlook (Milieu- en Natuurplanbureau, 2002). These are in turn based on previous Intergovernmental Panel on Climate Change (IPCC) scenarios and each follows two opposing trends: Global Economy combines globalisation with individualism, whereas Regional Community connects regionalism with cooperation. In the first scenario, government intervention in both the functioning of the agricultural market and spatial policy is limited. In the latter scenario, the European agricultural market remains partially protected and restrictive spatial policies apply in rural areas. Table 8-1 gives an overview of the assumptions of the two scenarios. In a way these scenarios reflect the shift in political conditions in the 1990s (Regional Community) to the neo-liberal outlook (Global Economy) as advocated in, for instance, the new Dutch Spatial Policy report. The scenarios thus offer a way of comparing the outcomes of two opposing political strategies on spatial planning.

The story lines of the scenarios were subsequently fed into sector-specific regional models to quantify the expected demand for various types of land use, e.g. residential, commercial and natural. The demand for agricultural land was estimated by applying the land-market model developed by the Agricultural Economics Research Institute, see Koole *et al.* (2001). The model uses a farm-type oriented micro-simulation approach, distinguishing: arable farming, market gardening (open-air annual crops), perennial crops (trees), greenhouse horticulture, grassland livestock farming (mostly dairying), zero-grazing livestock (mostly pigs and poultry) and mixed types. It predicts what may happen at each farm, given certain known characteristics of the farm for example relating to the availability of a successor, parameters on how it will react to pressures and opportunities, and assumptions derived from the scenarios on what these pressures and opportunities will be. The demand from the other land-use functions was derived from the various sector-specific models that were applied in the preparation of the National Nature Outlook study (De Nijs *et al.*, 2002).

Table 8-1. Basic assumptions and related spatial implications for the scenarios

	Global Economy	Regional Community
Socioeconomic conditions		
Economic growth	2.9% per year	2.3% per year
Population	17.1 million	18.4 million
Societal focus	Individual freedom	Regional cooperation
Economic orientation	Free market prevails	Government intervenes
Government intervention		
Common agricultural policy	World markets for agricultural products	Internal EU support under conditions, no export subsidies
Spatial policy	Less restrictive policies	Restrictive policies for rural areas
Nature policy	Protection of most valuable areas only	Larger areas protected, nature development
Water management	No restrictions on urbanisation	Local restrictions on urbanisation
Agricultural trends		
Total agricultural land use	Strong decline of agricultural land use	Decline of agricultural land use follows historic trend
Rural land prices	Local increase/decrease	Slight overall increase
Agricultural production	Large-scale, industrial farming	More extensive, small-scale farming
Agriculture and nature conservation	No combination of agriculture with natural values	Diversified rural development
Agricultural sectors	Industrial dairy and greenhouse farming grows; arable farming declines	Less growth in dairy farming and greenhouses; arable farming constant
External pressures		
Urbanisation	Urban sprawl in rural areas, strong increase in low-density dwellings	Concentration near existing urban areas
Commercial functions	Abundant growth, preference for highway locations	Limited growth, public transport accessibility promoted
Recreational facilities	Concentration around bigger cities	Realised following existing plans
Nature development	Acquisition through private persons (new estates) and organisations	Acquisition by national government following ecological main structure

Source: adapted from Milieu- en Natuurplanbureau (2002).

The expected total agricultural area per scenario until 2030, related to the historic trend is depicted in Figure 8-1. The Global Economy scenario shows a dramatic decrease in the cultivated area. The high-intensity, highly productive, technically advanced subsectors are likely to flourish – albeit with further momentous changes that will undoubtedly affect the landscape. In the Regional Community scenario the decline resembles the 1960-1980 trend, when land consolidation and other policies led to rationalization of farms and land being taken out of production. Intensive animal husbandry is expected to be much smaller and less intensive, with a free-range component. The average farm will be smaller; and there will be more emphasis on the integration of agriculture with other functions, such as nature, recreation, and residence (hobby farming). There will be much emphasis on preserving an attractive environment around the cities.

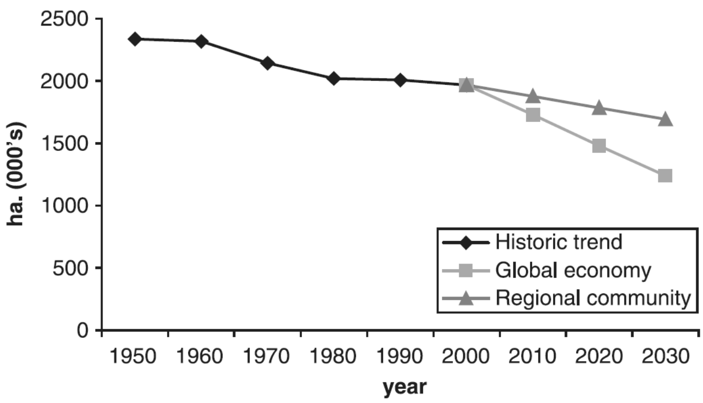

Figure 8-1. Total agricultural area in the 1950 -2030 period according to two scenarios.

Source: CBS (2004) for historic trend, Koole *et al.* (2001) for scenario projections.

6. MODELLING CHANGES IN LAND USE: THE *LAND USE SCANNER*

The *Land Use Scanner* is an information system for simulating future land use. It combines a model for allocating space to land-use classes, a GIS-type computer programme, and a spatial database containing present land use and data on the suitability of land for various types of use. It has been used in various policy research documents for simulating the impact of policy decisions and of autonomous trends on future land use. The system essentially balances claims on land from the various land-use categories with the amount of suitable available land. In this section, the system will be briefly described. For a fuller account the reader is referred to Hilferink and Rietveld (1999) and Schotten *et al.* (2001).

The model is grid-based, dividing the Netherlands into cells of 500 by 500 metres. Each cell contains information on which proportion of its area falls into what land-use class. Our application distinguishes 14 types of land use: 4 kinds of agriculture, 2 residential classes (including a rural low-density type of dwellings), commercial, recreational and natural land use, water and various types of infrastructure. The model allocates claims on land derived from specialised sector models to the available space in the most efficient way. Efficiency is here defined as reconciling competing claims such that the user who can draw most benefit from realizing his claim at a particular location will get the land. This means that we must distinguish between different dimensions of land suitability for different purposes: the quality of the land itself (e.g. in terms of soils where agricultural use is concerned); the existing use (which represents a cost if it is to be changed); infrastructure and accessibility; the proximity of other land use of the same type (i.e. residential areas are preferably not planned in the middle of an industrial area); and government policies pertaining to the area. The total suitability for a land-use type represents the net benefits to be obtained by using that cell for that purpose. The higher these benefits, the greater the probability that the land use in question will be realized. The applied logit equation simulates a bidding process between competing land users (or, more precisely, land-use classes): each use will try to get its total claim satisfied, but may be outbidded by another category that derives higher benefits from the land. Thus, it can be said that the model, in a simplified way, mimics the land market. The government policies that strongly limit the free functioning of the Dutch land market are included in the definition of the model's suitability maps by means of taxes and subsidies.

The probability of a projected pattern depends, apart from the exogenous variables contained in the scenarios, mainly on the values given to the parameters in the model related to land suitability. Modifying these will alter the predictions made by the system, and the values actually used reflect the researchers' assumptions. The *Land Use Scanne*r aims to show what land-use changes are most likely in which regions – the regions themselves not being predefined but defining themselves through the patterns generated. Results should thus be regarded as answers to 'what if' questions rather than hard predictions.

7. RESULTS

The simulation results provide insight in the spatial patterns that may arise under different socioeconomic conditions and thus help answer our questions related to the future of agriculture: what will remain of the current agricultural landscape and what new land-use configurations will evolve. In our discussion of the simulation results we will focus on the most dynamic, central-western part of the country (Figure 8-2).

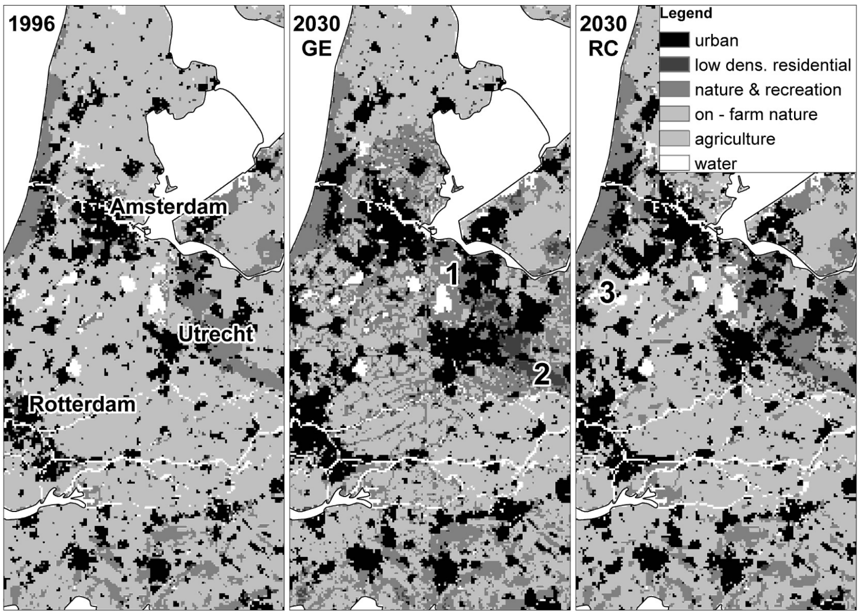

Figure 8-2. Current (left) and projected land use for the Global Economy (middle) and Regional Community scenarios (right) according to the *Land Use Scanner* simulations. The views cover the centre-west part of the Netherlands, measuring approximately 75 km from west to east. Numbers are explained in the text.

The Global Economy scenario offers the most striking contrasts with the current situation. Agricultural has almost disappeared in the regions surrounding Amsterdam and Utrecht, where strong increases in urban land use, nature and recreation can be found. The latter increase is especially dominant between the two cities (indicated with the number 1 in Figure 8-2), reflecting the large-scale conversion of relatively marginal dairy farming land into privately owned nature and recreation areas that offer attractive living environments for the creation of new country estates. The popular woodland areas north and east of Utrecht (number 2) attract large low-density residential areas. Urban pressure is intense also in the southern part of the Delta metropolis (around Rotterdam and The Hague); however that region shows less demand for nature and recreation areas.

The Regional Community scenario presents a very different picture. Not only is the decrease in agricultural land less than in Global Economy; but small-scale organic farming, the integration of agriculture and nature/landscape conservation, and the maintenance of open areas for recreation near urban areas lead to new opportunities for farming. The *Land Use Scanner* predicts, for instance, that the nature conservation on farms will become common in the belt between The Hague and Amsterdam (3), just south of a large arable-farming region situated on very productive soils. In other parts of the region, nature and recreation areas will increase in importance.

The present study clearly indicates the magnitude of the changes the Dutch countryside is facing. The two opposing scenarios show the possible consequences of the proposed shift from government-driven spatial planning to market-oriented spatial policies. In our simulations the shift towards less restrictive planning in combination with the creation of a truly free world market for agricultural products could lead to a virtual disappearance of agriculture in parts of the western Netherlands. A mosaic of different types of urban, nature and recreation areas could emerge instead, establishing new park-like landscapes. A less radical change is suggested by the combination of current spatial restrictions and a still partly protected agricultural market. Even the western part of the country then manages to retain a largely agricultural outlook, partially owing to the combination of agriculture and nature conservation. Such are the choices that spatial policy-makers face regarding the future of agriculture in the Netherlands.

IN MEMORIAM

February 2005 Jan Groen, our co-author and initiator of this research project passed away. We are very thankful for his enthusiastic and knowledgeable contributions and we will greatly miss his warm and stimulating personality.

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Chapter 9

CHARACTERISING URBAN CONCENTRATION AND LAND-USE DIVERSITY IN SIMULATIONS OF FUTURE LAND USE[1]

Abstract: This paper presents two sets of functional indicators that were implemented and tested for the assessment of spatial aspects of future land-use configurations as simulated by a land-use model. This is potentially useful for the ex-ante evaluation of spatial planning policies. The indicators were applied in a Dutch case study and relate to two important themes in Dutch spatial planning: compact urbanisation and mixing of land uses. After a short introduction of these themes, the sets of indicators are presented which are used for their evaluation. These indicators are applied to simulations based on two scenarios for land-use development in the Netherlands up to 2030. After a discussion of the results we conclude that the combined application of land-use models and indicators produces new and potentially useful information for policy makers, although both the model and the associated indicators are still in a state of development.

Key words: Land-use simulation; spatial planning; indicators; urban concentration; land-use diversity.

[1] This chapter is published by Springer Science and Business Media as: Ritsema van Eck, J. and Koomen, E. (2008) Characterising urban concentration and land-use diversity in simulations of future land use, *Annals of Regional Science* 42 (1): 123-140.

Chapter 10

LAND-USE SIMULATION FOR WATER MANAGEMENT[1]

Application of the Land Use Scanner in two large-scale scenario studies

Abstract: Land use is one of the major components influencing local hydrological characteristics. Future land use is thus important in studies that focus on the upcoming challenges for water management. This chapter describes two applications of the *Land Use Scanner* model on a national or larger scale, in which the scenario method is used to simulate future land-use patterns.

Key words: Land use; spatial planning; spatial dynamics; water management.

[1] This chapter is published by Springer Science and Business Media as: Dekkers, J. and Koomen, E. (2007) Land-use simulation for water management. Chapter 20 in: Koomen, E., Stillwell, J., Bakema, A. and Scholten, H.J. (eds.) *Modelling land-use change; progress and applications*, Springer, Dordrecht, pp. 355-373.

Chapter 11

AN INTEGRATED DISCUSSION SUPPORT SYSTEM FOR NEW DUTCH FLOOD RISK MANAGEMENT STRATEGIES[1]

Abstract: Climate change will impact sea-level rise, river discharge and precipitation in the Netherlands although there is no profound indication of their exact amount and associated time horizon. However, to be safe in the future, measures should be taken in advance. In order to facilitate discussions on the subject of flood risk management strategies a system is developed that intends to support the discussion on long-term adaptability of the Netherlands to flood risk. Its aim is to facilitate the learning process of the user on the subject, instead of giving unambiguous answers on what management strategy is preferable. Concerning the content of the system, it aims to give insight into the impact of various flood risk management strategies. The output of the system provides valuable information about flood risk in terms of: flooding probabilities, potential damage and potential number of casualties. The system, furthermore, aims to show the costs and benefits of proposed safety strategies.

Key words: Discussion support system; climate change; flood-risk management; flood-impact assessment; land-use simulation.

[1] This chapter is published by Springer Science and Business Media as: Van der Hoeven, N., Aerts, J., Van der Klis, H. and Koomen, E. (2008) An Integrated Discussion Support System for New Dutch Flood Risk Management Strategies. Chapter 8 in: Geertman, S. and Stillwell, J. (eds.) *Planning Support Systems: Best Practices and New Methods*, Springer, Berlin (forthcoming).

PART IV: CONCLUSION

Chapter 12

CONCLUSION AND DISCUSSION

Abstract: This final chapter summarises the most important findings of the preceding chapters and discusses the main methodological improvements of this thesis. The conclusion is centred around the three main research themes: quantifying spatial developments; assessing the impact of spatial policies; and simulating future spatial developments. By way of discussion, the main methodological improvements are highlighted in relation to the issues of: the applicability of very detailed spatial data; the integration of various analysis methods; and the simulation of future land-use changes.

Key words: Spatial analysis; physical planning; methodology; policy implications.

1. INTRODUCTION

The current thesis combines various forms of spatial analysis and many newly available and highly detailed spatial data sets in a series of studies related to different spatial planning issues. These studies relate to both urban and rural areas and they focus on actual physical planning policies as well as some of the policy concepts and general notions that underlie these policies. Besides having a spatial planning focus the presented research also addresses several methodological issues related to data applicability, integration of analysis methods and simulation of land-use changes. The studies forming this thesis centre around three main research themes:

A. how can spatial developments be quantitatively characterized?;
B. to what extent do specific spatial policies impact spatial developments?;
C. how can simulations of future land use support policy makers?

The studies related to quantifying spatial developments (theme A) aim at providing insight in ongoing processes mostly linked to urbanisation as a solid base for policy formulation. These studies have a strong methodological focus as they include many new and highly detailed spatial data sets and various advanced analysis methods including hedonic pricing, self-organizing maps and complex regression analyses. The studies on the impact of spatial policies on spatial developments (theme B), on the other hand, have a strong policy focus. They, furthermore, relate to predominantly rural areas, as opposed to the more urban orientation of the preceding theme. The studies related to the simulation of future land use (theme C) combine a methodological focus related to the potential merits of current land-use models with an outlook on the policy implications of their results.

The following three sections summarize the outcomes of the presented studies per main research theme, devoting a sub section to each of the ten research questions introduced in Chapter 1. The final section of this chapter then highlights the main methodological improvements in this thesis and discusses possible pathways for further research.

2. QUANTIFYING SPATIAL DEVELOPMENTS

Several studies in this thesis prove that contemporary, detailed spatial data sets in combination with different spatial analysis techniques allow for the quantification of spatial developments. The following sections summarise the findings related to the economic valuing of open space, the quantitative description of urban intensification and concentration processes and the characterisation of land-use diversity.

2.1 Valuing metropolitan open space

The central research question in Chapter 3 is: how can the value of open space be quantified from a city dwellers' perspective? To answer this question the hedonic pricing method is applied to detailed data sets describing house prices and their structural and locational characteristics. This method establishes the added value to residential property of open (non-urban) areas that provide opportunities for rest and recreation.

The estimation results indicate that the availability of local open space (a view of open space and/or the presence of local patches of open space) has a significant positive contribution to house prices. This impact is only found in a relatively short distance range: the added value decreases to zero at a distance of around 50 metres from a house, depending on the case study area. Less conclusive evidence is found about the contribution of larger areas of regional open space to house prices. This may, amongst others, indicate that this essentially regional characteristic is not well-suited to explain local house prices.

The clearly positive impact of local open spaces in the immediate vicinity of houses provides policy makers with additional arguments for the creation of green spaces in new residential areas. The results can, in fact, be used in discussions about a partial recovery of the construction and maintenance costs for the green spaces that increase the property values.

2.2 Describing urban intensification processes

Chapter 4 addresses the question: how can current urban intensification processes be described? The urban volume indicator proposed here provides an adequate characterisation of the actual physical appearance of the city in time and space. This quantitative description is based on a combination of highly detailed spatial data sets including a 5 metres grid height data set. It allows for an objective, highly detailed analysis of urban patterns in three dimensions.

The potential of this indicator is first tested in a spatio-temporal analysis of the (historic) urban development of the city of Amsterdam. This study shows the gradual lateral extension over the past century as well as the growing importance of numerous high-density zones. The application of the self-organizing map approach underlines these observations and, furthermore, indicates at the recent emergence of small, but extreme high-density developments near stations at a considerable distance from the centre. The urban volume indicator is also applied to spatially compare the four major Dutch cities. This study shows a distinction between cities in which high-density areas are concentrated in the original city centres and cities where these areas are at a considerable distance from the centre. A subsequent statistical analysis indicates that high densities are favoured by the proximity of (intercity) train stations rather than motorway exits.

The urban volume indicator thus helps to visualise and quantify the relative strength of the opposing centripetal and centrifugal forces that shape cities. In this respect it provides useful information about actual urban densities and ongoing urban intensification processes for the debate on urban (re)development. It puts the current discussions on the suggested edge-city type of development into a quantitative perspective, indicating that this process still has a fairly limited impact on Dutch urban morphology. Moreover, the development of high-density zones is related to the presence of (intercity) train stations whose locations, at least in the Netherlands, can be influenced through spatial policies and government investments.

2.3 Characterising urban concentration and land-use diversity

The third research question relates to themes of urban concentration and land-use diversity and aims at finding a method to characterise these spatial policy issues in land-use maps. This methodology was subsequently applied in a simulation of future land use to answer the question to what extent these policy objectives are likely to be met. Both questions are dealt with in Chapter 9. Here we summarise the methodological results related to the former question. The policy-implications related to the latter question are discussed in Section 4.2.

To select indicators that are effective, they should: 1) relate to the specific policy themes; 2) be intuitively understandable for policy makers 3); capture the essence of the simulation results; and 4) discriminate between different simulation outcomes. The proposed methodology consists of a combination of individual indicators that capture various aspects of urbanisation such as: magnitude (through general composition indices); spatial pattern (grid cell based urbanisation degree); concentration (patch-size distribution); compactness (average urban area circularity); and mixing of land uses (grid cell based diversity indices). The combined use of these composition and configuration indicators at various scale levels makes it possible to unambiguously interpret the projected spatial developments.

The importance of scale-issues in implementing and interpreting indicators can hardly be overstressed. Spatial scale (e.g. grid cell size), thematic scale (e.g. land-use typology) and extent (e.g. study area) are crucial in the application and interpretation of indicators in land-use simulation. The impact of spatial scale is, for example, demonstrated by the urban area size dependency of the presented shape-complexity indicator.

3. ASSESSING THE IMPACT OF SPATIAL POLICIES

Three studies show the extent to which spatial policies impact spatial developments. The first two demonstrate that open space preservation policies have been effective. These studies focus at the national and local level respectively. The third study makes clear that existing spatial policies did not lead to a measurable loss of socioeconomic vitality in rural areas.

3.1 Analysing the effectiveness of national open space preservation policies

The first of the chapters dealing with the impact of spatial policies studies how the effectiveness of open space preservation policies can be assessed at the national level. The presented analysis of transition matrices using detailed land-use data sets covering the full country with a 25 metres resolution shows that restrictive policies have been relatively effective in limiting urban development.

In the areas where the two different types of restrictive zoning policies apply, the rate of urbanisation has been lower than in non-restricted areas. Urban development was not stopped completely in these areas, but when we realise that urbanisation pressure was above average here, the effectiveness can be considered impressive. The current mitigation of existing restrictive policies related to open-space preservation thus contains the serious risk that municipalities will find more opportunities to allow urbanisation in open spaces. This possible impact is illustrated in Chapter 8.

In many of the restricted areas nature development is the dominant process. This transformation of agricultural land follows national policies that aim at improving ecological values, providing recreational opportunities and preserving the open, non-urban character of these areas. In combination with restrictive policies the stimulated conversion from agricultural land to nature seems to be an effective, albeit costly way to preserve open space.

3.2 Explaining the local success of open space preservation policies

Chapter 6 looks at the effectiveness of open space preservation policies at the local level and wishes to explain how this success became possible. It builds on the GIS-based land-use change analysis of the preceding chapter and looks specifically at the Midden-Delfland area where the Buffer zone restrictions were supplemented with a special Reconstruction Act that governed its land reallocation.

The comparison of land-use changes in this area with changes in other Buffer zones and in the rest of the Netherlands shows that two aims of the Act, the preservation of open space and the development of recreational areas, have been achieved. The activities set out to accomplish the third aim of improving dairy farming conditions have had less impact. As the problems and solutions for this specific agricultural sector stretch beyond the scope of the reconstruction, the general conclusion is nonetheless that combination of restriction and reconstruction has been successful.

In a subsequent, qualitative analysis using in-depth interviews and a policy analysis several clues are offered to explain the success. The tactical idea of developing recreational areas at the urban edges to stop sprawl and the availability of sufficient funds and appropriate institutions were marked by the respondents as reasons for the successful open-space preservation in the area. The presented study suggests that clear restrictive policies that are maintained for prolonged periods in combination with additional instruments that aim at acquiring agricultural land and strengthening its recreational and natural values are important factors in successfully preserving open space.

3.3 Quantifying rural vitality

Analysing to what extent rural areas are suffering from a loss of socioeconomic vitality is the main question underlying Chapter 7. A GIS-based methodology using a wide range of detailed geographical data sets is applied here to describe the rather vague policy concept of rural vitality. Following a strict socioeconomic interpretation in which housing, employment, demography and level of facilities are considered important indicators, it becomes possible to quantitatively assess the actual state of rural vitality and analyse its development over time.

Based on the selected indicators, small settlements and the surrounding open areas do not seem to perform differently from the rest of the country. From the presented analysis then, it cannot be concluded that the general vitality of the countryside is deteriorating within the investigated period. An initial look at the variation between different regions does not show clear signs that rural vitality is related to a location at the periphery of the country.

The presented findings contradict the current National Spatial Strategy that introduces this policy concept and states that the quality of life and the vitality of various, more rural areas, are deteriorating. In fact, the general spatially non-explicit policies hinted at in the policy agenda and execution program related to the National Spatial Strategy seem to lack a foundation in the observed rural developments. The vitality of the rural surroundings may indeed be at stake at specific locations and for certain socioeconomic groups, but in order to formulate sensible general spatial policies a more precise definition of the problems at hand is needed. The conceptualization of the rural vitality theme described here can provide a starting-point for further discussions on this aspect of the future of our rural areas.

4. SIMULATING FUTURE SPATIAL DEVELOPMENTS

To demonstrate the potential of land-use simulations for policy makers, four studies are presented that support current discussions on: 1) the future of agriculture; 2) policies related to urban concentration and land-use diversity; 3) possible water shortages; and 4) flood risk management.

4.1 Assessing the future of agriculture in the Netherlands

The simulation of future land use performed with the *Land Use Scanner* model in Chapter 8 provides insight into the spatial patterns that may arise under different socioeconomic conditions. These simulations help answer the research question: what future lies ahead for agricultural land in the Netherlands?

The presented scenario study clearly indicates the magnitude of the changes the Dutch countryside is facing. Urban functions and nature are expected to continue to claim agricultural land, but the spontaneous abandonment that, for example, occurs in peripheral areas in Europe is considered highly unlikely as the quality and accessibility of the Dutch land is generally very good. The two opposing scenarios, furthermore, show the possible consequences of the proposed shift from government-driven spatial planning to market-oriented spatial policies. A shift towards less restrictive forms of planning in combination with a strong increase in urban functions could lead to a virtual disappearance of agriculture in parts of the western Netherlands. A mosaic of different types of urban, nature and recreation areas could emerge instead, establishing new park-like landscapes.

A less radical change is suggested by the combination of current spatial restrictions and a moderate increase in urban types of land use. Even the western part of the country then manages to retain a largely agricultural outlook, partially owing to the combination of agriculture and nature conservation. Such are the choices that spatial policy-makers face regarding the future of agriculture in the Netherlands.

4.2 Evaluating future urban concentration and land-use diversity

The land-use simulations introduced in the above-mentioned chapter are also applied to answer the question: to which extent do future land-use patterns meet the current planning objectives of urban concentration and land-use diversity? Chapter 9 tests the potential of the indicators related to the spatial policy themes of urban concentration and land-use diversity already discussed in Section 2.3.

The proposed indicators related to urban concentration clearly mark the differences between the two scenarios. One scenario indicates that a stronger emphasis on economic development combined with less restrictive spatial policies, which are the current aims of the central government, may lead to more extensive forms of urbanisation that could threaten natural and recreational values. The opposing scenario shows that a continuation of the hitherto prevalent restrictive policies could lead to fewer and larger urban areas than the current situation. In terms of land-use diversity the two scenarios do not perform very differently, but application of this indicator indicates potential ‘hot-spots’ for mixed land use that can be of great interest to policymakers.

The presented model results are based on a series of assumptions, choices and interpretations and can by no means be considered as an exact prediction of future land-use patterns. The opposing outcomes of the two scenarios do however provide insight in the possible consequences of future socioeconomic conditions and the implications of spatial policy related choices. The results maps also show where these problems are most likely to occur. Therefore, they may be especially useful as a starting point for locally targeted policy measures to counteract expected negative local consequences of general developments and generic policy.

4.3 Analysing future water shortages

Chapter 10 focuses on the question: how can land-use simulations be used to assess possible water shortages in the future? From the two case studies presented here, we conclude that land-use models, such as the *Land Use Scanner,* are adequate instruments to simulate future land-use patterns within a scenario-analysis framework. The applied model proved to be a flexible and open system that allows for the integration of different information sources and the combination with other models for the additional assessment of hydrological impacts.

To facilitate a better integration of *Land Use Scanner* results with the hydrological models it is supposed to feed, a number of improvements has been suggested by the involved hydrological experts. These relate to the level of detail, the land-use typology and the heterogeneous character of the grid cells. The level of detail should preferably be changed from the 500 by 500 metres grid applied in this study to 50 by 50 metres grid cells. The current land-use typology can be improved by adding a distinction in more land-use types with different evaporation characteristics. The final suggested improvement is the output of homogenous grid cells relating to only one type of land use, instead of the current heterogeneous approach that assigns fractions of the cell to a number of land-use types.

The suggested improvements related to the level of detail and the inclusion of homogenous grid cells are included in a renewed version of the *Land Use Scanner*, that has recently become available. The following section discusses an application of this renewed model version.

4.4 Describing the flood-risk impact of spatial safety strategies

The final study of this thesis answers the question how the impact of spatial safety strategies on future flood risk can be assessed. This is demonstrated by the development of a discussion support system (DSS) for water managers that facilitates the debate on different future trends, their impact on flood risk, and the effects of new flood-safety strategies. The DSS follows a scenario approach where the uncertain future is captured in an integrated set of climate and socioeconomic scenarios that permit the assessment of future flood safety and vulnerability to water damage in the Netherlands.

A crucial component in the system is the simulation of future land-use changes according to different scenarios and spatial safety strategies, and based on this, the assessment of future flood risk. The relatively detailed 100 metres grid resolution of the renewed *Land Use Scanner* model makes it possible to perform such calculations on possible future land-use configurations, where these were hitherto limited to more detailed and complex models restricted to the current situation.

The DSS will not exactly predict what will happen nor tell precisely what measurements should be taken, but it acts as a learning instrument that provides insight into possible future developments and some of the options that exist to cope with these projected changes.

5. METHODOLOGICAL IMPROVEMENTS

The preceding sections summarised the most important findings of this thesis in relation to the spatial planning issues referred to in the included studies. The presented research, however, also brings about several methodological improvements that can be related to the subsequent phases of the spatial analysis process (exploration, explanation, simulation, planning support and evaluation) that were introduced in Section 4.1 of Chapter 1. This section discusses the progress in spatial analysis methodology that underlies many of the presented studies and indicates possible pathways for further research. The discussion is organised following the main phases in the spatial analysis process. As a final conclusion the benefits of integrated research methods are discussed.

5.1 Exploration and explanation

A methodological improvement that the exploratory and explanatory studies of Chapters 3 and 4 have in common is the application of highly detailed spatial data. Especially the urban volume analysis shows the enormous potential of high resolution height and other spatial data sets that are currently becoming available in many countries. The increased availability of highly detailed spatial data also benefits the studies related to evaluation and simulation. The availability of detailed data sets in combination with powerful contemporary personal computers, for example, made it possible to increase the resolution of land-use simulation from 500 to 100 metres (Chapter 11).

The potential of highly detailed data sets is not limited to the examples presented in this thesis. It is also present in other data sets that recently became available from such varied sources as the newest generation of remote sensing satellites, large-scale inventories of cadastral institutes, and the tracking and tracing of mobile-phone users. The latter type of data can, for example, be used in the (real-time) monitoring of traffic flows based on the movements of individuals. But also for many other socioeconomic phenomena we are now able to use fine-grained data that allow the exploration and explanation of spatial processes at scales that were unimaginable until recently.

From the presented studies it also becomes clear that such highly detailed data sets offer considerable challenges, especially when it comes to visualising and analysing fine-scaled developments over extensive areas as was the case in Chapter 4. The increased level of detail of newly available data sources, in fact, calls for a rethinking of the methods currently used in exploring and explaining spatial processes, leaving many new research roads open to explore. The provision of highly detailed data essentially allows a shift from more aggregated, cross-sectional research on populations (e.g. neighbourhoods) to more specific research focussed on individual objects (e.g. buildings or persons).

In *exploratory* analysis one of the research issues related to this shift towards micro-level developments concerns the highlighting of small-scale features in extremely large datasets. This visualisation problem is comparable to the finding of a needle in a haystack and calls for visualisation methods that enhance specific features at the cost of others. In Chapter 4 this was done through the application of filtering techniques that highlighted the maximum values in relatively large neighbourhoods.

Apart from demanding faster computers and more efficient programming routines, the use of micro-level data in *explanatory* analysis calls for specific attention to the issue of scale. This is extremely important as different processes are likely to be dominant at different scale levels. The fact that the value of *regional* open space does not seem to be clearly linked to *local* house prices (Chapter 3) hints at this issue. Besides considering the scale dependency of spatial developments it is also important to take account of the links that exist between different scale levels (Verburg et al., 2004). Chapter 1 (Section 4.2) briefly discussed this issue. The use of micro-level data also allows for a shift in attention from explaining general processes at an aggregated level to analysing the contribution of particular factors to specific processes. This shift in focus is exemplified in Chapter 4 by the analysis of the factors that explain the development of small, high-density zones in urban areas.

5.2 Simulation

The four chapters related to land-use simulation (8-11) present an interesting cross section of recent advances in the development of land-use change models. From the presented studies we can infer a number of observations related to the applicability of this type of instruments in general and the applied *Land Use Scanner* model in particular. These observations relate to: the contradiction of needing detailed results in uncertain situations; the application of the scenario method; the calibration and validation of land-use models and the propagation of errors.

An important contradiction in the application of the *Land Use Scanner* and most other land-use models relates to the need for highly detailed simulations, in terms of both spatial (grid cell) and thematic (number of land-use types) resolution, in long-term studies where many uncertainties exist. Solving this contradiction between the need for local-level detail and large-scale uncertainties regarding future developments is a major task for further research. Interesting related attempts include the construction of multi-scale models (e.g. Veldkamp *et al.,* 2001 or Verburg *et al.*, 2007) and the increased attention for agent-based modelling, as is discussed by, for example, Ettema *et al.* (2007). The scenario method offers a structured approach to deal with the many uncertainties related to future developments, but has some limitations as is discussed below.

Scenario simulation results are heavily reliant on expert judgement, so their validity is questionable. This is inherent to the scenario approach, as is also discussed by Klosterman (1999) in his description of the *What if?* scenario-based planning support system. The limited validity is not a serious problem as long as the simulation outcomes are treated for what they are worth: images depicting possible future developments following a large number of scenario-related assumptions. This guideline for interpreting the results is quite often ignored in subsequent presentation and use of the outcomes. Devising new ways of presenting uncertain information might help overcome this difficulty.

A way to provide information on the validity of the simulation outcomes is to calibrate and validate the applied land-use models. This provides valuable information about the performance of the models, the relative importance of individual driving forces and the magnitude of current spatial developments, but only applies to the often short calibration periods. The use of such rigorous validation exercises is thus limited for scenario studies dealing with uncertain future conditions that are not necessarily linked to past developments. Scenario analyses therefore need a certain degree of imagination. However, in accordance with Verburg *et al.* (2004), the need is felt to seriously test the capacity of land-use models to produce sensible outcomes. Preliminary validation exercises for the *Land Use Scanner* model have therefore been carried out (Loonen *et al.*, 2007; Loonen and Koomen, 2008; Pontius *et al.,* 2008).

An additional worry for this type of study, which relies on the consecutive use of several models, is the propagation of errors. Initial model results are themselves used as input in a number of subsequent model steps, that each may add extra uncertainties, assumptions and related errors to the original outcomes. This is a well-known issue in GIS (e.g. Heuvelink, 1998) that, however, has received limited attention in the application of land-use models. An initial sensitivity analysis has been carried out for the *Land Use Scanner* (Dekkers, 2005), but more work needs to be done, especially on the consequences of the repeated transformations of model results and the consistency of the scenario-related assumptions in the different models.

5.3 Planning support

Increasing the usability of results is an important issue in the planning-related application of spatial analysis and, more specifically, in land-use simulation models. Options that help presenting, interpreting and comparing modelling outcomes include: the construction of 3D visualisations; the application of interactive presentation media; and the development of indicators that summarise results in relation to policy issues. The implementation of 3D visualisations is beyond the scope of this thesis, but promising research related to the *Land Use Scanner* is underway (Borsboom-van Beurden *et al.*, 2006; Rodríguez-Lloret *et al.*, 2008). The incorporation of interactive or tangible presentation media such as the 'TouchTable' that allows multiple users to view, query and edit geographical information in group sessions is another topic of recent research (Scotta *et al.*, 2006). Application of this device in a spatial planning context has recently started and will be part of further research.

The development of indicators that objectively describe the land-use simulations in relation to specific policy themes was an important element in the preceding three chapters. The assessment of simulation outcomes dedicated to specific themes was considered to be helpful in translating geographical output into meaningful information. These assessments can either be incorporated in the land-use model itself or be executed in subsequent steps in separate models. While the current thesis focussed on developing indicators related to a limited number of policy themes (i.e. urban concentration, land-use diversity, water shortage and flood risk), ample room exists for developing methods to express impacts on a wide range of other themes, including: biodiversity, open-space fragmentation, landscape values and overall space scarcity. An especially interesting policy theme in this respect is the potential for multifunctional land use. This concept is currently receiving a lot of policy attention as a possible solution for solving the land-scarcity problem. Proper incorporation of this concept in contemporary models of land-use change, however, is still in its infancy (Willemen *et al.*, 2007, Van der Heide *et al.*, 2007) and thus demands serious research efforts. Another, hitherto unexplored impact assessment that can be obtained from the presented land-use simulations relates to the issue of spatial inequity. As the model outcomes are available at a fine resolution for the whole country it is fairly easy to distinguish regional differences in terms of, for example, commercial development or the provision of open space. This type of results can be interesting for regional policy makers that want to assess the performance of specific regions relative to others.

A type of planning support that has received little attention in this thesis is the goal-oriented application of analysis and modelling techniques. This normative approach can inform policymakers about possible optimal solutions for spatial planning issues. Chapter 2 hinted briefly at the possibilities of optimisation techniques in land-use modelling and numerous examples of such applications exist. In fact, the *Land Use Scanner* model that is discussed extensively in this thesis has been applied in several studies that aimed at optimising land-use patterns. These applications present different land-use simulations that each follow general scenario conditions and a specific policy objective such as: nature protection, adaptation to climate change and increased accessibility (Borsboom-van Beurden *et al.*, 2007; MNP, 2008). The resulting maps inform policymakers about potential alternative solutions for current spatial problems.

5.4 Evaluation

The main methodological improvement underlying the studies related to evaluation is the increased availability of geographical data that is relevant to spatial policy themes. *Ex-post* evaluations typically rely on the availability of comparable data sets describing subsequent moments in time. Detailed continuous land-use data sets of different time steps, for example, proved to be important in the studies related to the evaluation of the impact of restrictive spatial policies (Chapter 5 and 6). Whereas the availability of several highly detailed socioeconomic data sets for different time steps, allowed the creation of the time series of vitality indicators presented in Chapter 7. These studies, however, only consider relatively short periods as longer time series of methodologically consistent relevant data sets are not available. Ironically it is the continuous improvement of existing data sources that, partly, causes the observed inconsistencies. For comparative evaluation research the availability of consistent time-series data thus remains a challenging research issue.

The *ex-ante* evaluation of the possible impacts of spatial strategies as presented in Chapter 9 and 11 bypasses this limitation through simulating, rather than observing spatial developments. This approach has, of course, the drawback that it incorporates elements of expert judgement and thus contains a larger degree of uncertainty than the *ex-post* evaluations.

5.5 Integrated research methods

Many of the presented spatial analysis studies rely heavily on the use of GIS and its potential to integrate and analyse data from different sources. Its spatial analytical capabilities allowed, for example, the detailed description of the small settlements and the integration of many different data sets to characterise their vitality discussed in Chapter 7. With the power of contemporary personal computers, it becomes possible to integrate and process the large amounts of spatial and tabular data describing the whole country of the Netherlands. GIS also proved to be an important means to integrate the many different data sources relevant to house prices (Chapter 3) and urban development (Chapter 4).

This thesis also presents a more fundamental level of integration through the combination of different research methods derived from geographical information science, geography, economics and other sciences. This is evident from, for example, Chapter 3 that presents a geographical analysis to process base data for an econometric valuation study. Chapter 4 also combines techniques from different disciplines including new exploratory data techniques typical of GIS and more complex regression analyses. Similarly, the studies into the effectiveness of spatial policies (Chapter 5-7) introduced GIS-based transition matrices and time-series analysis in the realm of spatial planning research, thus adding a quantitative geographical notion to the polemic, often qualitative, planners' discussions on such topics.

The water management related chapters (10 and 11) combine socioeconomic scenario analysis and economics-based land-use modelling with more physically oriented models related to water availability and flood risk. To incorporate notions of causality in the descriptive geographical analysis of Chapters 6 and 7 interviews with stakeholders, more common in social sciences were performed. The importance of thematic and methodological integration is, in fact, also expressed by other researchers in this field (Verburg *et al.*, 2004). Many of the integrated approaches presented in this thesis were, furthermore, only possible through close cooperation within multidisciplinary teams. The presented studies thus clearly advocate the creation of such diverse teams to explore, explain, simulate and evaluate spatial developments in relation to spatial planning.

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Ruimtelijke analyse voor ruimtelijke beleidsvorming

Samenvatting (summary in Dutch)

De inrichting van de ruimte om ons heen is onderwerp van vele, soms verhitte discussies. Zo maken sommigen zich druk om de verrommeling van het landschap ten gevolge van de toenemende verstedelijking, terwijl anderen vrezen dat de veelheid aan ruimtelijke beperkingen het platteland op slot zet en de lokale vitaliteit bedreigt. De zorgen over de mogelijke gevolgen van klimaatsverandering voor bijvoorbeeld overstromingsrisico's of de beschikbaarheid van voldoende zoet water leiden ook tot kritische vragen over de ruimtelijke inrichting van ons land: moeten we ons waterbeheer aanpassen? kunnen we volstaan met het verhogen van de dijken? of is er meer ruimte voor de rivieren nodig? Het is aan de overheid om voor al deze problemen een passende oplossing te vinden die recht doet aan de uiteenlopende, soms conflicterende belangen van verschillende maatschappelijke groeperingen en de diverse lopende en te verwachten ruimtelijke ontwikkelingen. Hiervoor is het van belang dat de aard, omvang en oorzaken van deze ontwikkelingen duidelijk zijn. Op basis van een gedegen probleemanalyse kunnen dan verschillende beleidsalternatieven worden ontworpen die vervolgens weer op hun mogelijke effecten getoetst kunnen worden. Idealiter worden de ingevoerde maatregelen na afloop ook geëvalueerd om te bezien of het beoogde doel is bereikt. In al deze achtereenvolgende fasen speelt ruimtelijke analyse een belangrijke rol.

Deze dissertatie presenteert een aantal studies waarin met behulp van gedetailleerde geografische gegevens en uiteenlopende analysetechnieken ruimtelijke problemen worden geanalyseerd, bestaand beleid wordt geëvalueerd en mogelijke toekomstige ontwikkelingen worden gesimuleerd. Allereerst wordt in Hoofdstuk 1 een uitgebreide introductie gegeven over de gangbare ruimtelijke analyse methoden en het nut van deze analyses voor ruimtelijke beleidsvorming. Hoofdstuk 2 gaat vervolgens dieper in op de methoden en theorieën die gebruikt worden bij het modelleren van ruimtegebruiksveranderingen, omdat dit soort modelsimulaties een belangrijk onderdeel van deze dissertatie zijn. Het volgende deel van deze studie analyseert ruimtelijke processen in heden en verleden. Daarbij ligt de nadruk eerst op het kwantificeren van huidige ruimtelijke ontwikkelingen die relateren aan verstedelijking (Hoofdstuk 3 en 4) en vervolgens op het evalueren van de effecten van bestaand ruimtelijk beleid in landelijke gebieden (Hoofdstuk 5, 6 en 7). Het laatste deel van dit proefschrift gaat in op het simuleren van mogelijke toekomstige ruimtegebruikspatronen (Hoofdstuk 8 tot en met 11), waarbij deels de effecten van voorgenomen beleidswijzigingen in beeld worden gebracht.

Kwantificeren huidige ruimtelijke ontwikkelingen

De studies die ingaan op het kwantificeren van huidige ruimtelijke ontwikkelingen hebben meer specifiek betrekking op de (economische) waardering van open ruimte en het beschrijven van de derde dimensie (hoogte) in stedelijk gebied. De eerstgenoemde studie (Hoofdstuk 3) concludeert dat de directe nabijheid van open ruimte leidt tot hogere huizenprijzen. In analyses van drie verschillende huizenmarktgebieden (Amsterdam, Leiden en het Gooi) blijkt dat huizen binnen 50 meter van parken, sportvelden, waterlopen of andere open gebieden een tot 8 procent hogere prijs hebben dan huizen die verder weg liggen. Dit soort informatie is van belang voor beleidsmakers en kan bijvoorbeeld gebruikt worden bij de inrichting van nieuwe woonwijken. De meeropbrengst die de aanleg van publiek groen in de directe nabijheid van huizen oplevert zou gebruikt kunnen worden om een deel van de stichtings- of onderhoudskosten te financieren. Ook kan een indicatie van de ‘verborgen’ waarde van bestaande open ruimte gebruikt worden in discussies over het behouden van dit soort gebieden. De aanwezigheid van grotere, regionale open ruimte met minimale omvang van 500 hectare, zoals recreatiegebieden, bossen, landbouw-gebieden, binnen enkele kilometers van huizen heeft een veel minder duidelijk effect op huizenprijzen. Kennelijk speelt dit regionale aspect geen grote rol in de totstandkoming van lokale huizenprijzen. Dit betekent natuurlijk niet dat mensen geen interesse hebben in dergelijke open ruimten, maar het geeft aan dat ze er bij de aanschaf van een huis weinig tot geen extra geld voor over hebben.

De studie naar bebouwingshoogten in stedelijk gebied (Hoofdstuk 4) introduceert een nieuw begrip: stedelijk volume. Door een combinatie van gedetailleerde topografische en hoogtegegevens is het mogelijk een vrij nauwkeurige beschrijving te geven van daadwerkelijke verstedelijkingspatronen in drie dimensies. Hiermee zijn twee lokale casestudies gedaan. De eerste analyseert de historische stedelijke ontwikkeling in Amsterdam in de periode 1900-2000. Hieruit blijkt dat met name na 1970 op diverse plekken in de stad kleine gebieden met hoge dichtheden zijn ontstaan. De tweede studie vergelijkt de ruimtelijke patronen in stedelijke volume van de vier grote steden: Amsterdam, Rotterdam, Den Haag en Utrecht. In Rotterdam en Den Haag blijkt de hoogbouw zich te concentreren in het centrum, terwijl in Amsterdam en Utrecht de hoge dichtheden verder van het centrum te vinden zijn. Uit een nadere statistische analyse blijkt dat de aanwezigheid van hoge dichtheden vooral verklaard wordt door de nabijheid van intercity stations. Voor beleidsmakers zijn deze analyses interessant omdat ze de discussie over het toenemend belang van de randen van de stad ten koste van het traditionele centrum in een kwantitatief perspectief plaatsen. Op dit moment is in geen van de onderzochte steden sprake van uitgestrekte hoogbouwzones aan de randen die de historische centra figuurlijk in de schaduw stellen. Daarnaast geven de studies aan dat voor het ontstaan van bebouwing in heel hoge dichtheden de nabijheid van goede treinverbindingen van belang is. Stedelijke intensiveringsprogramma's hebben dus waarschijnlijk een grotere van kans van slagen op zulke locaties.

Evalueren van bestaand ruimtelijk beleid

In drie verschillende studies is gekeken naar de effecten van ruimtelijk beleid. Al deze studies hebben gemeen dat ze op het landelijk gebied gericht zijn. Hoofdstuk 5 onderzoekt de effectiviteit van het nationale restrictieve ruimtelijke beleid ter bescherming van de open ruimte. Meer specifiek is gekeken naar de mate waarin restricties binnen het Groene Hart en de Rijksbufferzones de verstedelijking hebben tegengehouden. Uit een vergelijk van gedetailleerde ruimtegebruiksbestanden van 1995/1997 met die van 2003/2004 blijkt dat binnen de restrictieve beleidsgebieden bebouwing minder is toegenomen dan in de omliggende niet beschermde gebieden. De verstedelijking is dus niet geheel gestopt, maar wel afgeremd. Dat is geen geringe prestatie als bedacht wordt dat met name de Bufferzones juist in die gebieden zijn ingesteld waar een grote stedelijke druk heerst. Het afzwakken van dit beleid zoals dat oorspronkelijk in de Nota Ruimte werd beoogd, zou dan ook zeer waarschijnlijk de hoeveelheid open ruimte sneller hebben doen afnemen.

In Hoofdstuk 6 is vervolgens voor een specifieke Bufferzone (Midden-Delfland) gekeken hoe het relatieve succes van dit beleid verklaard kan worden. Belangrijk hierbij is dat de Bufferzonestatus in dit gebied vergezeld ging van een speciale reconstructiewet die tot doel had: 1) de open ruimte te beschermen; 2) recreatieve gebieden te ontwikkelen; en 3) de agrarische omstandigheden voor met name veeteelt te verbeteren. De analyse van ruimtegebruiksveranderingen leert dat de eerste twee doelen behaald zijn: er is zeer weinig bebouwing bijgekomen in de bestudeerde periode, terwijl de hoeveelheid natuurgebied, die hier tevens een recreatieve functie heeft, sterk is toegenomen. De omstandigheden voor de veeteelt zijn overigens, net als in de rest van Nederland, niet verbeterd. Uit diverse diepte-interviews en een studie van relevante beleidsdocumenten bleken twee factoren van belang voor het beschermen van open ruimte: 1) het belang van de ontwikkeling van recreatief aantrekkelijke gebieden om verstedelijking tegen te gaan; en 2) de beschikbaarheid van voldoende financiële en institutionele middelen. Onder die laatste categorie valt onder meer de duidelijke en langlopende restrictieve Bufferzoneregelgeving en de speciale status volgend uit de reconstructiewet.

De vitaliteit van het platteland staat centraal in Hoofdstuk 7. In navolging van de Nota Ruimte die dit begrip introduceert, is vitaliteit opgevat als het vermogen van rurale gebieden om relatief zelfstandig te kunnen (blijven) functioneren. In dit onderzoek ligt de nadruk op meetbare, sociaal-economische indicatoren gerelateerd aan woningaantal, werkgelegenheid, demografie en voorzieningenniveau. Moeilijk kwantificeerbare begrippen als lokale identiteit of gemeenschapszin zijn buiten beschouwing gelaten. Met behulp van een groot aantal geografische gegevens is een analyse gedaan van de vitaliteit in twee opeenvolgende jaren: 1996 en 2000. De belangrijkste conclusie hierin is dat de rurale gebieden van Nederland op basis van de onderzochte indicatoren niet slechter presteren dan de meer stedelijke gebieden. Verder toont een analyse van drie perifere en twee meer centraal gelegen rurale gebieden geen duidelijk verband aan tussen een afgelegen locatie en vitaliteit. Deze bevindingen contrasteren sterk met de Nota Ruimte en aanverwante beleidsdocumenten die aangeven dat het slecht gesteld is met de vitaliteit van het platteland. Op basis van deze studie kan getwijfeld worden aan deze uitgangspunten en de noodzaak van specifiek beleid op dit vlak.

Simuleren van toekomstige ontwikkelingen

De voorlaatste vier hoofdstukken gaan in op het simuleren van toekomstige ruimtelijke ontwikkelingen. Hoofdstuk 8 kijkt naar de toekomst van het agrarisch ruimtegebruik in Nederland. Landbouw neemt nu nog tweederde van het Nederlandse landoppervlak in, maar regelmatig wordt betwijfeld of deze sector nog wel levensvatbaar is en ook in de toekomst het aanzien van het land kan bepalen. Met behulp van twee uiteenlopende scenario's is in beeld gebracht welke ruimtegebruiksveranderingen tot 2030 te verwachten zijn. Beide beelden hebben gemeen dat stedelijke functies (wonen, werken en recreatie) en natuur meer ruimte gaan claimen ten koste van landbouw. Het is echter niet waarschijnlijk dat de landbouw om bedrijfs-economische redenen gronden ongebruikt zal laten zoals elders in Europa in afgelegen gebieden gebeurt. Hiervoor is de bereikbaarheid en kwaliteit van de gronden in Nederland over het algemeen te goed. Het scenario dat een sterke economische groei combineert met een verder terugtredende overheid laat een sterke toename zien van de verstedelijking, met name in de aantrekkelijke landschappen die nu nog beschermd worden door diverse ruimtelijke restricties. Landbouw verdwijnt in dit geval uit een groot deel van west Nederland. Het andere scenario combineert een minder sterke economische groei (en dus een geringere vraag naar ruimte voor wonen en werken) met de huidige ruimtelijke restricties en laat dan ook een ruimtelijke beeld zien dat meer op de huidige situatie lijkt. Ook in het westen speelt landbouw dan nog een rol van betekenis, mede door de verwachte combinatie met agrarisch natuurbeheer. De verschillende scenariobeelden laten zien welke gevolgen ruimtelijke beleidskeuzen kunnen hebben en zijn daarmee behulpzaam bij het afwegen van verschillende beleidsopties.

Dezelfde scenariobeelden zijn als input gebruikt in Hoofdstuk 9 waarin onderzocht is hoeverre mogelijke ruimtelijke ontwikkelingen overeenkomen met de huidige beleidsambities op het gebied van compacte verstedelijking en meervoudig ruimtegebruik. Hiervoor zijn verschillende indicatoren geselecteerd die: 1) specifiek gericht zijn op de betreffende beleidsthema's; 2) intuïtief te begrijpen zijn; 3) de essentie van de simulatieresultaten blootleggen; en 4) onderscheidend werken op verschillende scenario's. Het gecombineerde gebruik van diverse indicatoren die gericht zijn op omvang, ruimtelijk patroon, concentratie, compactheid en meervoudig ruimtegebruik biedt een duidelijk inzicht in de verschillen tussen de scenario's. De toepassing van de indicatoren op de ruimtegebruiksimulaties behorend bij het scenario met hoge economische groei en beperkte ruimtelijke restricties laat een zeer verspreide uitbreiding van stedelijke gebieden zien. Deze versnipperde verstedelijking zet de natuurlijke en recreatieve waarden van de omgeving onder druk. Het tegenovergestelde scenario laat zien dat voortzetting van het huidige beleid leidt tot minder en grotere stedelijke gebieden. Dit compactere verstedelijkingspatroon legt minder druk op de open ruimte. De gemiddelde meervoudigheid of diversiteit van het ruimtegebruik verschilt niet veel tussen beide scenario's. Opvallend is wel dat de locaties met de sterkste menging van functies verschillen per scenario. Het model suggereert daarmee waar functies mogelijk gecombineerd kunnen worden en welke functiecombinaties daar denkbaar zijn.

Hoofdstuk 10 onderzoekt hoe ruimtegebruiksimulaties gebruikt kunnen worden om mogelijke toekomstige watertekorten in kaart te brengen.

Ruimtegebruik is namelijk een van de factoren die van grote invloed is op de waterbalans in een gebied. Belangrijk hierbij is onder meer de toename in verhard oppervlak die leidt tot versnelde afstroming van neerslag en dus een beperkter aanvulling van de grondwatervoorraden. De resultaten van ruimtegebruiksimulaties uit twee verschillende case studies (de Nederlandse ‘Droogtestudie’ voor RIZA en het Midden-Europese Elbe stroomgebied) zijn daartoe ingebracht in afzonderlijke hydrologische modellen. Dit geschakelde gebruik van verschillende modellen levert een effectieve methode op die allereerst diverse scenariogebonden aannamen over de toekomst integreert tot ruimtegebruiksimulaties en deze vervolgens vertaalt in gevolgen voor de beschikbaarheid van water voor verschillende functies. Op basis van de modellencombinatie worden enkele methodische verbeteringen voorgesteld voor het toegepaste ruimtegebruiksmodel Ruimtescanner. Deze hebben onder meer betrekking op het vereiste ruimtelijke detailniveau, de indeling in verschillende ruimtegebruiks-categorieën en de wens te komen tot homogene, in plaats van heterogene gridcellen. In de vernieuwde versie van het model, die op initiatief van het Milieu- en Natuurplanburau is ontwikkeld, hebben veel van deze verbeteringen een plek gekregen.

De vernieuwde, gedetailleerder versie van de Ruimtescanner met homogene cellen is toegepast in de laatste studie die in deze dissertatie is beschreven (Hoofdstuk 11). Het model is hier toegepast in een analyse van mogelijke toekomstige overstromingsrisico’s. Hierbij is speciaal gekeken naar het potentiële effect van ruimtelijke veiligheidsstrategieën op het beperken van het overstromingsrisico. Deze strategieën behelzen het verhogen van dijken, het reserveren van extra ruimte voor de rivieren en het aanleggen van grote terpen. Het risico is hier berekend als kans maal schade. Deze schade wordt per gridcel bepaald op basis van de verwachte waterdiepte na overstroming en het aanwezige ruimtegebruik. Per regio worden specifieke kentallen gebruikt die het gebruik van de ruimte vertalen in economische waarde (van bijvoorbeeld huizen) en potentieel aantal slachtoffers. Door per veiligheidsstrategie de mogelijke schade te vergelijken met de geschatte kosten is het mogelijk de effectiviteit van verschillende maatregelen onderling te vergelijken. Om dit vergelijk te vergemakkelijken is een Discussie Ondersteunend Systeem gebouwd dat beleidsmakers inzicht geeft in mogelijke klimatologische en sociaal-economische ontwikkelingen en de effecten, kosten en baten van de verschillende veiligheidsstrategieën.

Discussie

De dissertatie sluit af met een beknopte discussie van enkele methodologische vernieuwingen die zijn toegepast in de gepresenteerde studies en die ook in verder onderzoek van belang kunnen zijn. Allereerst betreft dit de toepassing van de zeer gedetailleerde ruimtelijke gegevens die tegenwoordig uit diverse bronnen beschikbaar komen. Het gebruik van deze gegevens vraagt om nieuwe analyse- en visualisatiemethoden die in staat zijn om zeer lokale, maar belangrijke ruimtelijke fenomenen voor het voetlicht te brengen. Het is hierbij noodzakelijk om rekening te houden met de schaalafhankelijkheid van processen, want de drijvende krachten op een hoger schaalniveau, zijn niet noodzakelijkerwijs dezelfde als op lager schaalniveau.

Verder worden enkele kwaliteitsaspecten benoemd die relevant zijn bij het simuleren van toekomstige ruimtegebruiksveranderingen. Deze betreffen allereerst de spanning tussen de behoefte aan gedetailleerde resultaten voor het doen van effectbepalingen en de grote onzekerheden die gepaard gaan met toekomstige ontwikkelingen. De veelgebruikte scenariomethode biedt de mogelijkheid zeer uiteenlopende ontwikkelingen te beschrijven en daarmee de bandbreedte te verbeelden waarbinnen processen zich mogelijk gaan afspelen. Een nadeel van de methode is echter dat 'expert oordelen' hierin een zeer belangrijke rol spelen waarmee hun betrouwbaarheid in twijfel kan worden getrokken. Bij wijze van referentie is het is dan ook belangrijk dat de modellen op basis van waargenomen ruimtegebruiks-veranderingen vooraf worden gekalibreerd en gevalideerd. Op deze wijze kan de correcte werking van het model getest worden, het relatieve belang van verschillende drijvende krachten gekwantificeerd worden en de omvang van huidige ruimtelijke processen inzichtelijk gemaakt worden. Een recent uitgevoerde validatie van de vernieuwde Ruimtescanner versie heeft hier een belangrijke aanzet toe gegeven en tevens aangetoond dat de verschillende allocatie-algoritmen die nu in het model beschikbaar zijn vrijwel identieke resultaten leveren.

Een belangrijk kwaliteitsaspect bij het opeenvolgend toepassen van verschillende modellen is het voortplanten van fouten en onzekerheden. Om de omvang hiervan in te schatten zijn in het verleden verschillende gevoeligheidsanalyses met het ruimtegebruiksmodel Ruimtescanner uitgevoerd. Verder onderzoek naar de onzekerheden die ontstaan in de complete keten vanaf de toeleverende sectorspecifieke modellen tot de aansluitende effectbepalingen in aparte modellen staat echter nog in de kinderschoenen. Daarnaast is er ook behoefte aan methoden die helpen om dit soort simulatieresultaten te presenteren op een wijze die recht doet aan de inherente onzekerheden.

Een andere mogelijke verbetering van het modelinstrumentarium betreft het vergroten van de bruikbaarheid van de resultaten in het ruimtelijke planvormingsproces. Belangrijke nieuwe ontwikkelingen hierin zijn: het ontwikkelen van 3D-visualisaties, het toepassen van indicatoren op andere beleidsthema's dan in deze dissertatie zijn genoemd (bijvoorbeeld ruimtedruk of biodiversiteit) en het gebruik van interactieve presentatie-media. Een voorbeeld van laatstgenoemde ontwikkeling wordt gevormd door de zogenaamde 'TouchTable' die het mogelijk maakt speciale sessies te organiseren waarin meerdere gebruikers tegelijkertijd informatie kunnen bekijken, bevragen en toevoegen. Op elk van de bovengenoemde punten wordt momenteel onderzoek uitgevoerd aan het SPINlab van de Vrije Universiteit Amsterdam en op andere plaatsen in binnen- en buitenland. Dit proefschrift is dan ook slechts een momentopname in een zich continu ontwikkelend onderzoeksveld.

Een laatste conclusie in deze dissertatie betreft het belang van integratie van kennis en informatie uit verschillende bronnen en vakgebieden. Dit geldt zowel voor het samenbrengen van gegevens uit zeer diverse bronnen als, op een fundamenteler niveau, voor het combineren van onderzoeksmethoden uit verschillende disciplines. Veel van de studies in dit proefschrift combineren kennis en methoden uit geografische informatie wetenschappen, geografie, economie en andere wetenschappen. Alleen op deze manier is het mogelijk complexe ruimtelijke vraagstukken te beantwoorden.

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