

# The Impact of Land-Use Policy on Urban Fringe Dynamics

## Dutch Evidence and Prospects

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**Abstract** Concern for the loss of open space around urban areas has given rise to various forms of land-use policy that aim to steer urban fringe dynamics. This chapter explores the potential of geospatial analysis to characterise land-use dynamics in the urban fringe and in particular focuses on the impact of land-use policies in steering these developments. The Netherlands is used as a case study because this country has a long-standing tradition of applying such policies and is generally considered to represent a successful example of restrictive spatial planning. Yet, these policies have received substantial criticism in the past decade and are currently being transformed by the National Government. Based on the observed degree of success of current open space preservation policies we make an attempt to simulate the potential implications of the proposed policy changes.

## 1 Introduction

### 1.1 *Land-Use Policy and Urban Dynamics*

Urban fringe dynamics put pressure on the open spaces that surround urban areas and thus limit the potential of these green areas for biodiversity, agricultural production and a wide range of other landscape services such as: water regulation and storage, air quality improvement and recreational opportunities. Concern for the deterioration of these services has given rise to various forms of land-use policy that aim to steer urban fringe dynamics. Open space preservation policies in western countries generally aim to manage urban growth through a range of concepts such as: zoning, urban growth boundaries, transfer of development rights

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and related financial instruments (Frenkel 2004). These policies relate to the contested topic of urban sprawl and are a key planning theme in the United States and many other western countries (Bartlett et al. 2000; Romero 2003; Bae and Richardson 2004; Gailing 2005). A useful overview of common approaches and methods in open-space planning is provided by Maruani and Amit-Cohen (2007). Van der Valk and Van Dijk (2009) present an extensive discussion of planning options and their relation with actual open space dynamics and planning institutions.

This chapter explores the potential of geospatial analysis to characterise land-use dynamics in the urban fringe and in particular focuses on the impact of restrictive land-use zoning policies in steering these developments. As a case study we selected the Randstad region in the Netherlands. This is a typical urban fringe region consisting of a mix of big cities, towns and villages surrounded by a substantial amount of open space as will be described in the next section. From a policy perspective, the Netherlands offers an interesting case study environment because it is generally considered to have a successful institutional policy framework for the management of urban development and the preservation of open space (Alpkokin 2012; van der Valk 2002; Alterman 1997; Dieleman et al. 1999; Koomen et al. 2008b). Yet, several studies also mention negative impacts that can be associated with the implemented land-use policies in the Netherlands. These impacts include issues such as: the mismatch between location of homes and jobs that leads to an increase in car use (Schwanen et al. 2001); the sharp increase in land prices following from the combination of spatially explicit zoning regulations and the deregulation of housing development at the end of the last century (Dieleman et al. 1999); and the limited fulfilment of the demand for green types of suburban housing (Rietveld 2001). These issues gave rise to an ongoing debate about the future of spatial planning in the Netherlands (e.g. Korthals Altes 2009; Roodbol-Mekkes et al. 2012). Following this debate National Government has recently introduced new, less stringent types of restrictive policies and is currently considering abolishing the more restrictive policies that were typical for the Netherlands.

We aim to assess the relative effectiveness of the various restrictive land-use policies that were in place in the past 15 years and demonstrate how this knowledge can be used to assess the potential impact of proposed policy changes. The presented results are of particular interest to other countries that consider the introduction or revision of similar land-use policies.

## ***1.2 The Dutch Randstad in Perspective***

The Netherlands is often considered as one of the most densely populated countries in the world. While this popular image is close to the truth – the country's population density of 400 inhabitants per km<sup>2</sup> rank it in the top ten of independent countries<sup>1</sup> – it is important to consider that the major Dutch cities are relatively

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<sup>1</sup> Source: United Nations (2011).

small. The two biggest cities of the country (Amsterdam and Rotterdam) each have a total population of less than one million inhabitants and do not even qualify for a position in the top 500 of largest cities in the world.<sup>2</sup>

In fact, the urban system in the most urbanised western part of the Netherlands has a peculiar layout: it consists of four larger cities and several smaller ones that are separated from each other by open spaces and that together form a horseshoe-shaped settlement pattern around a central open space that is mainly used for agriculture. This layout was first recognized in the 1920s (Faludi and Van der Valk 1994) and has since then become known as the combination of the Randstad (literally rim-city) and Green Heart. These elements have been central to Dutch spatial planning in the Netherlands in past 50 years and their origin, characteristics and evolution has been described in many publications (Burke 1966; Hall 1966; Ottens 1979; Faludi and Van der Valk 1994). To this date the elements of this specific layout are recognisable: the Randstad and Green Heart now contain about 6.5 million inhabitants, but the differences between the cities and surrounding open areas are substantial. The individual cities have densities of, for example, 6,500 (The Hague) or 4,500 (Amsterdam) inhabitants per km<sup>2</sup> and are among the most densely populated urban areas of Europe.<sup>3</sup> The density in the Green Heart on the other hand is about 10 times lower (595 inhabitants per km<sup>2</sup>).<sup>4</sup>

An initial idea about the magnitude of land-use change in the country can be obtained from the aggregate national statistics provided by Statistics Netherlands. Figure 1 shows how the amounts of land devoted to the main types of use have changed in the past century. It clearly indicates that the Dutch landscape is still dominated by agriculture. In the first half of the twentieth century the amount of agriculture even increased as a result of the conversion of open nature areas (mainly heath land) and the reclamation of large inland water bodies (not included in the presented statistics). From about 1970 onwards the amount of agricultural is decreasing, mainly to accommodate the strong growth of urban areas and, to a lesser extent, the increase in forest following the national plans for the development of a National Ecological Network. An extensive discussion and international comparison of this planning concept is provided elsewhere (Jongman et al. 2004).

These aggregate statistics sketch the general, national trends in spatial developments but cannot be used to assess the impact of land-use policies. Such policies do not necessarily aim to change national developments, but rather steer local land-use changes. These changes and their relation with restrictive policies will be analysed with different methods and datasets as is discussed in the next section.

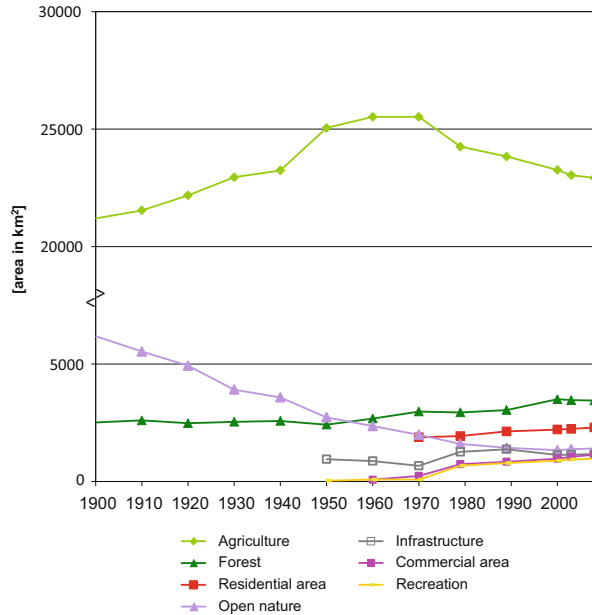
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<sup>2</sup> Source: [www.citymayors.com](http://www.citymayors.com).

<sup>3</sup> According to the Urban Audit of Eurostat (<http://epp.eurostat.ec.europa.eu>).

<sup>4</sup> This density is based on data from Statistics Netherlands (2012) and calculated by dividing the total number of inhabitants of all municipalities that fall for more than 50 % within the Green Heart by their land area.

**Fig. 1** Historic land-use changes in the Netherlands 1900–2008 (Source: Statistics Netherlands 2012). Note that some types of land use are only registered in the second part of the century



### 1.3 Longstanding Planning Tradition Under Revision

Although Dutch national spatial planning has its roots in pre-war concepts and ideas (Faludi and Van der Valk 1994), it only came to fruition in 1958 when the main principles for the development of the western part of the Netherlands were presented by the State Service for the National Plan (RNP 1958). Their report proposed to steer the expected strong urbanisation pressure away from the Green Heart and the existing cities in the Randstad to growth centres just outside the rim of cities (Fig. 2). This concept had several objectives: accommodating the expected urban growth in the direct vicinity of the Randstad, preserve the agricultural Green Heart, and prevent the existing cities from growing together and becoming metropolises with more than one million inhabitants (Faludi and Van der Valk 1994).

These main ideas were central to the five national planning reports that were drafted by the Ministry responsible for public housing and spatial planning in the following 50 years and that formed the basis for planning at lower tiers of Government. Key elements in these reports were: the preservation of the central open space and the designation of eight Buffer zones<sup>5</sup> between the major cities of the Randstad (V&B 1960) and bundled deconcentration (V&RO 1966). This latter policy initiative resulted in the development of New towns where suburbanisation could be

<sup>5</sup> These are strategically designated green corridors between large urban areas that aim to prevent them from growing together.



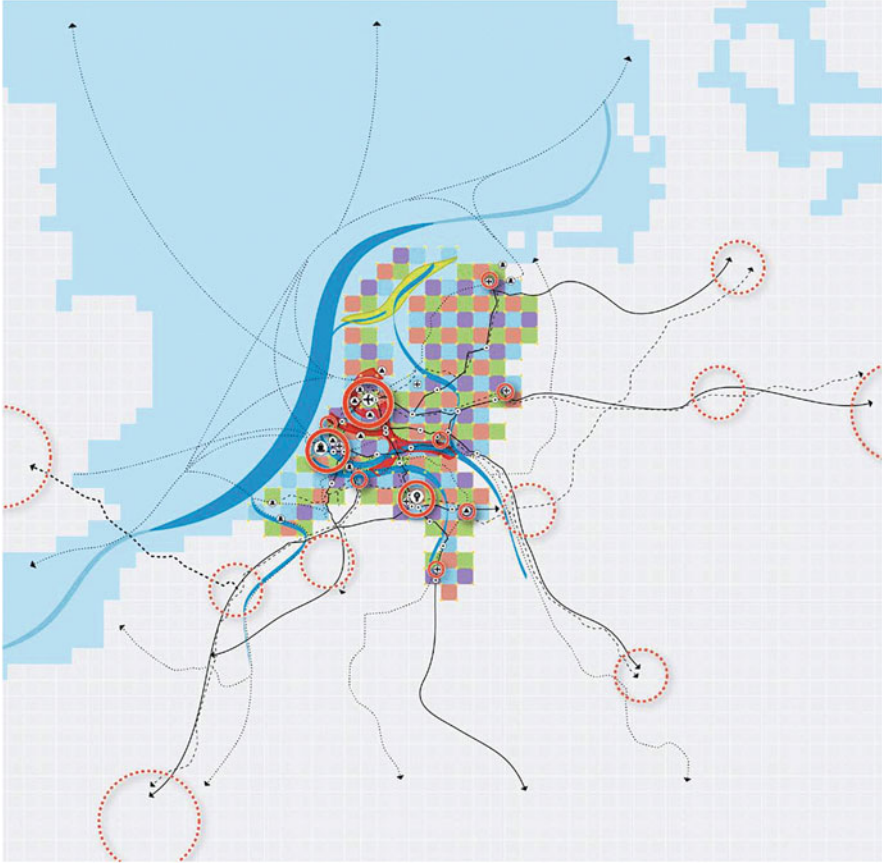
designated and which are meant to replace the more restrictive Buffer zone and Green Heart policies, as well as those parts of the Dutch landscapes that were approved as world heritage sites by UNESCO. These two labels are meant as a signal for planners to take local landscape values into consideration, but they do not actually limit the possibilities of urbanisation as strongly as, for example, Buffer zones do. The protective capacity of these regulations in areas with a strong urbanisation pressure can thus be doubted.

In 2011 a draft for a new national planning report was published that, for the first time ever, presented an integrated vision of all ambitions on the spatial structure of the country, infrastructure development and further investments in natural areas (I&M 2011). Despite its considerable integrative ambitions this new national planning report foresees a limited role for National Government in spatial planning (Kuiper and Evers 2011b). This is in part reflected by the relatively abstract figure that summarises the spatial plan of the report (Fig. 3). When this recent plan is compared to the one of 1958 (Fig. 2) the increased attention for the other parts of the country and the hinterland are apparent, but even more striking is the absence of spatially explicit policies. None of the New towns, Buffer zones, protected landscapes or other concrete policy interventions that were characteristic for Dutch spatial planning are incorporated in this new spatial vision. In fact, this report proposes to transfer more responsibilities to lower tiers of Governments than any preceding report. National Landscapes are suggested to become solely the responsibility of provinces, while the more restrictive Buffer zone designations are suggested to be abolished altogether. The proposed changes in spatial planning described in this report have been established by the Minister in March 2012. The potential spatial impacts of the proposed policy changes have been documented in a Strategic Environmental Assessment report (Elings et al. 2011) and will also be discussed briefly in this chapter. The impact assessment of the changes in policies related to open space preservation in that report is partly based on assessments of the relative success of current spatial policies that aim to preserve open space as will be discussed in the next sections.

## 2 Methodology

This chapter describes the major land-use transitions in the past 15 years in the Randstad area based on a variety of highly detailed spatial data sources. Specific attention is paid to the impact of restrictive zoning policies in limiting urban development in specific areas. In this section we introduce the methods that we applied and spatial data sets, while the subsequent section will discuss the main results.





**Fig. 3** The spatial vision depicted in the current established national spatial plan for the Netherlands (Source: I&M 2011). The *circles* denote core economic areas, the *coloured squares* symbolise existing mixes of land use, the *lines* depict important transport routes

## 2.1 Spatial Analysis Techniques

Spatial analysis techniques applied to detailed geographical data offer a useful tool to analyse the impact of spatial policies. Longley and others already used this combination in 1992 to assess the influence of the well-known Green Belt zoning regulations in Britain (Longley et al. 1992) by comparing the geometry of settlements which were subject to such policy with those which were not. Similar more recent examples of the spatial analysis of the impact of zoning regulations exist for, for example, Israel (Frenkel 2004), the Netherlands (Koomen et al. 2008b) and China (Zhao 2011).

In a first analysis, this chapter builds upon a quantitative GIS-based study into the relative success of the long-standing restrictive spatial policies in the

Netherlands that was performed several years ago (Koomen et al. 2008b). We follow up on that analysis and provide two additions: the use of a longer time period with more recent data to analyse whether recent policy changes have resulted in a change in urban fringe dynamics and the inclusion of detailed spatial data sets from other sources to test the robustness of previous results. The second analysis in this chapter is an addition to the first analysis. The results of both analyses are compared and together provide a complete overview of the main trends and processes.

In our first analysis, we use rasterised land-use data and calculate a transition matrix based on pixel-by-pixel comparison of subsequent datasets. Transition matrices are commonly applied in land-use change analysis (see, for example, Pena et al. 2007). The resulting matrix summarizes the number of changed cells as well as the number of unchanged cells from 1 year to the next for all distinguished land-use types, allowing us to assess the relative importance of specific changes. An advantage of this cell-by-cell comparison approach is that it makes land-use changes spatially explicit and thus allows for them to be visualised in the form of maps. Further, the approach describes the actual transitions that occur between land-use types, rather than describing the aggregate changes provided by regional statistics such as the ones shown in Fig. 1. By applying spatial selections on these transition maps we are able to aggregate the total number of specific transitions in different regions and thus highlight differences in urbanisation speed in various restricted and non-restricted zones in the Randstad. More specifically, we focus on the Buffer zones, the Green Heart and the additional areas that were later designated as being National Landscapes.

The second analysis uses zonal statistics to sum cell values of object-based datasets within different regions, in this case providing the total number of houses per grid cell within regions with different spatial planning regimes. By comparing the total number of houses on an aggregate level for different years, we can calculate growth in housing stock in absolute and relative terms. Zonal statistics can be created with standard GIS procedures that are available in most GIS-software packages.

## 2.2 *Land-Use Simulation*

Land-use change models are useful tools to support the analysis of the consequences of land-use change (Koomen et al. 2008a). They can, for example, help formulate adequate spatial policies by simulating potential autonomous spatial developments or, perhaps more importantly, by showing the possible consequences of different policy alternatives. Policy makers can thus be confronted with a context of future conditions and an indication of the impact the spatially relevant policies they propose.

The model we apply here – Land Use Scanner – is rooted in economic theory. It is an integrated land-use model that offers a view of all types of land use, dealing



with urban, natural and agricultural functions. It has been developed in 1997 by a group of research institutes and has been applied in a large number of policy-related research projects in the Netherlands and abroad. The model's basics and recent calibration have been described extensively elsewhere (Koomen and Borsboom-van Beurden 2011; Loonen and Koomen 2009).

The model is often applied to perform what-if type of applications that visualise the spatial developments given development scenarios. In that respect it is comparable to well-known rule based simulation models such as the original California Urban Futures (CUF) model and the What If? system (Landis 1994; Klosterman 1999). In the context of strategic, scenario-based national planning, the model proved to be a especially valuable tool to inform policy makers about potential future developments (Schotten et al. 2001; Borsboom-van Beurden et al. 2007; Dekkers and Koomen 2007) or to provide ex-ante evaluations of policy alternatives in both national (Scholten et al. 1999; Van der Hoeven et al. 2009) and regional contexts (Koomen et al. 2011b; Jacobs et al. 2011).

The Land Use Scanner balances the demand and supply of land using three main model components:

1. External regional projections of land-use change, usually referred to as demand or claims, that are land-use type specific and can be derived from, for example, sector-specific models of specialised institutes;
2. A local (cell-based) definition of suitability that incorporates a large number of spatial datasets referring to current land use, physical properties, operative policies and market forces generally expressed in distance relations to nearby land-use functions;
3. An algorithm that allocates equal units of land (cells) to those land-use types that have the highest suitability, taking into account the regional land-use claim. This discrete allocation problem is solved through a form of linear programming (Koomen et al. 2011a).

## 2.3 *Data Sets Used*

### 2.3.1 **Raster Data**

We use four 25 m resolution versions of the spatial land-use databases from Statistics Netherlands referring to the years 1996, 2000, 2003 and 2008. These data sets allow the identification of main land-use change trends, despite some methodological issues: to a certain extent, classification is done by hand and there are some interpretation and definition differences from year to year (van Leeuwen 2004; CBS 2008). Part of the observed transitions will thus refer to differences in spatial delineation (i.e. interpretation and definition differences) from 1 year to the next.

The original datasets are aggregated into a limited number of major land-use classes that are necessary for analysing the urbanisation process. Seven main types

of land use are distinguished based on the initial set of 38 land-use types: (1) built-up areas, (2) urban green (e.g. bare soil, parks and building lots with a functional relation to the neighbouring urban area), (3) greenhouses, (4) other agriculture, (5) infrastructure, (6) nature and (7) water. These aggregate classes allow for an effective analysis of the main land-use transitions in the studied period. The reason why we distinguish greenhouses separately from other agriculture is because of its distinct urban appearance and relevance to spatial planning. The latter is indicated by the fact that Dutch government has projects in place that aim to remove dispersed greenhouse locations from areas with a high landscape value such as the Buffer zones (see, for example, EL&I 2009). Apparently greenhouses are considered an unwanted form of land-use change.

The various transitions that occur between the main groups of land use can be captured in four land-use change processes: (1) actual urbanisation, (2) potential urbanisation, (3) nature development (i.e. construction of new nature, for instance as part of the National Ecological Network, NEN) and (4) other changes (e.g. infrequent transitions between agriculture and water, or between greenhouses and infrastructure). As our focus is on the main objective of land-use planning – limiting the conversion of open space into urban use- we disregard minor land-use modifications or changes in land-use intensity in our analysis.

### 2.3.2 Object Data

For the object-based analysis, we use a dataset containing the number of houses per 100 m grid cell for the years 2000, 2003, 2004 and 2008, provided by PBL Netherlands Environmental Assessment Agency. As Evers et al. (2005) explain, this dataset is based on a combination of data sets containing information on the location of houses and population. For our analysis, two underlying data sets are important: (1) ACN (*Adres Coördinatenbestand Nederland*) provided by the Dutch Land Registry Office (*Kadaster*) that contains the x,y-coordinates of all addresses in the Netherlands; and (2) ‘Geo-Marktprofiel’, a direct marketing data set from Bisnode containing a wide variety of data on characteristics of households and number of houses per six-digit zip code centroid in the Netherlands. Other datasets are used as well to determine the main function of objects, but these are less relevant so we do not discuss them here.

Noteworthy is the fact that the providers of these data sets have constructed them for their own specific purposes and not necessarily for the analysis of (spatial) changes in the number of houses and people. Next, the ACN-data set is known to be not entirely up-to-date in areas where a lot of address mutations take place, such as large-scale urban development locations and inner city reconstruction zones. Also, in rural areas the x,y-coordinate of an address may lie outside the objects (houses) it refers to but within the wider boundaries of the cadastral parcel. Potentially this means that the location of an object is misplaced by 50 m or more, possibly causing it to be added to an adjacent grid cell in the data set we use for our analysis. Further, the Geo-Marktprofiel data set is known to differ from the data of Statistics

Netherlands in terms of number of houses and households. This is caused by a different definition of the objects at hand. Statistics Netherlands, for example, does not consider house boats to be houses, where GeoMarktprofiel does. Validation analysis by other researchers who use the same data, however, indicates that these differences are very small and that the data corresponds to reality (see, for example, Tesser et al. 1995).

The most important data quality issue for our analysis, however, is the fact that before 2004, the ACN data set overestimated the number of addresses. This was due to an inconsistent registration of house number additions (e.g. 2 and II for second floor apartments) that in some cases made the same residential object show up twice in the data set (Evers et al. 2005). In 2004, a one-time correction has taken place, removing around 200,000 addresses from the dataset. Because of this fact, we are forced to split our analysis in two periods: 2000–2003 and 2004–2008.

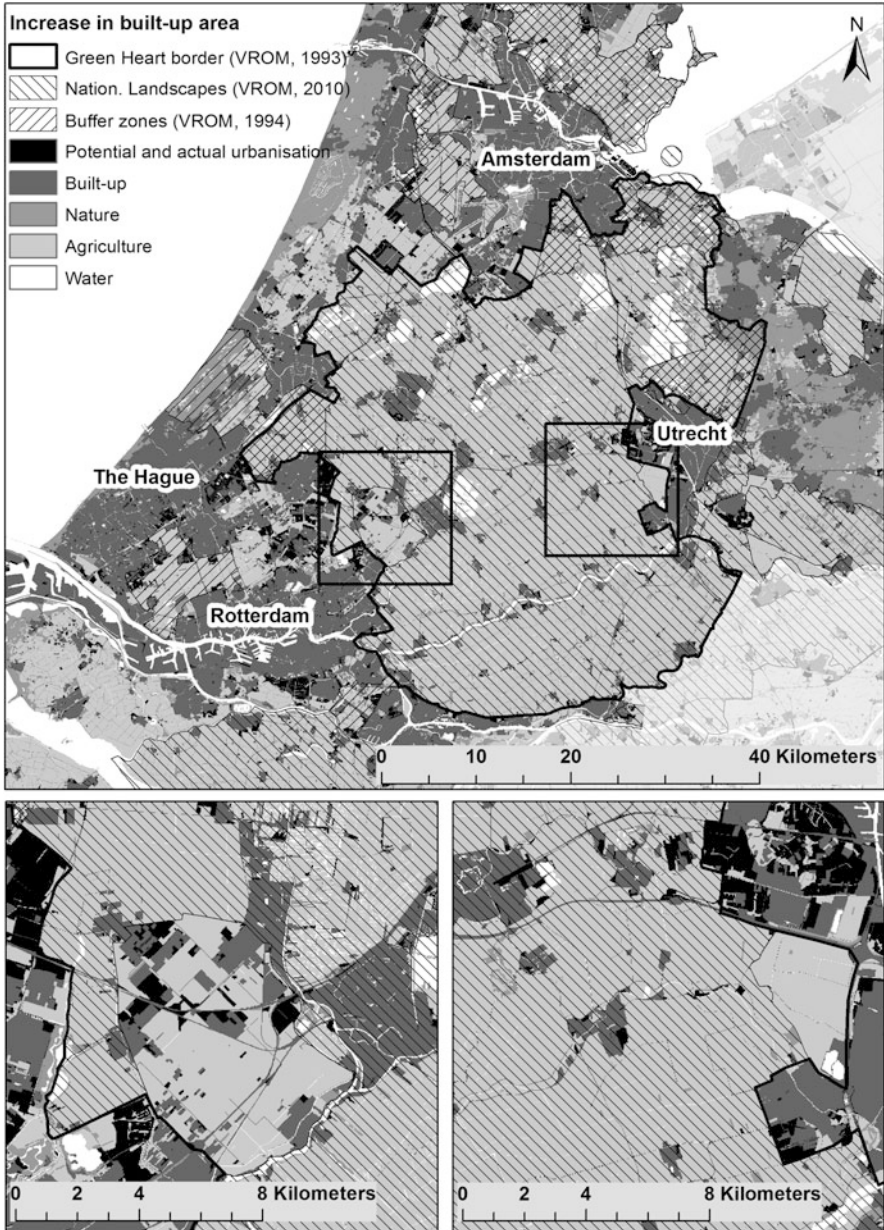
## 3 Results

### 3.1 *Raster-Based Analysis*

This section describes the results of the raster-based analysis of land-use transitions between 1996 and 2008. In our analysis we focus on different restrictive regimes in the Randstad area: Buffer zones, the Green Heart and the newly formed, less restrictive National Landscapes. For the latter category we only look at those areas that were not previously protected under the more restrictive Buffer zones and/or Green Heart policies. Urban development in the restrictive policy zones is compared to developments in the non-restricted part of the Randstad.

Figure 4 provides an overview of the described zones and shows the urban development locations observed during 1996–2008. The figure indicates that most development takes place in relatively large concentrated urban extensions in the direct vicinity of the larger urban areas. These developments follow from the compact city philosophy that was especially prominent in the fourth national spatial planning report (VROM 1989). Most of these developments are located outside the restrictive policy zones. However, in some cases they lie within them, eventually leading to the adjustment of the zoning regulations. This is particularly prominent in the Green Heart zone that has been adjusted in 1993 and again in 2004 (see Pieterse et al. 2005; Koomen et al. 2008b). Such adjustments show the tension between policies that have a shared objective (open space preservation) but differ in their approach (promoting compact cities or regionally limiting urban development). The insets of Fig. 4 illustrate this process.

Tables 1 and 2 present the *net* land-use change for the most important transition processes in the three subsequent 3–5 year periods, aggregated for different spatial planning regions. They summarise all observed transitions between the seven aggregate land-use classes under four main processes of land-use change.



**Fig. 4** Urban development in the Randstad (*highlighted area*) in the 1996–2008 period. The black locations depict all transitions into Urban area, Infrastructure, Urban green and Greenhouses and this includes both the potential and actual urbanisation processes described in the text. The insets show locations where the Green Heart contour has been adjusted and urbanisation has followed (*left*) or is likely to do so in the future (*right*)

**Table 1** Most important net land-use transitions for the Buffer zones (within the Randstad only) and the Green Heart

Land use change (Net)		Buffer zones						Green Heart					
		1996–2000		2000–2003		2003–2008		1996–2000		2000–2003		2003–2008	
From	To	(ha)	(%)	(ha)	(%)	(ha)	(%)	(ha)	(%)	(ha)	(%)	(ha)	(%)
<i>1. Actual urbanisation</i>													
Agriculture	Built-up	88	0.14	401	0.63	191	0.30	409	0.22	660	0.35	1,052	0.56
Nature	Built-up	16	0.03	138	0.22	114	0.18	113	0.06	539	0.29	447	0.24
Urban green	Built-up	–8	–0.01	58	0.09	–13	–0.02	–15	–0.01	72	0.04	–3	0.00
Greenhouses	Built-up	29	0.05	39	0.06	–56	–0.09	240	0.13	–31	–0.02	254	0.14
Agriculture	Infrastructure	4	0.01	0	0.00	–1	0.00	5	0.00	14	0.01	–3	0.00
Nature	Infrastructure	26	0.04	101	0.16	53	0.08	65	0.03	47	0.02	115	0.06
Urban green	Infrastructure	–1	0.00	–9	–0.01	37	0.06	–26	–0.01	2	0.00	60	0.03
<i>2. Potential urbanization</i>													
Agriculture	Urban green	837	1.31	193	0.30	151	0.24	26	0.01	17	0.01	181	0.10
Greenhouses	Urban green	645	1.01	145	0.23	103	0.16	574	0.31	772	0.41	544	0.29
Agriculture	Greenhouses	12	0.02	–10	–0.02	–16	–0.02	499	0.27	625	0.33	467	0.25
<i>3. Nature development</i>													
Urban green	Nature	180	0.28	57	0.09	64	0.10	1	0.00	–24	–0.01	–7	0.00
Agriculture	Nature	175	0.27	168	0.26	103	0.16	74	0.04	171	0.09	83	0.04
Urban green	Nature	–36	–0.06	3	0.00	13	0.02	446	0.24	98	0.05	125	0.07
Agriculture	Nature	235	0.37	142	0.22	100	0.16	20	0.01	–93	–0.05	–20	–0.01
Water	Nature	–24	–0.04	22	0.03	–10	–0.02	417	0.22	203	0.11	166	0.09
<i>4. Other changes</i>													
Net change ( $\times 1,000$ ha; %)		133	0.22	83	0.13	40	0.06	104	0.06	65	0.03	136	0.07
Total surface ( $\times 1,000$ ha)		1.2	1.94	0.8	1.32	0.5	0.76	1.5	0.82	1.6	0.85	1.9	0.99
		64						187					

**Table 2** Most important net land-use transitions for the National Landscapes (only within the Randstad and excluding the Buffer zones and the Green Heart) and the non-restricted part of the Randstad

Land use change (Net)		National Landscapes (excl. other restricted zones)						Randstad excluding restricted zones					
		1996–2000	2000–2003	2003–2008	Total	1996–2000	2000–2003	2003–2008	Total	1996–2000	2000–2003	2003–2008	Total
From	To	(ha)	(%)	(ha)	(%)	(ha)	(%)	(ha)	(%)	(ha)	(%)	(ha)	(%)
<i>1. Actual urbanisation</i>													
Agriculture	Built-up	121	0.15	307	0.39	326	0.41	1.0	2,447	0.87	2,243	0.79	4,157
Nature	Built-up	101	0.13	106	0.13	131	0.17		943	0.33	423	0.15	1,063
Urban green	Built-up	-6	-0.01	-3	0.00	16	0.02		-16	-0.01	50	0.02	134
Greenhouses	Built-up	52	0.07	55	0.07	78	0.10		1,401	0.50	1,385	0.49	2,275
Agriculture	Built-up	0	0.00	1	0.00	3	0.00		82	0.03	46	0.02	116
Infrastructure	Infrastructure	-17	-0.02	117	0.15	46	0.06		38	0.01	160	0.06	216
Nature	Infrastructure	-2	0.00	8	0.01	10	0.01		-41	-0.01	-12	0.00	30
Urban green	Infrastructure	-7	-0.01	23	0.03	43	0.05		39	0.01	186	0.07	322
<i>2. Potential urbanisation</i>													
Agriculture	Urban green	401	0.51	44	0.06	343	0.43	1.0	4,613	1.63	2,735	0.97	2,452
Greenhouses	Urban green	376	0.47	21	0.03	320	0.40		4,058	1.44	2,378	0.84	2,202
Agriculture	Green houses	2	0.00	0	0.00	13	0.02		206	0.07	329	0.12	311
<i>3. Nature development</i>													
Urban green	Nature	131	0.17	81	0.10	70	0.09	0.4	348	0.12	29	0.01	-61
Agriculture	Nature	-4	-0.01	13	0.02	1	0.00		127	0.05	489	0.17	298
Water	Nature	132	0.17	74	0.09	73	0.09		-141	-0.05	265	0.09	190
<i>4. Other changes</i>													
Net change ( $\times 1,000$ ha, %)		3	0.00	-7	-0.01	-4	0.00		281	0.10	227	0.08	87
Total surface ( $\times 1,000$ ha)		44	0.06	73	0.09	94	0.12	0.3	-14	0.00	-2	0.00	21
		0.7	0.88	0.5	0.64	0.8	1.05	2.6	170	0.06	219	0.08	437
		79							7.4	2.61	5.7	2.01	7.3
									282				7.2



We have chosen to distinguish urbanisation in two processes: actual and potential urbanisation. Actual urbanisation refers to a change into built-up area or infrastructure, whereas potential urbanisation refers to the new development of urban green or greenhouses. The latter process indicates the development of land uses with a distinct urban appearance that, especially in the case of urban green, often precede various types of built-up land (such as residences or businesses). Yet, these types of land use are not yet fully urbanised and transitions back to more rural types of land use are still possible. This reverse process is much more unlikely in the case of built-up land. To highlight the process of nature development that is supposed to be especially prevalent in the Buffer zones we have also summarised transitions related that indicate new nature areas. The remaining minor transitions are summarized under 'Other changes'. These include all other possible transitions that are not listed under the three main processes listed above, such as those from: water to urban area, water to greenhouses, greenhouses to Infrastructure et cetera. To be able to compare the amount of transition between different zones a percent change per transition is calculated by dividing the amount of change by the total surface of the respective zone.

The tables only show net transitions because we want to focus on the dominant spatial processes. So when we present the transitions from, for example, Agriculture to Built-up, this is the result of all transitions from Agriculture to Built-up minus the transitions from Built-up to Agriculture in that period in the respective region. Pixel-to-pixel comparisons of these highly detailed data sets highlight many small-scale transitions that are partly related to mapping and classification issues such as changes in the minimum mapping unit from year to year. These issues are acknowledged by the data provider (Melser 2012). The high temporal resolution and distinction of three subsequent short transitions periods also increases the amount of observed change: inner-city redevelopment processes, for example, may be observed as an urban area to urban green transition in period 1 and an urban green to urban area transition in period 2. Similarly the development of agricultural land into natural areas (woodlands) may follow an intermediate urban green (vacant land) stage. The combination of classification and mapping issues and short-term temporal changes makes that our three-period description of transitions show 35 % more change than a one-step assessment of transitions between 1996 and 2008 does. We have chosen for this high temporal resolution, however, to be able to study potential changes in urbanisation speed that may be the result of policy changes over time.

The tables show that the non-restricted part of the Randstad is by far the most dynamic area in the Randstad with a total net change of about 20,000 ha in the total observed 12-year period. This is equivalent to about 7 % of the total surface area of the non-restricted part of the Randstad and indicates that approximately 0.6 % of this region changes its use every year. The other areas are much less dynamic: the total net change in the Buffer zones is equivalent to about 4 % of that area, whereas this share is about 3 % in both the Green Heart and the additional area that has more recently been designated a National Landscape within the Randstad. These dynamics mainly refer to actual and potential urbanisation processes that typically are

equally strong in each region, claiming in total about 3.1 % and 3.5 % respectively of the total non-restricted region in the Randstad and about 1 % each in the other regions in the total studied period. When we focus on the restricted landscapes we find that in the Buffer zones both potential urbanisation and nature development are more prevalent (claiming 1.8 % and 0.7 % respectively of the total Buffer zone area) than in the Green Heart and National Landscapes (claiming 1.0 % and 0.4 % respectively of these areas). This may point at the strong policy attention to the Buffer zone where often recreational facilities and natural areas were being developed (van Rij et al. 2008).

When we look in more detail at the process of actual urbanisation we find that in most regions the land that becomes built-up was previously in agricultural use. Only within the non-restricted areas of the Randstad this used to be mainly urban green, probably indicating that in these areas agricultural land is relatively scarce and green forms of urban land (allotment gardens, small green spaces and building lots) are more prevalent and apparently also likely to become urbanised. Nature areas hardly change into urban types of land use. They are probably better able to withstand the urbanisation pressure because of specific (inter)national nature and biodiversity protection policies and the reluctance of nature land owners to sell their land for urbanisation. Natural land in the Netherlands is typically owned by Governmental or not-for-profit nature conservation organisations that have the specific objective of preserving natural areas.

The temporal dynamics do not offer a clear signal; the relative strength of the observed processes varies over time in a different way for each region. These dynamics do not seem to be related with policy changes over time and may, in fact hint at the complex and coincidental relation between planning, economic opportunities and spatial developments. Exactly which development will take place at a particular location at a certain moment in time will depend on many factors. The Dutch planning system is notoriously slow in keeping up with changes (Van Rij 2009); spatial plans may need a long time to become reality because of the various governmental layers that may be involved and (legal) procedures that have to be followed. For the same reasons spatial restrictions may linger on for quite some time after they have been abolished at one governmental layer. Once development plans are approved and implemented it may still take several years before the final results can be observed because of lengthy construction processes (in particular with infrastructure development) or altered socio-economic conditions (e.g. changing societal consumer preferences, sudden financial crises). So developments that are observed at a particular year are not necessarily related to the planning and socio-economic conditions of that moment.

### ***3.2 Object-Based Analysis***

In addition to the raster-based analysis that focussed on land-use changes we also analysed regional changes in the total number of houses. This object-based analysis

of residential development focuses on two periods of three respectively 4 years between 2000 and 2008. Table 3 shows the annual growth in housing stock, housing densities and urbanisation rates within different (restricted and non-restricted) parts of the Randstad and for the Netherlands as a whole.

The results show that housing density is about five times higher in the Randstad (excluding protected zones) than the Dutch average. In absolute terms, the annual growth in number of houses in both periods is by far the largest in this zone, further enlarging the existing differences in absolute numbers and housing density. However, observing growth in relative terms, we find a substantial increase within the restricted zones, partly because of the low initial number of houses. In combination with low amounts of additional urban land within these restricted zones (recall our preceding analysis in this chapter) this indicates that a substantial part of new houses in these zones is realised within existing urban areas. Unfortunately we cannot analyse that in more detail as the spatial detail of this data is insufficient (or rather, not reliable enough).

Compared to the national totals, the growth of the housing stock within the Randstad is relatively low. This implies that other parts of the country accommodate a larger share of the new houses. This happens mainly at New towns and designated urban extension locations in the provinces that neighbour the Randstad region (most notably Flevoland and Noord-Brabant). This development may indicate that the Randstad is reaching its limits for further urban development in the currently common form that is dominated by a large share of single-family dwellings.

From Table 3 we can also observe that housing density is by far the lowest in the Buffer zones (87 houses per km<sup>2</sup> in 2008, even lower than in the rural, peripheral zone of the country). This shows that these zones are still truly open spaces where urban development is successfully limited.

### ***3.3 Assessment of Potential Future Changes***

The preceding sections have indicated that restrictive spatial policy is (partially) successful in limiting urban development in specific regions. This knowledge can be used to simulate potential future conditions. As part of the Strategic Environmental Assessment of the proposed changes in national spatial policy discussed extensively in Sect. 1.3, we applied Land Use Scanner to simulate the possible future urbanisation patterns that might arise under different policy scenarios. This section describes the way these simulations were constructed. For more information about the policy context and expected environmental impacts the reader is referred to the actual assessment report (Elings et al. 2011). The model uses a spatially aggregated version of the 2008 land-use raster data set from Statistics Netherlands as starting point for simulation at a 100 m resolution.

The new national spatial strategy proposes four sets of major changes from current national spatial policy:

**Table 3** Regional increases in number of houses and housing densities in different zones within the Randstad (2000–2008)

Region	Total surface area (km <sup>2</sup> )	2000		Annual change 2000–2003		Annual Change 2004–2008		2008	
		(abs.)	(/km <sup>2</sup> )	(abs.)	(%)	(abs.)	(%)	(abs.)	(/km <sup>2</sup> )
Randstad*	2,822	2,542,943	901	11,808	0.46	14,780	0.58	2,614,355	926
Buffer zones	639	52,084	82	368	0.71	270	0.50	55,302	87
Green Heart	1,872	279,638	149	2,406	0.86	1,941	0.67	297,785	159
National Landscapes*	791	107,223	136	968	0.90	817	0.74	113,537	144
<i>The Netherlands</i>	34,993	6,843,865	196	39,306	0.57	59,678	0.85	7,248,395	207

\*Excluding the other regions (such as Buffer zones) that partially fall within them

1. A new evaluation framework for investments in infrastructure that emphasises economic benefits;
2. Less national interference in urban development, abolishing transformation and urban concentration policy;
3. Limiting the ambitions for the National Ecological Network, focus on management of current natural areas, limited acquisition of new areas, no development of connection zones;
4. Stronger emphasis on internationally unique cultural historic landscape values of, for example, UNESCO world heritage sites, abolishing buffer zones and decentralising national landscapes.

The outcome of these policy changes, however, is uncertain. This is especially true for the impact of decentralising the responsibility for the National Landscapes. Provinces may decide to ease, continue or reinforce the current restrictive planning regime in these areas. To show the uncertainty related to the different possible attitudes of the three provinces involved, it was decided to show two potential, extreme outcomes: one in which current policies are fully maintained (reference alternative) and one in which they are abolished (new policy alternative). Neither outcome is necessarily more likely, but together they show the potential bandwidth of impacts. This scenario-based approach is advocated in strategic planning (Dammers 2000) and decision making (De Ruijter et al. 2011), but not very common in environmental assessment reports as was previously also recognised by Duinker and Greig (2007).

Table 4 summarises the main policy objectives and associated extreme spatial implications of the reference situation and the new policy alternative grouped per policy domain. These alternative-specific assumptions were translated in model input and first fed into the TIGRIS-XL land-use transport interaction model (Zondag and Geurs 2011) to obtain separate sets of regional projections of the demand for new residences and business estates for each alternative in 2040. Figure 5 presents an overview of the demand for urban land according to the Current and New policy alternatives compared to the historic trend. The figure makes clear that the additional demand for urban land for both alternatives is almost identical. These projected developments are, furthermore, in line with the trend in the past 30 years.

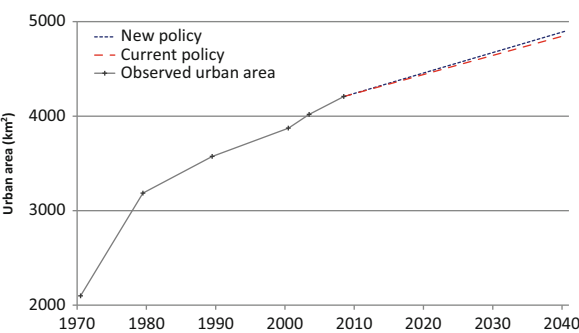
In a subsequent step these regional demands for additional urban land, together with alternative-specific, spatially explicit assumptions related to, for example, the presence (or absence) of specific policy restrictions, were fed into Land Use Scanner to simulate land-use patterns. These simulations were carried out by PBL Netherlands Environmental Assessment Agency as part of their ex-ante evaluation of the new policy report (Kuiper and Evers 2011a) and build upon initial work that was done for the 'Netherlands in the future' study (PBL 2010; Kuiper et al. 2011).

Figure 6 shows the simulated increase in urban area for the reference alternative that follows current policy and the new policy alternative. The figure essentially shows three states: new urban areas according to current policy, new urban areas according to the new policy alternative and new urban areas according to both

**Table 4** Overview of the main objectives and expected spatial implications of the Current policy (reference situation) and New policy alternatives grouped per policy domain

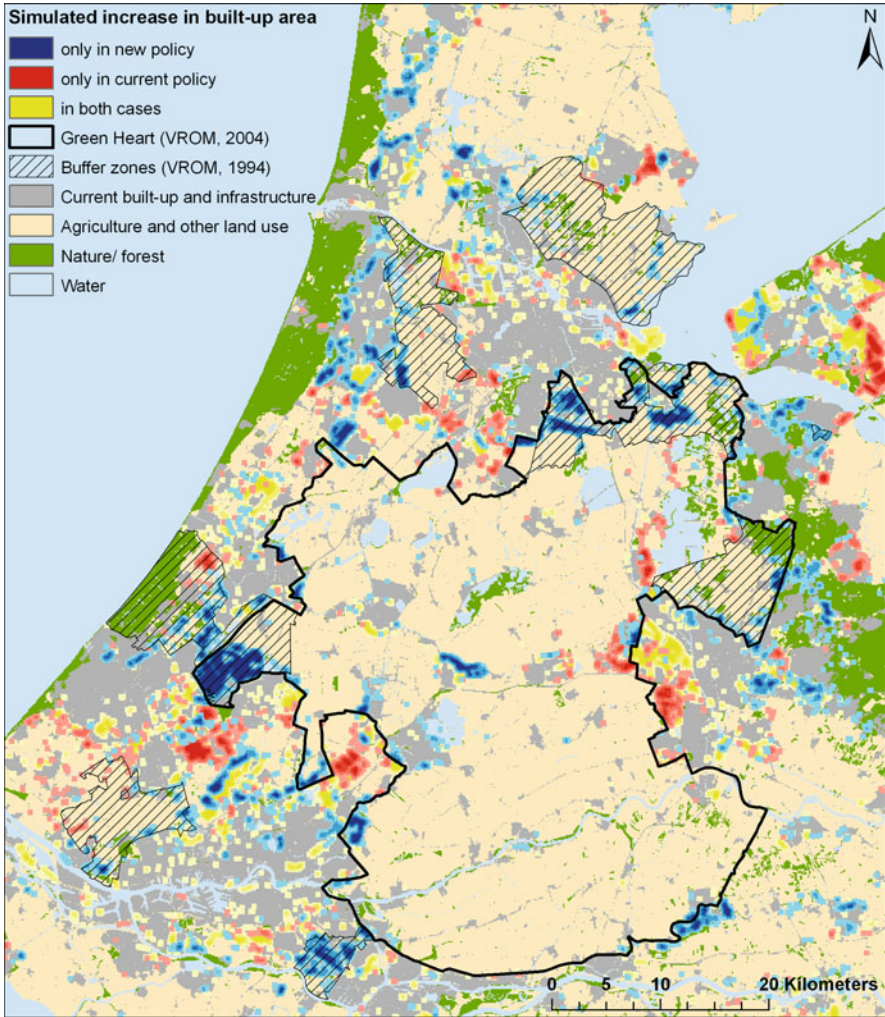
Policy domain	Current policy	New policy alternative
1. Mobility and accessibility	Current plans for development new infrastructure carried out	Stronger focus on economic benefits, but spatial implications uncertain: current plans are maintained
2. Urbanisation (residence/ commerce)	Bundling and transformation zones maintained, results in ca 30 % intensification (share of new residences built in current urban areas)	Bundling and transformation zones abolished: ca. 20 % intensification
	Supply steers location of new residences	Residential preferences and accessibility (demand) dominate location of new residences
3. Nature development	National Ecological Network realised in 2018 according to initial plan: 100,000 ha nature extra	Limited version of National Ecological Network: 20,000 ha extra
4. Unique landscape values	Buffer zones and National Landscapes limit urbanisation in specific areas	Buffer zones abolished, limited impact National Landscapes
	National Ecological Network and Natura 2000 areas limit urbanisation	Only international obligations limit urbanisation (UNESCO, Natura 2000)

**Fig. 5** Observed and projected urban area according to the Current and New policy alternatives (Source observed urban area: Statistics Netherlands 2012)



alternatives. The latter thus show locations that are likely to become urbanised irrespective of any changes in spatial policy. To visualise the uncertainty that is inherent to the simulation outcomes, the very detailed outcomes are not directly shown at their initial 100 m resolution. Instead, a visualisation technique is chosen that emphasises the presence of similar neighbours in a 500 m environment. With a moving window filter the 24 cells surrounding a central cell are evaluated; when all cells show the same value as the central cell a colour with a high intensity is





**Fig. 6** Simulated changes in built-up area for the new national spatial strategy and current policy (adapted from Kuiper and Evers 2011a). Colour intensity in simulated built-up area represents the amount of similar neighbours, so intensely coloured locations indicate likely large-scale urban development under specific policy conditions

selected, when no other neighbour has the same value a low intensity colour is selected.

Obviously the simulations offer indicative, almost caricatural images that do not allow detailed impact assessments with environmental impact models. But these simulations integrate the potential implications of domain-specific policies and help visualising the regional accumulation of the impacts associated with individual policy measures.

## 4 Discussion

This final section contains a discussion on the observed urban fringe dynamics in the Netherlands, the effectiveness of restrictive land-use policy in this particular case and the possible future changes that can be expected from the proposed policy changes. While discussing these aspects we also pay attention to more general methodological issues such as the applicability of the applied techniques and limitations.

### *4.1 Urban Fringe Dynamics and Policy Effectiveness*

The applied spatial analysis methods allow for a straightforward comparison of change within restricted and non-restricted zones. This approach yields useful information about actual land-use dynamics at the urban fringe and the effectiveness of regional differences in restricted development zones. This quantitative information can be used to provide some clarity in the often heated but rather conceptual discussions on the effectiveness of these policy measures

In terms of land-use dynamics, our raster-based analysis shows that the non-restrictive areas in the Randstad urbanise more quickly than the restrictive areas in this region. This analysis confirms that the restrictive spatial policies in the Randstad have been effective to limit urbanisation between 1996 and 2008. When we realise that these protected areas are located within the highly urbanised Randstad and are thus under a higher than average urbanisation pressure compared to the whole of the country, the effectiveness is even more impressive. We do note, however, that there still is some urbanisation going on in the restrictive areas, albeit at a much slower pace and more concentrated within existing urban area. The object-based analysis points at similar trends. The presented analyses thus confirm our preceding studies in which we used other and less recent spatial data sets (Koomen et al. 2008b, 2009) and the results are also in line with prior empirical work of others (VROM 2000; MNP 2004). The importance of zoning regulations was also acknowledged in an in-depth case study performed by Van Rij et al. (2008) that relied on literature reviews and interviews. They concluded that zoning regulations together with the development of local recreational potential were indeed effective in limiting urbanisation within the restricted zones. The developments that are taking place in the restrictive areas, for instance in the Green Heart, are urban extensions in a limited number of municipalities that are clearly in line with the compact-city philosophy that had a central role in Dutch spatial planning for the past decades.

In general, in both our analyses we do not observe a clear difference between the different restrictive areas, or between different periods. Thus we cannot observe impacts of, for example, the policy-shift in 2004. This might be partially attributed to the fact that the study period is relatively short and the policy change establishing

the National Landscapes is still rather recent. It may, in fact, show that planning is a slow and complex process, the outcome of which relates to, amongst others, a degree of inertia in the planning system, lengthy construction processes and changing societal, planning and economic conditions.

It is important to stress that the relative success of open space preservation policies was also due to specific conditions and additional policies that were in place (Dieleman et al. 1999). To keep specific areas open, policy makers in the past decades felt the need 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 the Buffer zone policy has been drafted together with 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 of it.

Obviously, the presented results do not provide information about the societal, economic or other forces that drive the observed changes. Apart from zoning regulations, other factors such as more limited accessibility, employment and service levels, may have influenced the regional differences in urban development. These factors are not considered in this chapter but will be considered for future explanatory studies that will apply regression analysis to link various spatially explicit driving forces (including spatial restrictions) with observed (changes in) urbanisation patterns.

Our analyses were hampered by limited data availability and data definition issues, leading to relatively short periods of analysis and some inconsistencies in the data. Fortunately, by combining two analyses of different data sets we were able to obtain a fairly robust idea about the relevant land-use dynamics in the area over the past decade. The use of local-level geographical data also allowed us to graphically represent land-use changes and visually analyse the patterns of change. That is a clear advantage over comparable efforts that rely on, for example, census statistics (see, for instance, Kline 2000; Nelson 2004). The object-based data did not allow detailed local assessments of urban development, but was found to provide reliable statistics at the regional level that correspond with other sources such as Statistics Netherlands.

## ***4.2 Potential Impacts of Proposed Policy Changes***

In addition to our GIS-based analyses of past land-use changes we applied simulation methods to assess potential impact of proposed policy changes. This approach provided a valuable tool to depict likely outcomes of policy changes and was successfully used in a recent Strategic Environmental Assessment report dedicated to the newly proposed national spatial strategy for the Netherlands. This what-if type of simulation typically relies strongly on expert judgement as it has to describe

the impact of policies that have not yet been implemented and whose effects cannot be observed. The GIS-based analyses of the effectiveness of similar policies as described in this chapter thus offer an important ingredient for the development and calibration of land-use simulation models.

A recent, interview-based study by Van Kouwen (2012) into the potential future spatial developments in National Landscapes made clear that most parties involved do not expect sudden changes from the proposed changes in national spatial policy. Representatives of governmental organisations at the national, regional and local level and societal partners base these expectations on their observations that: (1) provinces have already implemented current, more restrictive policies in their strategic visions that govern planning at the municipal level; and (2) new urban developments are unlikely under current economic conditions. These expectations, however, seem to be strongly linked to current political and economic conditions. When new regional governments are formed and the economy recovers, the current trend towards deregulation and decentralisation may lead to an increase in urban development in currently protected landscapes. Such threats to metropolitan open spaces have, for example, also been described by Van Rij (2009). Therefore, we strongly believe that the type of scenario-based simulations of potential impacts of policy changes described in this chapter offer a powerful approach to incorporate the notion of uncertainty in ex-ante policy evaluation.

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