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Analyzing and Simulating Urban Density

Exploring the Difference Between Policy Ambitions and Actual Trends in the Netherlands

Eric Koomen, Jasper Dekkers, and Dani Broitman

Abstract This chapter explores the potential of geospatial analysis to characterize land use dynamics in urban areas and the surrounding urban fringe. It focuses on the difference between policy ambitions and reality with respect to urban densification. Policy ambitions for the containment of urban development are ambitious in the Netherlands, as is evident from the many local objectives to concentrate residential development within existing urban areas. These ambitions are formulated as target shares of the total net increase in housing stock that should be realized within designated urban area boundaries. Following a GIS-based analysis of local changes in housing stock between 2000 and 2008, we are able to describe actual intensification shares and residential densities in newly-developed urban areas. We observe that, especially in the already densely-populated western part of the country, the realized urban intensification shares are below the specified policy goals/ambition levels. Using these observations along with scenario-based projections of the regional increases in housing stock, we are able to determine the demand for new urban land in 2020. Using a land use simulation model, we simulate the urban development processes until 2020 according to two scenarios and two policy alternatives. In the first policy alternative, growth in the number of house units is based upon policy ambitions, while in the second scenario growth is based upon observed trends over the past decade. The results show that current policy ambitions related to urban intensification levels will greatly help in containing the substantial urban growth that is projected in the case of a high economic and population growth scenario. If urban development follows past trends, unabated, thus demonstrating relatively low urban intensification shares, large-scale urban extensions are likely to occur.

Keywords Urbanization • Spatial analysis • Urban planning • Urban growth boundary

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Introduction

Spatial Planning and the Urbanization Paradox

In planning, policymakers define objectives and implement various types of instruments to realize specified ambitions. In the domain of spatial planning, typical instruments include urban concentration policies and/or policies set to protect open space, zoning regulations with regard to flood-prone locations, climate adaptation policies and financial measures and zoning regulations to attract new businesses or to reduce the amount of vacant office space (Kuijpers-Linde 2011). While ex-ante evaluation of proposed strategies and policies is common in the legal framework of environmental impact assessment, ex-post evaluation is much less common. Yet, this type of evaluation can be very insightful when new policies are proposed. Looking back at the degree of success of past initiatives can distinguish potentially effective alternatives from less effective ones.

This chapter aims to contribute to the urban land management debate by reflecting on past and future urban developments in relation to spatial policies that aim to steer them. We present an ex-post evaluation of the degree of success of urban containment policies and use this information to show how future developments may potentially deviate from current ambitions.

The Netherlands was selected as a case study for this analysis. In this country, strategic spatial policy is initially formulated in national-level policy documents. Subsequently, this framework is used to formulate more concrete policy ambitions for the regional (i.e., provincial) and local (i.e., municipal) levels. Prior to the establishment of the new national strategic vision for infrastructure and the environment (I&M 2011), spatial plans for the lower levels had to correspond with the ambitions set at a higher level. However, with the approval of the new national vision, the trend towards decentralization of decision-making power in urban planning has continued, and the relationship between urban land use planning at various scales is further changing. The nature of this change and its potential effect of moving from national-level, development-oriented planning towards the setting of the legal role for development-related decision-making at the regional and local levels, is discussed extensively elsewhere (Roodbol-Mekkes et al. 2012).

In our analysis of the effectiveness of urban containment policies we focus on the ambitions for urban intensification that we define as the process of increasing the number of housing units within existing urban area. The national strategic urban intensification policy goal was previously set at a minimum realization of 40 percent of the addition to the housing stock within the existing urban area of 2000 (VROM et al. 2004). This was a net ambition, representing the absolute change in housing stock comprised of the balance of newly constructed housing units minus demolished units while excluding renovated units. However, at the regional level policy ambitions seem to differ substantially. In order to obtain insight about the degree to which these policy ambitions differ regionally, we developed an inventory

of current policy ambitions with regard to urban intensification. The most recent relevant strategic visions were collected for each region or municipality. Appendix 1 presents the results of this inventory at the COROP-level.¹

An interesting pattern emerges from these intensification ambitions. In the Randstad, which is the most urbanized western part of the country, the intensification ambitions are typically more strict than in most other parts of the country. To illustrate, in the Greater Amsterdam region and the areas around Rotterdam and The Hague (see Fig. 1), the intensification ambition is for 60 percent of the new development to occur within the urbanized area (Keers et al. 2011), while the goal for the metropolitan area around The Hague (i.e., Haaglanden) is for 80 percent of new house units to be constructed within the existing urban area. Therefore, in the urban areas that already have the highest densities, the ambition levels are also set highest. In the regions with population decline at the edges of the country, ambitions regarding urban intensification are high for a completely other reason: more compact urban forms are expected to help maintain current urban facility levels (i.e. shops, restaurants, public services, etcetera).

With the approval of the new national strategic vision for infrastructure and the environment (I&M 2011), the national government does not retain the national policy goal of 40 percent urban intensification (40 percent of new development must occur within urbanization boundaries) anymore. Instead, the national government has adopted a three-step approach with regard to urbanization, recognizing the differences between regions and the need for tailor-made policies. First, demand for specific developments is examined. Next, the priority is to determine whether existing urban areas or existing buildings can be used to accommodate the demand. Only when an extension of the urban area is truly necessary, will this be allowed. With this new policy, the national government effectively gives provinces and municipalities the mandate to set their own policies with regard to urbanization and maintaining open space.

Prior analysis shows that over the past decade, a larger share of the additional housing stock (construction minus demolition) was built as urban extensions outside existing urban areas than was called for in the relevant planning documents (PBL 2010; Keers et al. 2011). Although substantial regional differences were observed in this study, the general suggestion was that the provinces comprising the Randstad had greater difficulty in meeting their intensification goals. The apparent discrepancy between high intensification goals and low degrees of success in implementing them in the most urbanized regions of the country is an interesting urbanization paradox that provides the motivation for this study. With the use of actual data for urban intensification scores, we aim to contribute to evidence-based planning. Such information can be used to adjust existing plans, or to draft new plans and policies that may prove to be more feasible.

¹The Netherlands has 40 COROP-regions. This administrative division is often used to represent statistical data and is identical to the European NUTS 3 division.

Fig. 1 Locations of the Randstad, the administrative (COROP) regions used in our analysis and the four largest urban agglomerations of the Netherlands (Source: VU-SPINlab, 2013)

Future Urbanization Scenarios

To show the potential impact of various urban intensification policy levels upon future urbanization patterns, we apply a land use simulation model. Such models are useful tools to support the analysis of the impact of spatially relevant policies (Koomen et al. 2008a). They can, for example, simulate potential autonomous spatial developments outside of the urbanized area and show the possible consequences of various policy alternatives.

In this study we apply a land use model to simulate potential urban development patterns according to two scenarios taken from the *Welfare, prosperity and quality of the living environment* scenario study (CPB et al., CPB et al. 2006). In that study, four scenarios are introduced which follow the well-known Special Report on Emissions Scenarios, or SRES-scenarios, of the International Panel on Climate Change (IPCC 2000). The scenarios differ in their emphasis on basic societal trends, and the balance of globalization versus regionalization and economic versus environmental values. To limit the number of results we have selected the two most divergent scenarios from the aforementioned study: the Global Economy (GE) and Regional Communities (RC) scenario.

The Global Economy scenario is part of the A1 scenario family in the SRES terminology; the scenario is based upon substantial population growth and strong economic growth. In the Regional Communities scenario (based upon the B2 scenario family of SRES) the population remains more or less stable, with modest economic growth and a higher unemployment rate. This scenario expects the population in the Randstad area to continue growing, but assumes a population decrease in certain peripheral areas. The two selected scenarios offer the most extreme outcomes in terms of the key variables that steer urban development (demographic change and economic growth), and thus bracket the range of potential changes. In this respect, they help in visualizing the most extreme situations that policymakers are likely to encounter. The inclusion of additional scenarios with intermediate values for key variables could potentially overburden policymakers with too much information.

For this study we translated the regional population projections associated with the two scenarios into a demand for urban land based upon two alternatives: (1) current policy ambitions related to urban intensification (i.e., share of net new housing stock to be facilitated within existing urban areas and prescribed dwelling densities in number of housing units per hectare); and (2) observed intensification results over the past decade. The empirical analysis underlying the latter alternative, and the resulting land demands, are discussed in subsequent sections. By combining two socio-economic scenarios (Global Economy/GE and Regional Communities/RC) with two alternative intensification options, we are able to produce four alternative simulations of future urbanization patterns that allow us to assess the potential impact of current policy ambitions under different demographic conditions (Fig. 2).

Figure 3 puts the projected growth in number of inhabitants and households in a historic perspective. The graph shows a continuous growth in the number of inhabitants and households since 1970, a trend which appears to slow down by the end of the century. The growth, according to the GE scenario, is mainly caused by more open migration policies in line with historic development. The RC scenario, on the other hand, shows a trend breach, assuming a stabilizing population following from an aging population and limited immigration (Hilbers and Snellen

Fig. 2 Combination of two socio-economic scenarios Global Economy (GE) and Regional Communities (RC) with two urban intensification alternatives (policy ambitions vs. empirical results) yields four possible futures

Fig. 3 Growth in number of inhabitants, households and housing units in the Netherlands, 1970–2020 (Source: Statistics Netherlands 2012 for 1970–2008; TIGRIS XL model of the PBL Netherlands Environmental Assessment Agency for 2008–2020)

2010, pp.25–28). Figure 3 also shows that average household density has been decreasing substantially over the past decades, causing the number of households to increase almost as fast as the total population. This particular trend is assumed to continue in the GE scenario, further reducing household size from 2.27 persons (2008) to 2.07 in 2020. Household size is expected to remain stable at 2.24 in the RC scenario.

The remainder of this chapter is organized as follows. In section “[Methodology and datasets](#)”, we present an overview of the applied methodologies and datasets – In particular the spatial analysis techniques used, and our land use simulation model,

Land Use Scanner, is discussed. Subsequently, we analyze past developments in the density of new urban areas, and the share of new dwellings facilitated in existing urban areas, in section “[Analyzing urban development](#)”. Then, in section “[Simulating urban development](#)”, we switch from empirical analysis to scenario simulation by taking two socio-economic world views and combining these with either Dutch urban policy ambitions or an empirical trend extrapolation. Section “[Discussion and conclusion](#)” then ends the chapter with conclusions and reflections on the results.

Methodology and Datasets

This section describes the methods and data sets we apply in our analysis. First, we discuss the spatial analysis approach we apply to describe local changes in residential density between 2000 and 2008. Then, we introduce the Land Use Scanner model used to simulate land use changes.

Spatial Analysis Techniques

Spatial analysis and detailed geographical data form a powerful combination to assess the effectiveness of spatial policies. By 1992 Longley and others had used this combination to assess the influence of Green Belt zoning regulations in Britain by comparing the geometry of settlements which were subject to such policy to those which were not (Longley et al. [1992](#)).

In our first analysis, we focused on residential density change establishing differences between urban development within and outside of existing urban areas. To this end, we employed several detailed raster datasets with a 100-meter resolution which described the urban area and contained the number of housing units in 2000 and 2008. In this analysis urban area is defined to include account all types of urban land use (mainly residences, but also associated elements such as shops, public buildings, parks, sports fields et cetera) except large industrial sites. Housing units (in this chapter also called dwellings) refer to individual residential objects that may be contained within larger buildings (e.g. apartments) or that differ in other respects from regular houses (e.g. houseboats). The datasets containing number of housing units per 100-meter grid cell are built based on a combination of sources related to the spatial location of built structures and households, as described in Evers et al. ([2005](#)). Due to slight data definition changes over time and the fact that each of the included data sources is aimed to fulfil different objectives the resulting number of housing units can differ from the official figures of Statistics

Netherlands (CBS). The 2000–2008 period was selected for analysis because it is longest possible time span without substantial data definition issues. The datasets with numbers of housing units, provided by the PBL Netherlands Environmental Assessment Agency, contain nearly the same municipal housing totals as Statistics Netherlands; there are differences of less than 0.3 percent of the total number of housing units per municipality between both datasets.

By comparing the detailed housing stock datasets of both years in a geographical information system (GIS) we can analyze local changes in number of housing units. The analysis distinguishes between: (1) intensification share (percentage of net addition to the housing stock within the 2000 urban area); (2) density of urban extension (expressed in number of housing units per hectare of newly developed urban area between 2000 and 2008); and (3) rural housing share (percentage of net addition to the housing stock outside the urban area of 2008). For the first case we made use of the boundary of existing built-up area in 2000 that was developed by the Ministry of Infrastructure and Environment in order to evaluate urban development processes. An extensive description of this dataset is provided by Odijk et al. (2004). To discern the new urban areas developed between 2000 and 2008 we compared the two land use datasets of these years provided by Statistics Netherlands. These datasets were used as base maps in the subsequent land use simulation efforts.

We use zonal statistics to sum cell values of the raster-based datasets within different regions. By comparing the total number of dwellings on an aggregate level for different years, we can calculate growth in housing stock in absolute and relative terms, in order to obtain insight about the net growth in housing stock and the changes in urban density. Zonal statistics can be created via standard GIS procedures available in most GIS-software packages.

Land Use Scanner

The second part of our study involves the simulation of future spatial patterns. The model we apply here, Land Use Scanner, is rooted in economic theory and has been applied in a large number of policy-related research projects in the Netherlands, in Europe and in other regions and countries. The model includes all types of land use, not only urban but also natural and agricultural functions. The Land Use Scanner is a GIS-based model that simulates future land use. It uses an expected regional land demand for different types of land use along with a local definition of suitability for these types of land use in order to create an integrated map of future land use (See Fig. 4 for an overview of the main components of the model).

The regional demand is typically derived from external sector-specific models or specialized sources. Local suitability is defined within the model using a large number of detailed geo-datasets that define the local conditions for each land use

Fig. 4 Basic layout of the Land Use Scanner model

type, and for each 100 by 100 m grid cell in the country. The land use for the base year of the simulation is used as an input here. Biophysical properties of the land, such as soil type and groundwater level, offer additional input for defining land suitability, in particular for agricultural and natural functions. In addition, policy maps such as municipal zoning plans, nature conservation areas and buffer zones are included. Finally, thematic maps are included, generally expressing distance relations (e.g., accessibility or distance from similar land uses assumed to influence commercial and residential developments). The local suitability factors included represent a positive or a negative influence on the suitability value of a land use type.

The allocation module uses an efficient algorithm which determines the optimal future land use based upon a given set of local suitability inputs and regional demands. Both aforementioned input components are processed by the allocation module of the model. As a result, the model allocates land in fractions per grid cell to the different land use types. These fractions function as probabilities signifying the inclination of a cell to adopt a particular type of land use. These probabilities reflect the demand for various types of land use and the scarcity of available land suitable for certain uses. The algorithm applied here is a doubly-constrained logit model that, in its simplest form, can be formulated as:

$$M_{cj} = a_j * b_c * e^{Scj}$$

in which:

- M_{cj} is the proportion of land in cell c expected to be used for land use type j ;
- a_j is the demand balancing factor (Constraint 1), which ensures that the total amount of allocated land for land use type j equals the sector-specific demand;
- b_c is the supply balancing factor (Constraint 2), which ensures that the total amount of allocated land in cell c does not exceed the amount of land that is available for that particular cell;
- S_{cj} is the suitability of cell c for land use type j based upon its physical characteristics, operative spatial policies and neighborhood relations.

The allocation results from an iterative process that mimics the bidding process of competing land use types. This process assures that all types of use fulfill their regional demand while trying to obtain their preferred (most suitable) locations. Land use types with a relatively high demand compared to the amount of land that is initially allocated to them, will offer the highest bid on the available land.

In the context of strategic, scenario-based national planning, the model proved to be a very useful tool to inform policymakers about potential future developments (Borsboom-van Beurden et al. 2007; Dekkers and Koomen 2007; Kuhlman et al. 2013). The model also proved useful for providing ex-ante evaluations of policy alternatives in national (Van der Hoeven et al. 2009) and regional contexts (Koomen et al. 2011; Jacobs et al. 2011) in the Netherlands and abroad (Hoymann 2010; Te Linde et al. 2011). The basics of the model and the process of its calibration have been described extensively elsewhere (Koomen and Borsboom-van Beurden 2011; Loonen and Koomen 2009).

In the application of this model presented in this chapter, we specifically focused on the impacts of policy ambitions related to urban development. The regional demand for urban area was based upon our own analysis and assumptions, as discussed in section “[Simulating urban development](#)”. Suitable locations for urban area were determined by: proximity to current urban areas; known urban development plans as incorporated in municipal or regional planning documents were included as well. This information is taken from an extensive survey performed by PBL Netherlands Environmental Assessment Agency.

In addition, a demand for natural areas was taken from the national plans for development of the National Ecological Network. In doing so, we followed the most recent national ambitions documented in the new national spatial strategy (I&M 2011; Elings et al. 2011). These revised plans foresee a more limited network of natural areas, for which new natural areas will only be developed on already acquired agricultural land, with plans for its eventual conversion. Data regarding the amount of land involved and its location is taken from a recent inventory of ratified natural areas plans (DLG 2010). For more information about these claims and definitions of suitable locations for natural areas, we refer to Dekkers et al. (2012).

For all other land use types (e.g., agriculture, greenhouses, industry, recreation) the future demand is set to the amount of land present in 2008. The suitability for these land use types is based solely on their 2008 location. By doing this we keep the non-urban land use patterns stable and, thus, maintain our focus on the impacts of the policy ambitions related to urban development.

As an increase in urban area is expected in almost all regions, land will have to be provided in areas currently allocated to other types of land use. In decades past the space required for urbanization was almost exclusively provided by grassland and arable farmland (Koomen et al. 2008b), therefore the model allows less land to be allocated to these types of land use. Furthermore, land for development is also provided by the land use type known as building lots (i.e. sites that have already been prepared for building activities).

Analyzing Urban Development

The observed residential density changes between 2000 and 2008 are summarized at the COROP level in Fig. 5 and included in Appendix 1. The appendix also includes the names of the COROP regions; in combination with Fig. 1, this serves as a reference for the reader as we discuss the trends hereafter.

The intensification share, which represents the percentage of new housing units built within the urban area existing in 2000, shows a distinct regional pattern. High values are generally encountered in the south, in parts of the Randstad and, to a lesser degree in the northeast of the country, whereas the lowest intensification shares (below 40 percent) are mainly found in the major urban areas of the Randstad (e.g. around The Hague, Rotterdam and Utrecht). Another area with a strikingly low intensification share is the province of Flevoland that consists of former lake areas that were reclaimed in the twentieth century. The existing urban areas in this region are typically less than 30 years old and apparently do not offer much opportunity for intensification. Moreover, this province has been designated to accommodate a substantial part of urban growth in the Randstad region in the past decades in new urban extensions. Another remarkable result is found for the COROP region of Delfzijl (in the far northeast of the map at left in Fig. 5) where the total number of housing units within the existing urban area declined while some urban development took place outside the existing urban area. Apparently, urban shrinkage and urban extension occurred simultaneously here between 2000 and 2008, indicating how developments may take place in other regions which may transition into areas of population decline in the following decades.

Appendix 1 shows that the policy ambitions for the intensification shares of new dwellings are in general higher than what is empirically observed. This is especially true for many urban areas in the Randstad where the ambitions are highest. As can be expected, the share of rural housing (denoting the newly developed, dispersed

Fig. 5 Urban intensification (percent of the total number of new dwellings added within the urban area contour of 2000) and densities of urban extensions areas for the period of 2000–2008. The COROP region of Delfzijl (in the far northeast) is left blank in the map at *left* as the total number of housing units within the existing urban area has declined

Fig. 6 Observed intensification share (percent of the total number of new dwellings added within the urban area contour of 2000), during the periods of 2000–2001, 2002–2003, 2004–2005, and 2006–2007 for the Netherlands and a group of the four largest urban regions encompassing Amsterdam, Rotterdam, The Hague and Utrecht (Source: Statistics Netherlands 2012)

dwellings that can be found outside of the mapped urban area of 2008) is typically low in the Randstad area (around 10 percent) and higher in the peripheral parts of the country (around 20 percent).

The intensification shares in the observed period are, of course, no guarantee for future developments. An obvious limitation might be that over time, it becomes increasingly difficult to find locations available for intensification. This process is hinted at in Fig. 6, which shows regional statistics on the intensification share for four subsequent 2-year periods. The figure compares the aggregate national intensification shares with the regional intensification shares for the COROP regions that include the four largest cities (Amsterdam, Rotterdam, The Hague and Utrecht). It appears to indicate that the intensification share, especially in the COROP regions encompassing the four largest cities, shows an overall decline from 2000 to 2007. In each time period, the intensification share of the group of four regions is lower than the share of the nation as a whole; as well, the group of four regions consistently shows intensification shares that are well below the high ambition levels (60–80% intensification) for these regions.

New urban areas created after 2000 are, in general, characterized by low densities, especially in the peripheral zones of the country. The lowest figures (less than 2 housing units per hectare) were observed in the northeast. Most northern areas and areas in the south-east and south-west of the country show densities in the range of 2 to 5 housing units per hectare. In most parts of the Randstad, the densities are

much higher (more than 10 housing units per hectare in the Amsterdam metropolitan region and in The Hague). The difference between those two extremes reflects the relative scarcity of land available for development in highly urbanized areas of the Randstad region, as compared with the country's periphery. The residential densities we observe are lower than typically described for urban extension plans. This is caused by the fact that we take into account all urban space required for complete urban extensions. In addition to the space taken by residences, this refers to elements such: local infrastructure, parks, schools, shops, businesses et cetera.

To a large extent, the empirically observed densities in the newly-formed urban areas mirror the intensification shares: high densities are found in regions with relatively low intensification shares, and vice versa. This may be related to the available amount of land available for urban development in relation to the demand for new dwellings. In peripheral regions, the demand for new dwellings is relatively low and can, to a large extent, be accommodated within existing urban areas that still have space available. When urban extensions are created in these regions, there is no strong incentive to build in high density as sufficient space is available. Conversely, in the more densely populated Randstad areas, where the demand for new dwellings is high, space is relatively scarce both within and outside of existing urban areas. This implies that options are limited to further intensify urban development within existing urban areas, and that urban extensions will also have little space available to accommodate a large demand.

It should be noted, however, that diversions from these general trends exist. Some regions within the Randstad are characterized by high intensification shares and show low densities in their urban extensions (e.g., Haarlem and Het Gooi). This may be partly related to the limited number of new housing units that were added to these relatively affluent commuting towns, which lack a strong increase in new inhabitants. Furthermore, the few dwellings added in these relatively wealthy regions are most likely larger than those of typical urban extensions.

Simulating Urban Development

Policy Ambitions Versus Trend-Based Extrapolations

The simulation of future urban development is based on the projected developments in total housing stock through 2020 according to the Global Economy (GE) and Regional Communities (RC) scenarios that were discussed in section "[Future urbanization scenarios](#)". Figure 3 shows that the net demand for new dwellings is much higher in GE than in the RC scenario; reflecting the higher population growth and the continuing decrease in average number of people per household in the GE-scenario.

These national projections were employed by PBL Netherlands Environmental Assessment Agency to obtain regional household projections for 2020 as part of their Delta Scenarios Study (Rijken et al. 2013). For each scenario, the net regional increase in housing stock was provided by the TIGRIS XL model, which calculates housing demand via a system of model components that include dynamic interactions (Significance and Bureau Louter 2007; Zondag and Geurs 2011). In essence, the model is comprised of labor market model that interacts with both a commercial real estate market model and a land market model via a transport model. The model uses information on regional workforces, labor demand, demographic data, data on commercial sites and numbers of households, housing units, persons, firms and jobs. For more information about the model components and variables we refer to Zondag and De Jong (2005).

For each of the two socio-economic scenarios, we then created two urban intensification alternatives in which the additional demand for urban areas is based upon either the observed intensification shares during the 2000–2008 period ('Trends' alternative) or the regional policy ambitions related to urban intensification ('Ambitions' alternative). To obtain an additional urban area demand from the projected regional changes in housing stock we apply the following steps based on the COROP region-specific outcomes of our empirical analysis (as listed in Appendix 1). First, we subtract the number of housing units that are likely to be built outside of formal urban areas, and that are thus not simulated as part of the urban land use category. The number of units belonging to this category is based upon the share of rural housing observed in the housing stock increase in the 2000–2008 period.

The intensification share (based upon either the observed values for the 2000–2008 period or the policy ambitions) is then subtracted in order to account for those dwellings that are expected to be facilitated within the urban area that exists in the base year of simulation. The remaining share of housing units is expected to form new urban areas, and the size of these areas is determined by dividing the corresponding number of units by the residential densities observed in the urban extensions formed between 2000 and 2008. The resulting additional urban demand for 2020 is then used as input for the Land Use Scanner model.

For the (near) future, growth is still expected in many parts of the country, but the projections for individual regions can differ substantially (PBL 2011). In some peripheral regions in the Netherlands, a population decline is expected – a trend that is already observed in the most peripheral regions in the northeast, southeast and southwest. The high-growth regions are mainly located in densely-populated and already highly urbanized areas.

Figure 7 shows the projected urban density at the national scale for the different simulations. The presented figures result from: (1) the projected net additional demand for dwellings, which differs for each scenario (GE versus RC), (2) the intensification shares that differ per alternative (policy ambitions versus empirical results); and (3) the observed density in the urban extensions formed between 2000 and 2008 (equal for all simulations). In both 'Trends' alternatives, the aggregate national urban density is lower than in the equivalent 'Ambitions' alternatives,

Fig. 7 Observed urban density (dwellings/ha) in the Netherlands through 2008 (Source: Statistics Netherlands 2012). The expected densities in 2020 are based on the combination of the scenarios and urban intensification alternatives (policy ambitions versus empirical results)

Fig. 8 Observed change in the amount of urban area in the Netherlands (in km²) through 2008 (Source: Statistics Netherlands 2012) compared to our simulation alternatives

showing that ambitions are indeed needed to maintain current density levels. In the GE scenario overall density levels are expected to drop because of the addition of many new housing units in urban extensions with relatively low densities.

The expected growth in urban area for 2020 which results from the aforementioned calculations is displayed in Fig. 8, together with the observed growth between 1977 and 2008. From the figure it is clear that the major difference in expected amount of urban area is more between the GE and RC scenarios, than between the Ambitions/Trends alternatives (4412 km², 4109 km² for GE Trends and GE Ambitions respectively, as opposed to 3690 km² and 3624 km² for RC Trends and RC Ambitions). In examining the demand for each of the four simulations, we observe that the difference in intensification shares indeed appears to be associated

with a difference in demand for urban area between the two GE scenario alternatives and the two RC scenario alternatives. This suggests the need for analysis and discussion of the potential impact of the alternatives under different socio-economic conditions.

Simulation Results

The main results of our simulations are displayed in Fig. 9. We stress that these simulation exercises are obvious simplifications of reality. For instance, we have only included a limited number of suitability maps and land use types for these simulations, and no additional land use demand for land use types other than urban area and nature. The upper-left map presents the main land uses in the central part of the Netherlands in 2008. The urban footprint of the Randstad cities is displayed clearly.

The simulation result of the GE Trends alternative is displayed in the upper-right map (Fig. 9). This is the most extreme scenario in terms of new urban extensions, since it assumes a high population growth rate and a decreasing number of persons per household, along with relatively high shares of new dwellings located outside of existing urban areas. The differences between the GE Trends simulation result and the 2008 land use map are considerable. We see that urban settlements grow together and an almost fully-urbanized crescent encompassing the main Randstad cities emerges. In parallel, a large land conversion process takes place in the Green Heart (the open green area between the major urban agglomerations of the Randstad), where relatively small cities increase their urban footprint by means of additional extensions.

The lower maps (Fig. 9) display the likely urban extension areas in the Ambitions alternatives (with RC Ambitions at middle-left and GE Ambitions at lower-left) and the Trends alternatives (with RC Trends at middle-right and GE Trends at lower-right). The expected increase in urban areas is demonstrated via a color intensity that reflects the probability of urban development (in fractions per grid cell, see section “[Land use scanner](#)”). Urbanization probabilities between 0.2 and 0.4 are considered low, higher than 0.4 but below 0.6 are defined as medium, and above 0.6 probabilities of urban development are categorized as high. The maps clearly show that in the GE scenario, there are more urban extensions than in the RC scenario. The GE scenario shows a clear difference between the Ambitions and Trends alternatives. Current policy ambitions related to urban intensification will greatly assist in containing the large urban growth that is expected in the GE scenario. Under the much more moderate conditions of the RC scenario, this difference is less clearly visible.

Fig. 9 Current (2008, upper-left) and simulated (2020, upper-right) land use according to the GE Trends alternative. The maps below display the simulated increase in urban area according to each of the four scenario and intensification alternative combinations: RC Ambitions (middle-left); RC Trends (middle-right); GE Ambitions (lower-left); and GE Trends (lower-right). Existing urban areas in 2008 are depicted in grey, while the yellow/red colors represent diverse grades of expected urbanization pressures according to the simulations

Discussion and Conclusion

Conclusions from the Empirical Analysis

One of the goals of urban planning policies in the Netherlands is to control the spatial footprint of urbanized areas in order to maintain relatively compact cities. An important policy instrument to achieve this objective is to specify urban intensification targets, defined by the share of new dwellings to be developed within actual urban boundaries. Ex-post evaluation of such policies can shed light on the degree of success of current policy ambitions. Therefore, we used geospatial analysis to perform ex-post evaluation of urban intensification policies. Using the evaluation results, we subsequently simulated plausible future urban development scenarios and compared policy ambitions and scenario outcomes.

In general, policy ambitions regarding urban intensification share were met in the past, but large regional differences exist. Relatively low intensification shares prevail in the larger urban areas of the Randstad where ambition levels are typically very high. These low values seem to coincide with high residential densities in the urban extensions. The combination of high intensification ambitions and relatively poor realization was introduced as the ‘urbanization paradox’ in the beginning of this chapter, and our analysis has at least partially confirmed its existence.

A probable explanation is that this phenomenon is caused by shortage of space within urban areas in the already densely populated cities. The most feasible building locations are likely to have been used for intensification in the past decade, making it more difficult for policymakers in these regions to realize their high ambitions. This explanation is supported by the fact that low intensification shares in the Randstad typically coincide with high residential densities in urban extensions, which is also assumed to result from the limited amount of available space. Some regional exceptions to this general trend exist in the Randstad area. Higher intensification rates and lower densities in extensions are found in COROP regions. This is often the case where relatively few new housing units are added.

Conclusions from the Simulation Exercise

Based upon the empirical analysis we are able to show that current ambition levels are needed to prevent extensive loss of open (non-urbanized) space. Should urban development (in terms of intensification share and urban extension densities) follow past trends, large-scale urban extensions are likely to occur. This is especially true when future socio-economic conditions resemble the Global Economy scenario. Whether or not this scenario with its associated strong increase in number of

households will become reality is beyond the sphere of influence of local or regional decision makers, but depends on (global) macro economic conditions and European and national regulations related to, for example, immigration. Local restrictions on urban development could, however, divert growth to neighboring towns.

Our simulation can easily be expanded to accommodate additional spatial restrictions or other types of development (e.g., agriculture, industry/commerce, recreation). Such simulations have been performed as part of other studies focusing on, for example, the environmental impacts of a new regional strategic vision (Koomen et al. 2011) or the potential for specific biofuel crops in the country (Kuhlman et al. 2013).

Discussion

Some general drawbacks should be considered in relation to the analysis presented in this chapter – the most important issue being that past developments offer no guarantee on the trajectory of future developments. This relates, for example, to the fact that policy objectives for intensification shares may not be realistic anymore because the most feasible urban redevelopment locations have already been put to use, as discussed earlier. But other (external), currently underexplored options or changing societal conditions may become important influences upon the possibilities for urban intensification and thus limit the validity of our simulation outcomes. We will discuss several of these potential developments here.

First, we may underestimate the option for transformation of existing vacant buildings like factories or offices into dwellings. Especially office buildings may offer opportunities for urban intensification as about 14 percent of the total office building stock was estimated to be empty in 2011 (DTZ Zadelhoff 2011), giving the Netherlands the highest office vacancy rates in Europe (Seebus 2012). A substantial portion of this empty building stock is expected to remain empty because the condition or location does not match current market preferences. Extensive office parks at poorly accessible locations thus run the risk of becoming the brownfields of the twenty-first century and are in need of redevelopment programs similar to those that helped to revitalize the former docklands in cities like Amsterdam and Rotterdam. Transformation clearly has advantages, but there are also challenges to be overcome – like the changing of local zoning designations, differences in building regulations for offices and dwellings, the relatively high costs involved in renovation and transformation and the lack of government funding in the current political and financial climate. The increased attention for the historical-cultural value of certain buildings and locations ensures at least some government funding for transformation of, for instance, old factories into dwellings. Also, over the coming decade 1100

church buildings are expected to become vacant (ND 2012). One way to preserve these often monumental buildings is to change them into apartments or give them another function, for instance, public services (RCE 2012). As the transformation of historic buildings and churches typically is a time-consuming and costly process it is not likely to become widespread practice, and it will probably be confined to popular cities with a high demand for attractive housing.

Second, since the establishment of the new national strategic vision on infrastructure and environment (I&M 2011), specific national restrictive zoning regulations (such as Buffer zones²) and nationally designated urban development zones (called Bundling zones) are effectively abolished, leaving the responsibility for urban containment with regional and local governments. This changing planning (discussed extensively elsewhere – see Koomen and Dekkers 2013; Roodbol-Mekkes et al. 2012) may have considerable impact upon urban development in the Netherlands. In particular, urban intensification processes may become more difficult to realize as local and regional authorities may lack the financial means and other resources necessary to make more expensive and complex inner-city redevelopment projects possible. Especially for the regeneration of brownfield sites, development costs are generally higher than for greenfield sites because land must often be sanitized first (ECORYS 2005; Van Hoek et al. 2011). Also, the complex legal and spatial planning procedures may hinder inner-city development (Warbroek 2011). Local authorities may also lack the knowledge or power to resist market forces that will favor the development of less complex and more profitable extensification projects. In fact, municipalities were often willing to sell land for commercial development as it provided, at least until the financial crisis of 2008, a welcome source of revenue (Van Hoek et al. 2011; Seebus 2012). Such developments may, however, be more costly for society as a whole than urban intensification projects, as is evidenced in societal cost-benefit analysis of extensification versus intensification projects (ECORYS 2005; Van Hoek et al. 2011).

Moreover, local governments are often tempted to out-compete each other in the provision of building lots in order to attract commercial and residential development and companies. This behavior was one of the causes for the over-supply in offices (Seebus 2012). Regional cooperation between local governments is thus preferred to avoid this kind of mutual competition that incurs substantial costs to society (KBB 2012; Kuhlman et al. 2012). An interesting suggestion is to apply the legal framework of ex-ante evaluation for infrastructure projects on housing development as well, thus providing a broader view of, and more knowledge about, the societal costs and benefits of projects to local policymakers. Also, in a recent policy debate in the Netherlands, scholars and policy makers discussed the imposition of a

²These green corridors were designated to maintain open spaces between major agglomerations and are discussed extensively by, for example, Koomen et al. (Koomen et al. 2008b) and Van Rij et al. (2008).

development tax on building projects outside existing urban areas, arguing that current policy instruments generate disproportionate negative external effects upon welfare. By replacing the policy instruments with a relative simple price mechanism such as a tax, these external effects would be avoided, while simultaneously making inner-city brownfield development more price-competitive in relation to urban extensification. Korthals Altes (2009) reviews this debate and explains why the tax instrument was, in the end, not implemented in the Netherlands.

Obviously, the current financial crisis has slowed or stopped most urban development. Should this crisis remain, developments may be more likely to correspond to the Regional Communities scenario. In fact, this scenario assumes a considerable population decrease in certain peripheral areas that may call for urban restructuring rather than urban growth. This implies that certain neighborhoods may face the demolition or redevelopment of particular parts of the housing stock. These developments are outside of the scope of this study and cannot be addressed in the current version of our land use model, but we anticipate on incorporating such aspects in our modeling framework as a part of ongoing research projects. One of these projects will explore potential changes in population distribution, associated spatial patterns, potential solution strategies and related impacts. The development of spatial planning and design concepts in this case will focus on accommodating population decline, while paying attention to the relationship between population and necessary facility provision levels. The Land Use Scanner simulation model will be adapted to accommodate the analysis and simulation of these phenomena.

Another related topic explored in a second project is the fact that the city has become more popular as a residential destination within the last decade, certainly among specific groups of people (De Groot et al. 2010). However, these groups may have specific location preferences and housing needs. If there is a mismatch between demand and supply in terms of housing and facilities, these groups may decide to relocate outside the city or to another city. We, therefore, initiated an analysis and simulation of location preferences of highly-educated knowledge industry workers. For the simulation of households in this project, the adapted Land Use Scanner will also be used.

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Appendix 1: Empirical Analysis Results

This table includes the basic results of our empirical analysis and the figures used in the subsequent calculation of additional urban area demand applied in land use simulation

COROP region		Housing stock change	Intensification (%)		Density in urban extensions	Rural housing	Expected housing stock change		Additional urban area (hectares)			
#	Name	(2000–2008)	Trends	Ambitions	(Dwellings per Ha)	(2000–2008)	GE	RC	GE trend	GE ambitions	RC trend	RC ambitions
1	Oost-Groningen	1770	54	80	0.73	28	6739	0	1640	717	0	0
2	Delfzijl en omgeving	−707	0 ³	100	1.19	8	1199	804	922	9	618	618
3	Overig Groningen	11,056	58	80	2.88	11	32,348	10,870	3427	1635	1152	549
4	Noord-Friesland	7917	44	37	3.41	16	20,404	5463	2371	2662	635	713
5	Zuidwest-Friesland	2961	31	40	3.07	23	6935	2139	1027	897	317	277
6	Zuidoost-Friesland	5547	40	40	3.03	22	13,341	4108	1671	1671	514	514
7	Noord-Drenthe	6725	37	40	3.84	13	15,193	6490	2003	1896	856	810
8	Zuidoost-Drenthe	3652	41	60	1.89	23	8457	2601	1630	1107	501	341
9	Zuidwest-Drenthe	3084	35	40	3.72	22	9366	2697	1086	997	313	287
10	Noord-Overijssel	12,160	34	40	5.47	19	29,308	14,989	2536	2309	1297	1181
11	Zuidwest-Overijssel	5272	34	45	6.85	14	11,300	2608	849	709	196	164
12	Twente	14,356	49	60	4.79	13	43,096	15,443	3422	2667	1226	956
13	Veluwe	18,052	48	40	4.51	15	52,290	19,351	4349	4984	1609	1844
14	Achterhoek	9930	58	40	3.22	18	22,639	11,523	1680	2428	855	1236
15	Arnhem/Nijmegen	19,455	48	56	5.24	13	70,862	26,300	5253	4455	1950	1653
16	Zuidwest-Gelderland	6109	49	40	3.22	17	20,707	4358	2202	2606	463	549
17	Utrecht	44,704	39	66	8.13	11	122,305	43,861	7490	4172	2686	1496
18	Kop van Noord-Holland	12,347	51	51	3.13	11	29,303	12,590	3595	3576	1544	1537

(continued)

(continued)

COROP region		Housing stock change (2000–2008)	Intensification (%)		Density in urban extensions (Dwellings per Ha)	Rural housing (%) (2000–2008)	Expected housing stock change (2008–2020)		Additional urban area (hectares)			
#	Name		Trends	Ambitions			GE	RC	GE trend	GE ambitions	RC trend	RC ambitions
19	Alkmaar en omgeving	8738	35	57	6.70	9	18,332	4924	1534	1017	412	273
20	IJmond	4558	31	100	6.19	12	15,469	1638	1423	21	151	2
21	Agglomeratie Haarlem	3297	83	99	0.51	6	17,149	0	3772	226	0	0
22	Zaanstreek	5608	41	97	11.49	11	15,718	4213	656	33	176	9
23	Groot-Amsterdam	42,261	49	82	10.49	11	100,297	20,463	3838	1389	783	283
24	Het Gooi en Vechtstreek	4365	82	78	1.65	6	21,539	3498	1585	1915	257	311
25	Aggl. Leiden&Bollenstr.	7897	57	60	6.59	6	40,036	9158	2214	2073	506	474
26	Aggl. 's-Gravenhage	30,460	21	80	15.18	6	70,369	18,643	3369	856	893	227
27	Delft en Westland	5710	52	60	6.12	11	21,911	8483	1320	1092	511	423
28	Oost-Zuid-Holland	6005	64	60	2.38	16	39,250	11,802	3409	3772	1025	1134
29	Groot-Rijmond	32,942	30	60	8.34	18	90,329	24,165	5651	3230	1512	864
30	Zuidoost-Zuid-Holland	7388	51	60	4.07	17	30,183	4555	2365	1931	357	291
31	Zeeuws-Vlaanderen	2156	46	75	2.36	10	4087	930	769	353	321	321
32	Overig Zeeland	8253	45	75	3.32	22	15,463	4842	1575	712	493	223
33	West-Noord-Brabant	17,213	61	62	3.74	15	40,844	16,007	2692	2603	1055	1020
34	Midden-Noord-Brabant	13,049	66	90	2.61	17	39,894	17,295	2739	794	1187	344
35	Noordoost-Noord-Brab.	17,801	54	66	4.20	18	55,307	20,446	3746	2741	1385	1013
36	Zuidoost-Noord-Brabant	21,421	57	70	5.43	10	65,997	21,979	4009	2771	1335	923
37	Noord-Limburg	8125	61	93	2.26	19	19,886	5215	1763	315	462	83
38	Midden-Limburg	5747	59	71	2.50	12	10,386	3136	1204	856	876	876
39	Zuid-Limburg	11,915	66	90	2.34	9	32,773	4570	3544	1048	494	146
40	Flevoland	23,928	18	3	8.35	11	52,224	19,948	4455	5281	1702	2017

³ Delfzijl lost dwellings within its 2000 urban area, but some units were added in urban extensions

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