Evaluating future urbanisation patterns in the Netherlands

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Abstract

Although the Netherlands is one of the most densely populated countries, two thirds of the land area are still under agricultural use. Major socio-economic changes are however expected for the agricultural sector. The increasing globalisation of economic relations in agriculture and the possible reduction of European price support to farmers are examples of such developments that may affect agricultural land use. At the same time other land use functions put increasing pressure on rural land in order to accommodate housing, employment, recreation and water storage. The present study takes a closer look at the expected spatial developments and simulates possible future urbanisation patterns by using an economics based land use model. The findings of this study may be especially interesting now Dutch spatial policy seems to be on the brink of loosening its traditional grip on spatial planning.

Introduction

Contrary to popular opinion agriculture is still by far the dominant land use type in the Netherlands. The past decades have shown a fairly steady but slow decline in the area under agricultural use as can be seen from Figure 1. Urban land use has increased by about 70.000 hectares in this 20 year period. Smaller increases can be found for nature (and woodland) and infrastructure. The apparent sharp rise in water area is caused by an administrative difference in assigning parts of the sea and other large water bodies to the municipal territories.

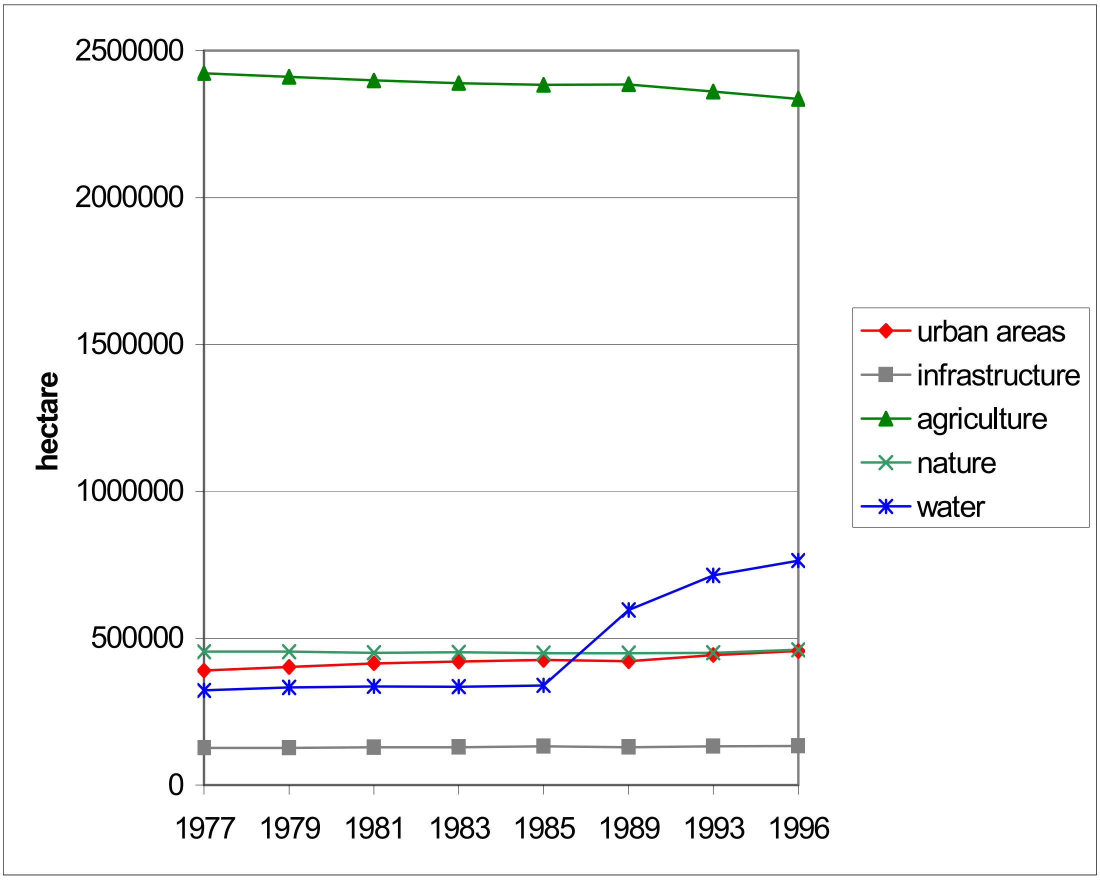

Figure 1 Land use in the Netherlands 1977-1996 (source CBS 2004).

Land use change in the Netherlands is thus a continuous process in which agriculture supplies the land that is in demand by other functions. The land is however not freely exchanged on an open market. The government intervenes on this market through spatial and economic policies. We will therefore first study current and expected developments on the supply (agriculture) and demand (urbanization etc.) side and then briefly discuss government intervention. This inventory helps us constructing the scenarios of possible future socio-economic developments that will be fed into our economics-based land use model. Two opposing scenarios of anticipated land use change are used to illustrate the possible extremes of future land use configurations. These scenarios vary both in their quantitative and qualitative description of the projected changes and put a different emphasis on the controlling powers of the Government. The simulated urbanisation patterns are evaluated through the application of various indicators in terms of their impact on a recurrent theme in spatial planning: the concentration of urbanisation.

The aim of this study is twofold:

1 to show the possible urbanisation patterns that may arise under different socio-economic conditions,
2 to evaluate the usefulness of different indicators of land use change related to the concentration of urbanisation.

Since the two scenarios are based on different assumptions on the strength of government intervention the outcomes may shed light on possible results of the shift towards economic development and the reduction of spatial restrictions that is currently advocated in spatial planning.

Agricultural developments

The internal structure of the agricultural sector has changed tremendously in the past decades. Recent inventories (van Bruchem 2001, Kuhlman 2003) have pointed out several important agricultural trends. The nature of these trends and the possible implications for the future development of agriculture are discussed below:

- Increase in farm size. The number of farms is in rapid decline, from 410,000 in 1950 to 90,000 in 2002. As the total area under cultivation has decreased much less, we can infer that the average farm is much larger today. Most farmland coming onto the market has thus been bought by other farms for expansion. The decline in the number of farms is expected to continue as it is still difficult for farmers to find successors due to socio-demographic and economic conditions (Luijt *et al.* 2003).
- Intensification. Higher inputs of both capital and consumables per hectare lead to higher yields. These inputs are now six times as high as in 1950. This intensification was partly made possible by technological progress. Although it is in principle impossible to predict inventions, there appears to be scope for further gains: remotely controlled machines, increased application of electronic sensors in various biological

processes, introduction of genetic technology, etc. Such innovations would lead to higher productivity and thus strengthen the position of the sector in competing for space. This does however not necessarily imply a higher demand for agricultural land as new innovations may also lead to more space-efficient forms of agriculture.

- Reduced national importance. The Netherlands is one of the largest exporters of agricultural products by value, mainly as a result of the highly productive green-house horticulture and zero-grazing animal husbandry. Economic growth in the agricultural sector has been below average however in the last decade, reducing its contribution to the gross national product. Agricultural importance has strongly declined in terms of its share in employment. Today only 190.000 people are directly employed in agriculture, a decline of 64 percent since 1950. The share of food in the household budget has also been greatly reduced. Agriculture is thus slowly disappearing from the public eye. As a consequence of which the traditional agricultural power bloc is loosing its strength, in turn opening up possibilities for other socio-economic groups.
- Diversification. An increasing number of farmers has recently started to provide a wide range of services: tourism; protect historical landscapes, wild plants and animals on their land in exchange for compensation; make land available for water storage; sell regionally typical produce at the farm or at an outlet they control; or provide care for patients who recuperate on farms. Apart from this, many farmers have also taken to other economic activities completely outside the farm. Not all of this diversification is new, of course, but it is receiving increased attention as a path for the future (van der Ploeg 2003).

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

External pressure

Commercial land use (industry, public and private offices, retail etc.) has increased over 40% in the 1980-2000 period (CBS 2004). This increase is heavily reliant on economic growth, but commercial land use is expected to grow anywhere between 14 and 34 % in the coming 20 years (Gordijn *et al.* 2003). Important locational preferences of businesses include: accessibility to a sizable workforce and proximity to amongst others highways. The potentially footloose ICT-businesses have not yet shown a specific preference for rural locations (van Oort *et al.*2003).

Residential land use has increased by 14 % in the 1980-2000 period (CBS 2004). This growth is expected to continue due to a slowly increasing population and growing prosperity. The latter leads to demand for bigger and second homes. Many people prefer a rural living environment, although a few green elements in a suburban environment normally suffice (Heins 2002). The rural spatial policies of the past decades may have prevented an extensive urbanisation of designated green areas. Recent initiatives now allow for the small-scale transformation of farm-land in new estates (Natuurnet 2002). Reforms in the zero-grazing sector offer further scope for transforming former stables into housing units.

Increased prosperity and an aging population contribute to an increasing demand for recreational space (VROM 2001). Rural areas attract a wide of range of recreational visitors who seek fun, leisure, thrills or tranquillity and thus prefer different locations and facilities (Metz 2002). Attractive landscapes that are within easy reach of many residents are likely to attract many leisure seekers (Veer en van Middelkoop 2002). New large scale recreational areas are mainly initiated by local governments, whereas commercial companies add for example horse riding schools, holiday- and funparks to the countryside. On a smaller scale individuals may offer farm-site accommodation and related facilities.

In the past two decades much attention has been given to the creation of new natural areas through the joint activities of governmental and private institutions. The creation of a large system of connected natural areas has slowed down in the past years due to increased land prices (Milieu- en Natuurplanbureau 2002). At the same time more attention is given to subsidising farmers to maintain natural values on their agricultural land. This support for farmers is also getting more attention in the recent reforms of the common agricultural policy of the EU. The character of the new nature areas could thus change from nature to agriculture-oriented, possibly leading to the preservation of current agricultural landscapes such as the typically Dutch meadows on the peaty soil in the north and west of the country.

New concepts in water management also put a claim on rural land. Current discussion focuses on assigning an extra water retention or temporary storage function to specific areas in such varied regions as the elevated sandy areas in the south and east, the low-lying polders in the north and west and along the big rivers in the centre of the country. Urbanisation restrictions may apply here, that can limit the possibilities for large scale industrial farming. These could however very well preserve current agricultural use by locally preventing further urbanisation.

Government intervention

The government asserts great influence on land use changes. Various departments of the Dutch National Government have laid important claims on the countryside for public functions as nature, recreation and water-storage as was discussed before. But the government, at both the national and the European level, also influences land use through its economic and spatial policies. This influence is especially strong on the agricultural sector and thus on large parts of the Dutch land surface. The opening up of the intra-European market and the many protectionist measures on a global scale have exercised an enormous influence on the vicissitudes of the sector. The national government has stimulated productivity by land consolidation and by subsidizing some subsectors, notably arable farming and dairying in the past, while facilitating the expansion of zero-grazing and promoting agricultural research. In recent decades, environmental policies have become increasingly important, as well as the promotion of animal welfare. Undoubtedly we are on the threshold of further major changes, with the proposed Fischler reforms in the Common Agricultural Policy of the EU, the expansion of the EU, and the increasing demands from parties outside the EU for liberalization of trade.

Besides these economic policies that mainly influence the prospects for the agricultural sector, the Dutch national and regional spatial policies have a strong influence on the future of the countryside. The relatively strict compact city-policy together with the related restrictions on many open, green areas decreased the possibilities for the conversion of agricultural land in the last decades, although these conversions were far from absent (VROM 2000). With the publication of the latest Spatial planning report (VROM/LNV/V&W/EZ 2004) the national Government offers more freedom to local municipalities to govern their rural areas. This may lead to more opportunities for the creation of residential and commercial areas in regions where this was formerly discouraged.

Constructing scenarios

The possible agricultural and external developments are linked to government intervention as was discussed before and they are furthermore dependent on general socio-economic conditions. To provide a coherent framework for studying the distinguished developments we have selected two scenarios for future spatial developments (Milieu- en Natuurplanbureau 2002-2). These are in turn based on previous IPCC-scenarios and follow each two opposing trends: global economy combines globalisation with individualism, whereas regional community connects regionalism with cooperation. In the first scenario the free market is an important ingredient. Government intervention in both the functioning of the agricultural market and spatial policy is limited. In the latter scenario equity and national sovereignty prevail. The European agricultural market is expected to partly remain protected and restrictive spatial policies will apply on many rural areas. Table 1 gives an overview of the scenarios and illustrates the way the expected agricultural and external developments are related to the supposed government intervention. In a way these scenarios reflect the changeover from the socio-economic conditions in the 1990’s (regional community) to the neo-liberal outlook on life (global economy) as is advocated in amongst others the new Dutch Spatial Policy report.

The scenarios thus offer a way of comparing the outcomes of two opposing political strategies on spatial planning. The story-lines of the scenarios were subsequently fed into sector-specific regional models to quantify the expected demand for various types of land use, e.g. residential, commercial and natural. The demand for agricultural land was estimated by using the land-market model developed by the Agricultural Economics Research Institute, see Koole *et al.* (2001). The demand from the other land use functions was derived from the various sector-specific models (de Nijs *et al.*2002).

	Global Economy	**Regional community**
Socio-economic conditions		
Economic growth	2.9 % per year	2.3 % per year
Population	17.1 million	18.4 million
Societal focus	Individual freedom	Regional cooperation
Economic orientation	Free market prevails	Government intervenes
Government intervention		
Common agricultural policy	World markets for agricultural products	Internal EU support under conditions, no export subsidies
Spatial policy	Less restrictive policies	Restrictive policies for rural areas
Nature policy	Only the most valuable natural areas are protected	Larger areas protected, Ecological main structure realised
Water management	No restrictions on urbanisation	Restrictions on urbanisation in designated areas
Agricultural trends		
Total agricultural land use	Strong decline of agricultural land use	Decline of agricultural land use follows historic trend
Rural land prices	Local increase/decrease	Slight overall increase
Agricultural production	Large-scale, industrial farming	More extensive, small-scale farming
Agriculture and nature conservation	No chances for agriculture combined with natural values	Diversified rural development
Agricultural sectors	Growth in industrial dairy farming and greenhouse horticulture. Arable farming considerably smaller	Less growth in dairy farming en greenhouses. Arable farming constant.
External pressures		
Urbanisation	Urban sprawl in rural areas	Concentration near existing urban areas
Commercial functions	Abundant growth, preference for highway locations	Limited growth, public transport accessibility promoted
Nature development	Acquisition through private persons and organisations	Acquisition by national government following Ecological main structure

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

Land Use Scanner

For our research we will use the Land Use Scanner, an integrated land use model that has been used for various policy related research projects. Applications include the simulation of future land use following different spatial planning perspectives (Schotten *et al.* 1997), the evaluation of alternatives for a new national airport (Scholten *et al.*

1999) and more recently the preparation of the Fifth National Physical Planning Report (Schotten *et al.*2001). A full description of the model is given by Hilferink and Rietveld (1999). In this section we will shortly introduce the model to set the context for our simulation of future urbanisation patterns.

The Land Use Scanner is a GIS-based logit model that simulates future land use and offers an integrated view on all types of land use. It deals with urban, natural and agricultural functions, normally distinguishing 15 different land use categories. The model is grid-based and uses almost 200,000 cells of 500 by 500 meter to cover the Netherlands. Each cell describes the relative proportion of all present land use types, i.e. a cell can contain more than one type of land use. It thus presents a highly disaggregated description of the whole country. Sector-specific models of specialized institutes, such as housing and employment models, provide the regional predictions of land use change that are used as input for the model. The predicted land use changes are considered as additional claims for the different land use types. The total of the additional claim and the present area for each land use function is allocated to individual grid-cells based on the suitability of the cell. Suitability maps are generated for all different land use types based on location characteristics of the grid cells in terms of physical properties, operative policies and expected relations to nearby land use functions. Unlike many other land use models the objective of the Land Use Scanner is not to forecast the dimension of land use change but rather to integrate and allocate future land use claims from different sector-specific models.

The model employs a logit-type approach, derived from discrete choice theory, to simulate the probability that a certain location is chosen for a specific land use. The crucial variable for the allocation model is the suitability s_{cj} for land use of type j in grid cell c. This suitability can be interpreted to represent the net benefits (benefits minus costs) of land use type j in cell c. The higher the benefits (suitability) for land use type j, the higher the probability that the cell will be used for this type. The economic rationale that motivates this choice behaviour resembles the actual functioning of the land market. The model is furthermore constrained by two conditions: the overall demand for the land use functions which is given in the initial claims and the total amount of land which is available for each function. By imposing these conditions a doubly constrained logit model arises that can be formulated as:

$$M_{cj} = a_j \cdot b_c \cdot \exp(\beta \cdot s_{cj})$$

In which:

M_{cj} is the expected amount of land in cell c that will be used for land use type j .

a_j is the demand balancing factor that ensures that the total amount of allocated land for land use type j equals the sector-specific claim.

b_c is the supply balancing factor that makes sure the total amount of allocated land in cell c does not exceed the amount of land that is available for that particular cell.

β is a parameter that allows for the tuning of the model. A high value for β makes the suitability more important in the allocation and will lead to a more mixed use land pattern, strongly following the suitability pattern. A low value will produce a more homogenous land use pattern.

s_{cj} is the suitability of cell c for land use type j, based on its physical properties, operative policies and neighbourhood relations.

The outcomes of the model are thus based on various external model results, a probability approach and many operational choices of the model user. The results should therefore not be interpreted as an exact prediction for a particular location but rather as a probable spatial pattern of land use change.

Analysing urbanisation

The urbanisation patterns in the two scenarios show great differences, as can be seen by the simulated increase in urban area in the central Netherlands in Figure 2. The regional scenario shows new large scale urban areas (indicated with number 1 in the figure) following local urbanisation plans as well as concentric extensions of existing urban areas (number 2). The global competition scenario is characterised by extensive urbanisation of attractive landscapes either covering large contiguous surfaces (3) or spontaneously creating new towns (4).

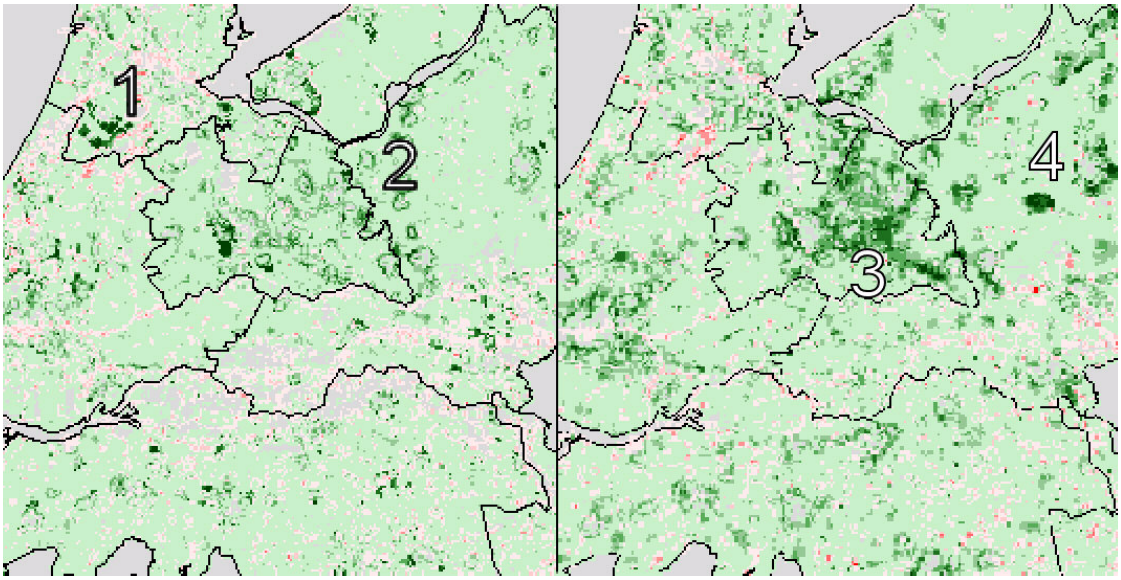

Figure 2 Simulated increase in urban area in the regional community (left) and global cooperation scenario (right). Darker colours indicate a stronger increase in the built-up area per cell. The numbers are referred to in the text.

To actually measure the degree of urbanisation and to quantitatively assess the way it corresponds to current spatial policies we can apply land use metrics or indicators. For quantifying urbanisation patterns we can make use of the extensive research in the field of landscape pattern metrics. McGarigal (2002) distinguishes two types of metrics that can be used to describe landscape patterns. *Composition metrics* quantify the variety and abundance of several landscape types without considering their spatial character, whereas *spatial configuration metrics* do refer to the spatial distribution of the various landscape types and focus on their individual patches (areas of a specific landscape type). Both types of metrics will be applied to the simulated urban growth in relation to Dutch spatial planning policies.

The urbanisation pattern in the Netherlands differs from that in many other metropolitan regions. Even the most densely populated western part of the country (the Randstad) can be characterized as a cluster of towns and open spaces (van der Cammen *et al.* 1988). Maintaining this special configuration was a crucial issue ever since the first Dutch report that related to physical planning (RNP 1958). The various planning reports that were subsequently drafted by the Ministry responsible for public housing and spatial planning strived to conserve the alternation of urban and open spaces through the introduction of concepts as the preservation of the central open space (V&B 1960) and bundled deconcentration (V&RO 1966). Later planning reports (V&RO 1977, VROM 1989) aimed to bring about compact cities through the concentration of urbanisation in the vicinity of existing cities in combination with restrictive policies on open areas. The latest planning report (VROM/LNV/V&W/EZ 2004) maintains these principles but has shifted its attention from restriction to stimulation, offering regional and local governments, private organisation and enterprises more freedom to commonly reach their goals.

To evaluate the degree to which the future urbanisation patterns match current spatial policies we will focus on a constant factor in spatial planning: the concentration of urbanisation. First some general composition indices are applied that are only based on the total, simulated urban surface area. Subsequently we will look at the spatial configuration of the individual urban areas, initially by calculating some simple statistics related to the number and size of these areas. Finally the form of the simulated urban areas will be studied in an attempt to describe their compactness. By using these different types of indicators we can quantify the extent in which the urban growth in the scenarios differs and furthermore typify which simulated urban patterns are closest to the spatial planning objective of concentrating urbanisation.

Total urban area

The most obvious indicators to describe urbanisation are the total built-up area and the urbanisation degree. Built-up being defined here as all land use functions that either predominantly consist of buildings or that are closely related to urban functions: residential and commercial land use, greenhouses, intensive livestock grazing stables and recreational facilities. The urbanisation degree is calculated as the percentage of the total Dutch land surface that is built-up. Table 2 shows the indicator values for both current and simulated land use. Urban growth is strongest in the global economy scenario as was to be expected from its characteristics. According to this scenario the total built-up area grows with more than 200.000 hectares to 17 percent of the total Dutch land surface. But also under less rosy economic conditions and with more government intervention in the regional community scenario the built-up area increases considerably with 150.000 hectares to 15 percent of the land surface.

Individual urban areas

The difference between the scenarios is more clearly exemplified by looking at the spatial configuration of the individual urban areas. Focussing on these individual areas is similar to the approach ecologists take when studying landscape patterns. Crucial in their description of changes in the landscape is the distinction of individual "patches" that consist of a single landscape type. We distinguish urban areas by tracing groups of adjacent urban cells using the 8 neighbour rule. Individual urban cells are considered to be part of a greater urban form when they are bordering other urban cells in any of their 8 adjacent cells. This method discerns extensive connected urban agglomerations that are typically much large than individual cities. The configuration of the urban areas is most easily described by their number and mean area, see Table 2. A similar approach is taken by de Nijs *et al.* (2001) in the environment explorer land use model. The regional community scenario shows the lowest number and highest mean size of the urban areas. The number of urban areas is in fact smaller than in the current situation. This clearly indicates that urbanization is strongly concentrated. The global economy scenario has the highest number of urban areas, thus indicating a more scattered urbanization pattern. The average urban area is in this case also larger than in the current situation. This is related to the strongly increased total urban area and not so much by a concentration of urbanization. The various indicator results should thus always be interpreted coherently.

	Current land use	**Global Economy**	**Regional community**
Total built up area[1] [ha]	464088	700570	612747
Urbanisation degree[2] [%]	11	17	15
Number of urban areas[3]	1380	1413	1208
Mean size of urban areas [ha]	227	331	338

Table 2 Urbanisation indicators for current and simulated land use.

Compactness of urban areas

A more elaborate way of looking at the spatial configuration of the urban areas is to actually account for their shape complexity. Since we are interested in the concentration of urbanisation we have selected the circularity ratio (see e.g. Selkirk 1982). This metric

[1] Total of residential and commercial land use, greenhouses, intensive livestock grazing stables and recreational facilities.

[2] Total built up area as percentage of the Dutch land surface (4152911 ha).

[3] An urban area consists of a group of adjacent urban cells (following the 8 neighbour-rule); each cell having a built up area of more then 15 hectare. This definition includes infrastructure in the built up area to prevent the unwanted separation of urban areas along infrastructure.

indicates how much a shape deviates from its smallest possible form (a circle) and is calculated through: circularity = $(4*\pi*\text{Area})/\text{perimeter}^2$. A shape that resembles a circle will have a value close to one, whereas a very elongated form will result in a value close to zero. Applied to our simulation result for the global economy scenario this gives the map shown in Figure 3.

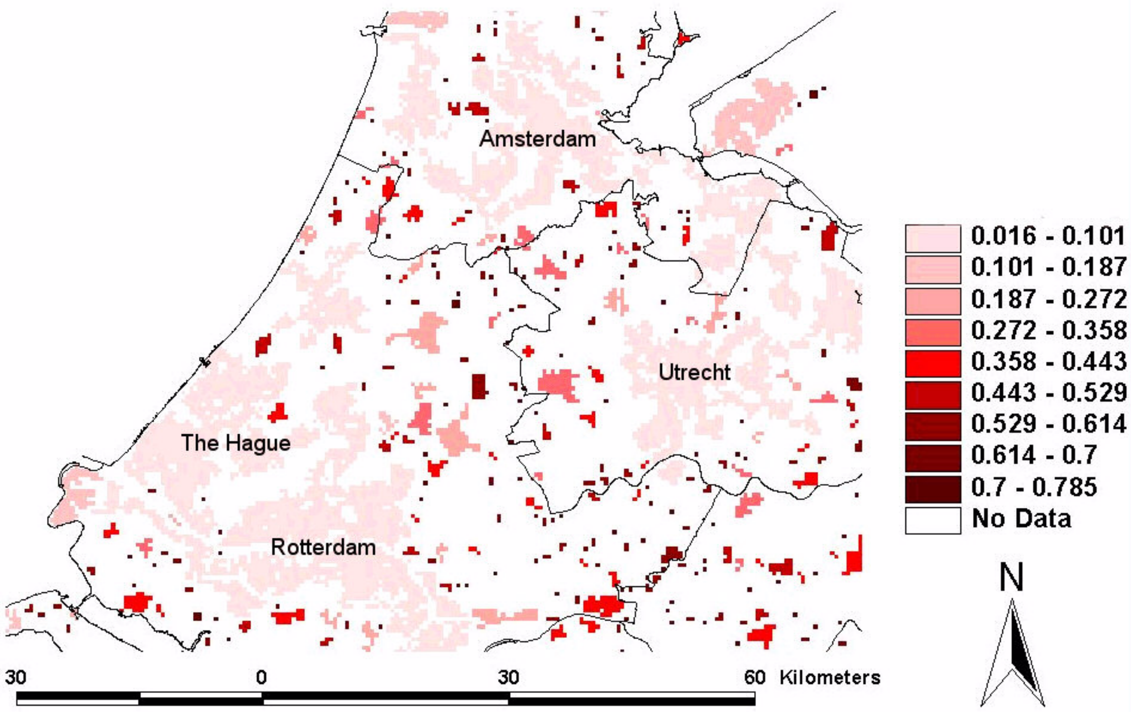

Figure 3 Circularity of urban areas in the global economy scenario. High values (dark colours) indicate compact forms.

The figure makes clear that the large urban areas around the biggest cities (e.g. Amsterdam, Rotterdam, The Hague) are not the most compact judged by their shape. These areas are however good examples of the concentration of urbanisation that is the much wanted outcome of Dutch spatial policy. Thinh *et al.* (2002) describe a comparable albeit more complex indicator to assess urban compactness based on the principle of spatial interaction. Analogue to the physical law of gravity the degree of interaction of all pairs of urban cells within an urban cluster is calculated, dependent on their urban surface area and mutual distance. The mean value of all interaction values of an urban cluster is taken as a measure for its compactness; interaction is expected to be strong when the city's structure is more compact. Applied to over 100 German cities their results are similar to ours: the large urban conglomerations of (Hamburg, Berlin) have a relatively low compactness.

Conclusions

The present study shows the urbanisation patterns that result from two extremely contrasting socio-economic scenarios. The global economy scenario depicts a strong increase in the total urban area and an even more notable rise in the number of urban areas. The opposing regional community scenario also shows a significant increase in the total urban area, but concentrates urbanisation in a smaller number of obviously larger urban areas. The difference in urban patterns is best illustrated by maps that represent the increase in the urban surface area per individual grid-cell. These maps show extensive planned additions to the urban landscape combined with concentric extensions of existing towns for the regional community scenario. The increased urban area in the global economy scenario on the other hand covers vast tracts of attractive landscape and even shows the spontaneous creation of a new city.

The combined use of dedicated graphical and tabular output greatly helps interpreting the simulation results. Simple one dimensional indicator values related to the studied urbanisation theme provide an instantaneous and clear overview of the model outcomes. The maps with increased urban area per grid cell are very helpful in showing the changes in urban patterns. Results that would have been far less obvious in the hitherto used maps of dominant future land use. The representation of the actual compactness of the urban areas through the calculation of circularity is not considered very useful since it fails to incorporate the concentration of urbanisation in large, albeit irregularly shaped urban areas.

The presented model results are based on a series of assumptions, choices and interpretations and can by no means be considered as an exact prediction of future land use patterns. The opposing outcomes of the two scenarios do however provide insight in the possible consequences of future socio-economic conditions and the implications of spatial policy related choices. The simulation results for the global economy scenario for example indicate that the stronger emphasis on economic development combined with less restrictive spatial policies that is the current aim of the central government may lead to more extensive forms of urbanisation that could threaten natural and recreational values.

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