Measuring urban concentration and land-use diversity in maps of simulated future land use

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Introduction

Future land use is an important theme in the preparation and evaluation of spatial planning reports. These studies typically look several decades ahead and describe the outlook of the future by means of a set of scenarios with different socio-economic conditions. Land-use models are commonly used to indicate possible future land-use patterns according to the scenario conditions. In order to help policy-makers and researchers interpret, compare and evaluate different scenario simulations quantitative measures are needed that objectively describe the resulting maps. Functional indicators should: relate to specific (policy) themes, be intuitively understandable for policymakers, capture the essence of simulation results and discriminate between different simulation outcomes.

This paper presents two sets of functional indicators that were implemented and tested for the assessment of spatial aspects of future land-use configurations as simulated by a land-use model. The indicators were applied in a Dutch case study and relate to two important themes in spatial planning: compact urbanisation and land-use diversity. The indicators are applied to simulations based on two scenarios for land-use development in the Netherlands up to 2030. A full account of this research is provided in Ritsema van Eck & Koomen (2007).

Urban concentration

An initial impression of the urbanisation patterns at hand is provided by a number of general composition indices and a visual presentation of the pixel-based density increase over time. By using this combination of composition and configuration indicators at various scales we can quantify the extent to which the urban growth differs between the scenarios and furthermore typify which simulated urban patterns are closest to the spatial planning objective of concentrated, compact urbanisation.

Subsequently we focus on metrics describing concentrations formed by a set of contiguous urban areas as these are most closely related to the spatial policies aimed at preserving the alternation of relatively large urban areas surrounded by sizeable non-urban (open) spaces that we want to evaluate. This focus on individual urban constellations 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. From their extensive work we select a limited number of indicators relating to patch-size distribution and shape complexity (Table 1).

Land-use diversity

Measures for diversity of land use in a raster cell can be derived from equivalent indices in ecology that for example measure biodiversity. A distinction can be made between distributional measures, which indicate the number of species and the distribution of

individuals over those species, and measures of variation, which measure the size and importance of the differences between the species present. Although it would be useful to have indices which combine both aspects, measuring both the distribution of individuals over the species and the degree to which these species differ from one another, at present such an index does not seem to be available (Baumgärtner, 2002). For measuring land-use diversity the first aspect, the distribution (of land over different functions) is crucial. Therefore we will only discuss the distributional measures. There are four basic measures in general use; it can be shown that these four are all equivalent to special cases of the so called Renyi diversity profile (Magurran, 1988). Because of its intuitively appealing interpretation we select Simpsons Diversity Index for this application (Table 1).

Table 1. Indicator values resulting from application to a land-use simulation study.

	current land use	scenario 1	scenario 2
urban concentration			
Total built-up area [ha]	491,710	693,253	610,420
Urbanisation degree [%]	12	17	15
Number of urban areas	1381	1414	1209
Average urban area size [ha]	227	330	338
Std.Dev. of urban area size	817	2203	1328
Average circularity ratio	0.27	0.21	0.24
land-use diversity			
Average Diversity index	0.38	0.41	0.37
Std.Dev. of Diversity index	0.21	0.23	0.21

Discussion

The presented set of indicators allows for a critical comparison of the urban patterns in the two opposing scenarios. Single indicators capture individual aspects of urbanisation like magnitude (through general composition indices), spatial pattern (pixel-based urban density), concentration (patch size distribution) and compactness (average urban area circularity). It is, however, the combined use of these indicators that offers a more complete overview on projected urban developments. A high average degree of compactness is for example not necessarily preferable from a spatial-policy perspective, if this compactness is associated with a large number of small, compact urban areas as this may pose a serious risk to open space fragmentation.

The diversity maps are also useful in the sense that they add depth to the maps of dominant land use that are normally used to present the simulation results of land-use change models. They show clearly that the some other agricultural areas will be more diverse in land use, especially in a free-market oriented scenario where agriculture suffers from fierce international competition and many planning restriction on land use are lifted. They also indicate that land use in the city will become less mixed and help pinpoint locations with potential for multi-functional land-use developments.

References

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Magurran, A. E. (1988) *Ecological diversity and its measurement*, Princeton university press.

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