Residential land-use density simulation

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Land-use simulation is an established part of the spatial planning process in the Netherlands (Koomen and Borsboom-van Beurden, 2011; Koomen et al., 2011). Existing modelling approaches have hitherto focused on urban expansion and are less well equipped to assess the impact of expected changes within the existing urban fabric as a consequence of, for example, regional population decline. Urban restructuring and intensification are now considered to be prominent issues in land-use modelling (Kuijpers-Linde, 2011). This calls for a change from an essentially land-cover type of approach common to most operational land-use models to a more object-oriented density-based approach. Our paper will discuss recent progress in describing current changes in urban densities and proposes an approach to incorporate this knowledge in a land-use simulation modelling framework. More specifically we will focus on capturing residential land-use density using highly detailed spatial datasets that describe the location of individual residences and residents.

Modelling framework

Land use is the spatial representation of the complex interaction between natural and human systems. It is the result of the behaviour of many different types of actors such as households, companies and farmers. This behaviour is represented in the objects they manage and create (houses, farms etc.). Combinations of objects can be classified as land-use types that are usually named after the dominant objects in an area (e.g. residential land, arable farm land). The distinction of these three layers (actors, objects, land use) is central to our modelling framework.

Our modelling framework combines the TigrisXL and Land Use Scanner model. The land-use and transport interaction model TigrisXL is used to simulate regional changes in numbers of actors and objects related to urban land use, based on trend-extrapolations or scenario-based assumptions on future conditions (Zondag and Geurs, 2011). Land Use Scanner is used simulate land-use patterns based on input from TigrisXL and other sector-specific models. The simulated land-use patterns are then used to describe impacts on various policy-related issues such as flood risk or urban sprawl based indicators calculation that are performed in Land Use Scanner itself or subsidiary models (Bubeck and Koomen, 2008; Ritsema van Eck and Koomen, 2008; Van der Hoeven et al., 2009).

Incorporating residential density in land-use allocation

In our new approach we combine the strengths of the regional-level land-use and transport interaction model (Tigris XL) with the local level land-use allocation model (Land Use Scanner). The former model provides the regional projections of numbers of households (and thus residences) while the latter deals with its spatial implications. More specifically we follow the next steps:

1. Add *local*, *object*-based layer information to Land Use Scanner *base year* (number of residences per hectare in base year);
2. Add *regional*, *object*-based layer information to Land Use Scanner regarding *future* years (number of residences per region);

3. Quantify *future regional land use* demand (number of hectares urban land use per region);
4. Simulate *future local land*-use patterns;
5. Add *local*, *object*-based layer information to local land use layer simulated in 4 (no. of residences per hectare in future).

Our contribution will highlight empirical work done to allow calibrate the allocation steps listed above. Using detailed (100 metres resolution) data on the spatial distribution of residents and residences we analyse urban intensification rates and densities of urban extensions.

Conclusion

The new residential density model allows for more efficient and transparent calculation of residential land demand than previous external procedures. Input information on numbers of residences and amount of residential land use and related assumptions (e.g. intensification share, residential density) is now accessible within Land Use Scanner, allowing the exploration of scenarios with different urbanisation strategies. Moreover, the residential density model allows for more efficient and transparent calculation of residential land demand than previous external procedures. Output information will be made available at both the regional and local (100 meter grid cell) level to allow the visualisation of local changes in residential density.

In subsequent research we will pay attention to updating the local layer info on number of residents (in addition to their residences). We, furthermore, strive to make the calculation of residential density a dynamic element in the allocation process instead of a static component whose value is determined before simulation starts. Based on, for example, regional land scarcity (reflected in high shadow prices in the simulation process) residential density and thus its land demand will be able to adapt.. The applicability of the proposed approach to assess different scenarios of urban development will be tested in regional case studies.

References

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