A Common Land-Use Change Model for Both the Walloon and Flanders Regions in Belgium

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***Abstract*—Floods, urban heat islands, mobility issues and other environmental and health risks increase with urban growth. For a sustainable planning of their territory, authorities need operational decision support tools, which can assess short and long-terms impacts of current, intended or optional policies on land-use change. This paper considers the application of a constrained cellular automata land-use change model within both the Walloon and Flanders region in Belgium. Some methodological steps needed for this application are discussed. A national land-use change model is seen as a key asset for sustainable spatial planning.**

Keywords-land-use change; cellular automata; sustainable spatial planning; risk assessment.

I. INTRODUCTION

The Walloon region, south of Belgium, has an urbanization rate of 17 km² per year [1]. Driven by demographic projections of 200,000 more households between 2011-2026 [2], a further increase of the impervious surfaces is expected. In Wallonia, urban growth occurs typically under the form of rural ribbon development. This type of development is a major source of fragmentation of natural habitats and enhances rural-urban commuting. This, in turn, increases health and environmental risks by extending pollution sources distribution. Through spatial planning policies, the Walloon authorities try to fix a threshold at 9 km² per year of extra soil sealing towards 2040 [3]. Such policies require a holistic and dynamic vision of the fast changing urban environment. Current and historical land-use/land-cover (LULC) can be assessed with existing geodata and satellite images within Geographical Information Systems (GIS). Possible future impacts of policies can be simulated by means of model-based scenarios. Since Wallonia has an extensive catalog of geodata for current and historical trends [4], regional policy makers and city planners have expressed an interest in developing an operational framework for LULC change modelling in a project called SmartPop.

Over the last decades a broad range of LULC models have been developed to assist land management. LULC models can be static or dynamic, spatial or non-spatial, i.e., exploring patterns of change vs. rates of changes, inductive or deductive, i.e., with model parameters based on spatial correlation vs. explicit description of the process, agent-based or pattern-based, i.e., emulation of individual decision makers vs. inference of underlying behavior for the observation of patterns in the LULC [5]. A spatially explicit approach is needed to project and explore alternative scenarios [6]. Choosing one of these depends on the goals, inputs and validation data available and technical skills (developers/end-users). The model used in this study is a dynamic spatially explicit model based on an inductive pattern-based approach. Cellular automata (CA) are discrete, abstract computational systems defined by a regular grid of cells that are characterized by a finite number of states evolving through time according to rules namely related to neighboring cells [7]. CA have perhaps been the most popular way to model land-use change and spatially-explicit population density [8]-[11] because (i) they are intrinsically dynamic, (ii) they are able to deal with high resolutions and thus produce results with a useful amount of detail and (iii) they outperform other models in realistically modelling land-use change. In CA-based LU models, LU change is explained by the current state of a cell as well as by the changes within the neighboring cells.

At European Union level, the MOLAND LULC dynamics modelling framework initiated in the early 2000's the use of CA to forecast the sustainable development of urban and regional environments [12]. The constrained CA LU change model developed by [13] proposes a tool for assessing scenarios of LU policies in support of spatial planning in Belgium. It has been applied over Flanders at

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100m resolution [14][15][16] and at the country scale at a coarser resolution (300m) [17][18]. In [18], an innovative travel time-based variable grid approach with transport network scenarios is used. Another approach is proposed by [19] where population projections [2] are used to model the suitability of constructible lands to host sustainable residential functions. The model compares space availability versus residential land demand. Residential land developments are prioritized using a multi-criteria GIS analysis.

Walloon administrations are interested in a high resolution (≤100m) predictive model of land-use change, for smart city monitoring of soil sealing expansion, risk assessment and sustainable planning. Such a model is currently not available in Wallonia.

This paper describes the steps in transposing the Flanders LU model to Wallonia. A similar approach will be applied in both regions since this is interesting for integrated planning. Homogenizing risks studies between regions is intended since natural hazards are not stopped by regional borders. However, model replication from one region to another is not straightforward. First of all different modelling goals, and geographical and social-economic contexts create a need for different parameter sets and scenarios. Secondly, availability, limited access, quality or semantic differences in existing data induce some model adaptations such as calibration, parameters and/or validation phases. Finally, knowledge of local and regional LU processes is required.

This paper will focus on the methodological choices and decisions taken through the application of the Flanders model to the Walloon region. Close collaboration between researchers from both regions as well as end-users commitment is needed during the process.

The paper is organized as follows: Section II briefly describes the constrained CA land-use change model initially developed for Flanders. The methodological steps for applying the model to Wallonia are detailed in Section III. A synthetic conclusion is proposed under Section IV.

II. LAND-USE CHANGE MODEL

The constrained CA land-use model is made up of three sub-models. These represent spatial dynamics that take place at three geographical levels: (1) ‘global’ level, i.e., the entire Walloon region, (2) ‘intermediate’ level, i.e., NUTS3 regions (Eurostat administrative units level 3, called arrondissements in Belgium), and (3) cellular level, i.e., a 100x100m grid [14][20]. At the global level, time series based on population growth and employment scenarios are needed. These global trends constrain the intermediate level, in which a spatial-interaction model is used to downscale the growth trends to the level of the intermediate level. At the local level, a CA-based model allocates to the grid cells the area needed for population and employment growth. This CA model simulates the evolving land-use until 2050 for each individual cell. The changing LU patterns result from spatial interactions that take place between the different land-uses within the immediate neighborhood around each cell. Besides this, the patterns are also constrained by institutional zoning status, physical suitability and transportation characteristics.

III. METHODOLOGICAL STEPS

The application of the constrained CA model to the Walloon region implies some particular contextual and methodological choices and decisions that are presented in this paper.

A. *Modelling goals and outcomes*

Identifying end-users and involving them closely in the model development process helps to precisely define the goals and outcomes. Surveys, meetings, workshops, etc. are various steps needed to create a decision makers group. Involvement of policy makers and international experts is done by integrating them into the project's steering committee or even directly as partners. This project also proposes an implementation group including scientists, data producers and decision makers from several administrations. Regional and local end-users have shown their willingness to participate in this group. They are involved in themes such as infrastructure (SPW-DGO1), mobility (SPW-DGO2), natural resources and environment (SPW-DGO3), spatial planning and geomatics (SPW-DGO4), health (SPW-DGO5), air and climate (AWAC), statistics (IWEPS) and cities (Liège) monitoring.

B. *Model inputs*

In Belgium, each region is responsible for its own geodata production and management. By consequence, data availability and data properties differ in Wallonia and Flanders. As an example, an important model input is a land-use map for the start year of the model simulation. The comparison and semantic adaptation between the existing LU maps for Flanders and Wallonia is necessary to define the land-use classes that are simulated by the model. A survey is currently being carried out to assess the users’ satisfaction regarding the existing Walloon LU map, as well as the expectation towards the modelled products. This survey addresses the number of classes, their precision, the update time-step (each year), the coverage (2050) or the derived sub products (spatial indicator).

Facilitated by INSPIRE, geodata access still vary between thematic products in both regions. Input data differ in terms of content, extent, production date, spatial resolution and quality. Simulations further rely on social-economic data sets to define trends in land-use. Availability of historical and projected social-economic data also differs between regions. This information is not always produced at the same spatial and temporal resolution. For each of these inputs dataset, a discussion and a choice are needed.

Moreover, the regional significance is checked. Some geo-criteria may have high impacts on future land-use

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change in one region, such as harbors in Flanders or slopes in Wallonia, while they are less significant in the other one.

C. Upcoming actions

During model implementation, additional decisions must be taken together with end-users. These include calibrating the model and defining future scenario(s), e.g., using historical and projected LU or population data, as well as assessing model flexibility, i.e., what consequences if new data/studies/directive is published. Validation step will be discussed in detail, e.g., field work or use of authentic data sources such as buildings. Qualitative and quantitative assessment of model outputs will be made by comparing them to other relevant geodatabases, e.g., PICC, CadMap, BelMap, etc. Final choices will be made regarding authorities access right to the model and results publication.

IV. CONCLUSION

Generic and common land-use change models are key decision support tools for sustainable spatial planning in the whole of Belgium. Involving end-users in the model development and application guarantees future valorization and use of this model. Land-use change simulation will help drawing policies that limit risks caused by further urbanization.

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