Transdisciplinary Collaboration Platform Based on GeoDesign for Securing Urban Quality

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1 Introduction

Guiding urban agglomerations towards more sustainable development is a great challenge (UN-HABITAT 2009). Existing concepts and rules for generating urban patterns of high urban quality do not work in today’s agglomerations and societies, and concepts for new (sub)urban qualities are needed (CARMONA et al. 2006, MODARRES & KIRBY 2010). New approaches need to facilitate collaborations between science and a variety of public and private stakeholders (DE JONG & SPAANS 2009, SCHOLZ 2011, KUNZE et al. 2011), enabling them to make decisions on urban development taking into account multiple dimensions and values, alternative development possibilities, performance indicators and uncertainties. Furthermore, developments in complex urban systems take place at multiple planning scales and time frames and therefore demand for a solid mutual understanding of spatially explicit information (DE JONG & SPAANS 2009, ERVIN 2011, NEUENSCHWANDER et al., 2011).

Simulation and modelling in a functional way might support such interactive and iterative collaboration processes. This process should be characterized by cooperation of non-academic stakeholders (society) and science, mutual learning and knowledge integration (SCHOLZ 2000). Such processes are defined as transdisciplinary, i.e., they integrate “disciplinary scientific and non-academic knowledge into an inter- and transdisciplinary research framework for complex problem solving” (ENENGEL et al. 2012, 106).

This paper presents the concept of a collaborative urban planning platform supported by a suitable combination of simulation tools for identifying sustainable urban patterns. Preliminary results of setting up this platform are shown exemplarily with a focus on urban green space patterns. A central element for the collaboration process is a library of quality criteria and rules for urban patterns from coupled design, social, ecological and economic perspectives. These specifications are encoded and made directly applicable as digital modelling rules. Combining disciplinary rules to interdisciplinary rule sets according to the situation of a specific urban case, GIS-based 3D visualizations of the urban patterns are generated and can be interactively explored. In this paper, details on gathering and operationalizing specific rules are given on the example of suburban green space patterns for the Swiss case region Limmattal, an urban agglomeration in the greater Zurich area.
2 Material and Methods

2.1 Urban quality

As urban quality depends on the respective disciplinary perspective, it has to be defined according to all dimensions. How an urban area presents itself can be described with the dimensions “Structure”, “Gestalt” and “Form” of the natural and built environment (ALEXANDER et al. 1977, SCHAEFER, 2011). “Structure” is determined by the topography, the distribution of land uses and land use densities, and the infrastructure. “Gestalt” is defined as the character and identity of each quarter and settlement. Urban design, architecture and the design of open spaces give the environment a culturally shaped “Form” (SCHAEFER 2011).

Quality of life in urban areas has an objective and subjective component. Within objective criteria for quality of life, spatial and structural characteristics but also functional, social aspects in the urban realm play a crucial role. From an ecological or landscape perspective, the services provided by the urban ecosystems can significantly support human wellbeing (BOLUND & HUNHAMMAR 1999). Major problems in urban areas caused by traffic and soil sealing, e.g., air pollution, wastewater disposal, urban heat islands, and noise, have to be solved locally. The urban ecosystems can contribute to reducing these problems if on one hand structure, age and composition of green spaces is adequate (quality). On the other hand, size, amount and spatial distribution on the regional and local level (quantity) is important, which can be increased, e.g., by enhancing ecological networks (OPDAM et al. 2006). In addition to services rather depending on the functioning of the environmental systems, cultural services such as possibilities for people’s identification are relevant (“Gestalt” and “Form”). For securing and sustaining these urban qualities, an intense societal examination of landscape aesthetics is required (RODEWALD 2011).

Ecological objectives and solutions, however, cannot be viewed independent of social, economic and design requirements and solutions. The obvious lack in quality of current cities and agglomerations is the result of insufficient implementation of interdisciplinary concepts for urban development in practice (KURATH 2011).

2.2 Traditional city planning methods

The complexity of urban and regional systems, the speed of urbanisation, and the uncertainty of developments with growing problems such as transport bottlenecks, housing shortage and shortage of space for recreation, exceed the abilities of traditional city planning methods (RATCLiffe & Krawczyk 2011). EISINGER (2009) and KURATH (2011) argue that securing urban quality requires both, abolishing sectoral thinking and robust processes of “producing the city”. New planning methods are needed, which help in designing novel urban patterns, securing urban quality. Such transdisciplinary research settings should organize a future oriented mutual sustainability learning and capacity building process among regional stakeholders, urban planning experts and scientists (see SCHOLZ 2011, 379).
2.3 Current simulation and modelling tools for urban development

Urban typologies are commonly used by urban planners for defining flexible frameworks in urban development (Schirmер et al. 2011). 3D visualization of the urban landscape is a straightforward method to provide these rule sets in a comprehensive form for stakeholders from science and practice. Particularly for fast interactive urban visualization of large areas, ESRI’s CityEngine system has shown to be a valuable tool for encoding typological rules to shape grammars, which generate 3D geometries of the urban layout at various scales (Halatsch et al. 2008, Schirmер et al. 2011).

In addition, integrated land use, transportation and environmental planning requires evaluation of different scenarios and policies, testing land use regulations, development subsidies or costs in relation to the transport system and the land use patterns. The complexity of spatial interactions has motivated the development of a number of urban simulation systems that forecast the behaviour of each component. For example, relations between land use patterns and traffic congestion can be analysed implementing agent-based transport simulation models (www.matsim.org) or computable general equilibrium models based on economic causality (Rutherford 1995). UrbanSim is one example for a sophisticated integrated urban simulation model providing reasonable and intuitive results to policy scenario inputs (WaddeLL 2011). Current research also develops models based on satisfaction of human needs in the urban living environment. This social dimension in urban simulation has only recently gained further attention (Feitosa et al. 2011).

Combining these simulation and visualization tools can facilitate a transdisciplinary urban collaboration platform (Schröth et al. 2011) by continuously accompanying the development of urban systems in a design-simulation-collaborative cycle.

3 Region Limmattal – An Agglomeration of Zurich (CH)

The Limmattal is the valley of the river Limmat bordered with rolling hills and extending over 24 km from east to west from Zurich city centre to the city of Baden (Fig. 2). It comprises an area of about 18’600 hectares, a population of about 165’000 inhabitants and 118’000 employees in the year 2010.

Fig. 1: Left: Position of the “Region Limmattal” in the Swiss urban system (nodes: settlement areas) and strength of its networking (lines: technical infrastructure). Right: Schlieren, Silbern and Altstetten are focal areas allowing further analyses on local level (black/dark grey = settlement areas).
The Limmattal is a typical suburban region challenged by the negative effects of urban sprawl, directly perceivable by aesthetic degradation, loss of environmental quality, cultural heritage and reduced quality of life (SCHUMACHER et al., 2004). The region, however, experiences high migration rates, with an estimated overall increase of about 30'000 people and 20'000 jobs by 2030. A comprehensive development concept for the whole region, guiding sustainable urban development paths, does not yet exist. Thus, the region provides a suitable case study for elaborating a regional development vision implementing the urban collaboration platform.

4 Results

4.1 Concept of a transdisciplinary urban collaboration platform

The overall goal is the development of a collaborative planning platform, where stakeholders of all planning levels and disciplines collaboratively analyse the current urban situation, develop scenarios and assess those alternative urban development patterns. This is supported by interactive 3D visualizations and indicators for urban quality. Through an iterative assessment and adaptation process of the virtual urban patterns on local and regional scales, sustainable urban patterns can be identified in a transdisciplinary dialogue (Fig. 1).

Fig. 2: Concept of the transdisciplinary urban collaboration platform

First, the diverse criteria for urban quality are made interoperable. Hard factors of building regulations (e.g. street widths, building heights, or target values for recreational space per inhabitant) and soft factors, such as elements for identification (e.g. cultural sites), are formatted systematically. In order to support clear imaginations of the future urban patterns, it is important to visualize and assess these patterns from the regional (conceptual) up to the building level (experiential). To this end we adapt and implement an urban typology (CATS 2009) and define 10 building types. An urban area is classified into building types and patterns. In addition, significant aspects of the existing buildings and respective green space types are mapped in the field. With this typology hard and soft factors are generalized into design principles that are transferable to any urban area.
In the next step, the general quantitative and qualitative design pattern rules are encoded to Computer Graphics Architecture (CGA) shape grammar rules. In ESRI’s CityEngine system (GIS-based procedural urban model) these are then implemented for geometric 3D modelling of urban patterns with roads, buildings and green spaces. These digital modelling rules provide a library of urban patterns, which initially include design and ecological specifications. Implementing the procedural urban model and changing interactively these CGA rules leads to new urban patterns.

The building types are the least common denominator in the GIS database allowing for linking the results of the behavioural modelling to the geometric, procedural urban model. We employ a land use transportation microsimulation (combination of UrbanSim and MATSim) as well as a Computable General Equilibrium Model (see section 2.3) to simulate and test possible consequences of policies, alternative transport systems and land use scenarios under complex system conditions. The modelling results deliver plausible future 2D urban patterns on a quarter to parcel level for a case study area, as well as indicator values, e.g., employment, population, traffic and congestion times. The 2D pattern maps are used as input to the geometric model.

When running the collaboration platform, the stakeholders define scenario framework conditions, which are operationalized for the modelling systems. 3D visualizations of the urban development scenarios as well as corresponding indicator values are used to conduct detailed analyses of urban design, economic, ecological and social impacts. The latter serve as a “reality check” for the scenarios, discovering how good different social needs of target groups are fulfilled. Furthermore, a trade-off model based on the stakeholders’ weighting of urban qualities based on indicator values can automatically change the input parameters for the size and distribution of buildings and urban green spaces. Various stakeholders can thus analyse possible options available in a collaborative spatial analysis, which provides both debatable normative values and qualitative aspects, such as identity and distinctiveness of new urban patterns.

4.2 Setting up the digital modelling library

In this paper, preliminary results of integrating ecological criteria into the urban typology are presented. This was part of the first steps for setting up the digital modelling library, i.e. the digital CGA shape grammar rules for generating procedural urban patterns, which allow for integrating specifications of spatial attributes from different disciplinary perspectives.

Table 1 shows an example of how specifications of building regulations and information on the green space’s potential for providing relevant ecosystem services (see Section 2.1) can be linked to the building type “Multi-family Houses”. Furthermore, an example of a typical, generalized pattern of multi-family houses and their respective green spaces in the Limmattal is given. Exemplars of several alternative patterns for this building type in the case study area are mapped and specified. In addition, the typical vegetation of the green space type is mapped. The information on relevant urban ecosystem services that can be provided by the green space type is the basis for defining the required qualitative and quantitative characteristics of the green spaces (= rules). According to these characteristics the green space type can be optimized in quality.
Tab. 1: Illustration of the urban typology on the example of the building type “Multi-family Houses” (ES = Ecosystem Services)

The patterns and their specifications were encoded to CGA shape grammars following the approach of Wissen Hayek et al. (2010). Executing the shape grammar rules on given parcels in the virtual model of the case study area, ESRI’s CityEngine system generates 3D urban patterns (Figure 4). In a next step, relevant quantitative indicators for assessing the quality of the green spaces will be linked to these visualizations allowing for an optimization of the patterns in participatory processes (Neuenschwander et al. 2011). Furthermore, the grammar will be augmented with rules of further disciplines.

Fig. 3: 3D visualization of current and alternative future urban patterns suitable for interactive exploration in the procedural urban model
5 Conclusions and Outlook

For sustainable regional and urban development, norms and values regarding objectives of all disciplines on the local up to the regional scale should be taken into account by various actor groups such as local authorities, planners, urban designers and architects, real-estate developers, nature protection, social or cultural organisations. The presented urban collaboration platform is thought to facilitate developing objectives for transformation of suburban areas towards a more sustainable development. It can provide the information on essential interdisciplinary norms and values – as shown on the example of recreational and ecological objectives – in form of digital modelling rules and 3D urban visualizations illustrating the spatially explicit implementation of the rules. Through allowing the actors to define desired values for specific needs, such as amount of building floor space or recreational space, the consequence of individual demands on all other needs can be demonstrated with the 3D visualizations, which will be linked with quantitative indicators for the local and regional scale. In this way, mutual learning processes of all actors can be initiated. The model cannot design sustainable urban patterns. Using such simulations in collaborative planning processes, however, can support taking into account a rather high degree of urban complexity required for securing urban quality.

References


