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Identifying urban transformation dynamics: Functional use of scenario techniques to integrate knowledge from science and practice

Timo von Wirth [a,*], Ulrike Wissen Hayek [b], Antje Kunze [c], Noemi Neuenschwander [b], Michael Stauffacher [a], Roland W. Scholz [a]

[a] Institute for Environmental Decisions (IED), Natural and Social Science Interface (NSSI), ETH Zurich, Universitaetstrasse 22, CHN J74.1, 8092 Zurich, Switzerland
[b] Institute for Spatial and Landscape Planning, Planning of Landscape and Urban Systems (PLUS), ETH Zurich, Wolfgang-Pauli-Str. 15, 8093 Zurich, Switzerland
[c] Chair of Information Architecture, ETH Zurich, Wolfgang-Pauli-Str. 27, 8093 Zurich, Switzerland

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ABSTRACT

Many urban regions are exposed to rapid growth, leading to vast changes in land use with diverse ecological, socio-economic, and aesthetical impacts. Regional scenarios are suitable for identifying possible urban development patterns. However, one challenge of scenario construction is integrating the knowledge of both science and practice for a better understanding of the complex interactions between impact factors in the urban fabric.

The objective of this research is to enhance process design for a collaborative scenario analysis in the context of urban development. The scenarios are constructed for a case study of the Limmattal region, a suburban agglomeration close to Zurich, Switzerland, and we demonstrate a functional structure for science–practice collaboration within the process of scenario building. The types of communication between science and practice are systematically varied, which leads to four consistent scenarios for 2030.

Our analyses of regional system dynamics reveal the most important feedback loop among five impact factors within the region, which allows for a better understanding of the systemic interactions in regional transformation. This process design shows the potential to support knowledge integration in research processes involving science and practice, and assists informed planning strategies for urban transformation.

1. Introduction

The transformation of an urban region is a complex, real-world problem. Clear transformation goals for urban areas often remain ill-defined [1] and research on such transformations must cope with interactions between human and environmental factors in a dynamic spatial system. Thus, new methodological approaches that support both science and practice in understanding the possible future development of the urban fabric are necessary.

Complex interactions are perceptible in suburban regions of agglomerations in Europe and worldwide [2]. Despite significant local differences, suburban regions are characterized by land consuming settlement development with lower utilization densities. Spatial patterns in suburban regions have been debated intensively in the discourse on urban sprawl phenomena [3,4]. Urban sprawl is associated with diverse environmental effects, such as the loss of green space, fragmented land-use divisions, and an increase in site distances, which, in turn, impacts transportation demands, resulting in higher energy consumption and traffic emissions [5,6]. The expansion of urban space at its fringes poses further threats to the quality of life by increased social segregation, loss of local identity and the aesthetic degradation of landscape and architecture [7,8].

These diverse social and environmental factors and the inherent uncertainties of spatial development exceed the

* Corresponding author. Tel.: +41 44 632 7584; fax: +41 44 632 1029.
E-mail address: timo.vonwirth@env.ethz.ch (T. von Wirth).

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abilities of traditional planning methods [9]; therefore, decision-making in urban planning has to cope with diverging preferences and complex interactions, not only between stakeholder interests, but also between the aforementioned components of urban structure [10,11]. A procedural challenge, Healey refers to as coping with the relational complexity of spatial transformation [12]. Her particular concern lies in adequate spatial conceptions and their subsequent prospective imaginations being articulated in strategic spatial planning.

Strategic planning frameworks attempt to complement a more coherent spatial logic in response to socio-spatial phenomena [13] such as resource protection, urban sprawl, meaningful land use regulations, and larger infrastructure investments. These phenomena may stretch beyond local or national administrative boundaries, interrelated within dynamic patterns of social and economic networks. Their spatial impacts and implications for place quality cannot be understood without taking into account the relationships between the actual physical places, the interaction of actors, and the meaning given to the places [14]. Accordingly, this relational complexity must be reflected in processes of strategic spatial planning.

One way to achieve a better understanding of these complex interactions (e.g., unintended rebound effects of zoning policies and new suburban housing developments) is to facilitate meaningful representations of different scientific disciplines and specific knowledge by practitioners in urban planning and design in the research process on spatial planning [15]. Transdisciplinarity makes this possible. It is a specific form of research setting in which actors from science and society collaborate in the common process of knowledge production [1,16,17]. As such, it follows the need to address complex, real-world problems from diverse knowledge domains, and facilitates capacity building and consensus formation [18]. Taking into account the diversity of scientific and societal views on real-world problems, their integration (e.g., knowledge, interests, values) is the main challenge in such research approaches [19]. Transdisciplinarity is distinguished from interdisciplinarity, which is defined as a mode of research that integrates concepts and methods of two or more disciplines but remains within the academic system [20].

Gaining insights into the future paths of an urban region requires an integrated, comprehensive and systematic method [9,21]. In this context, scenario development has evolved as a tool for effectively forming conceptions of an uncertain future [22–25]. According to Fahey and Randall [26, p.6], "scenarios are descriptive narratives of plausible alternative projections of a specific part of a future." Scenario techniques are distinct from other future-oriented projection methods (e.g., foresight, trend analysis, visioning) in their ability to integrate complexity and uncertainty. The use of scenario techniques in regional and urban contexts is relevant for modeling, planning, and learning about alternative spatial developments with inherent uncertainties [27–31]. They also help to provide insights into the preferences and decision-making of urban and regional planning actors [9,32].

Research on scenario techniques has made substantial contributions in the form of structured typologies and methodological frameworks [23,33–35]. However, further methodological enhancement is required for systematic procedures that integrate different knowledge domains of practice and science [36] and for adequate formats for scenario communication [36,37].

Only recently, the integration of stakeholders in scenario development was reviewed by Wangel [38], emphasizing the need to explicitly reflect the shaping role of key actors in scenario studies. Zegras and Rayle [39] examined how scenario planning is able to enhance science-practice collaboration in a regional planning context for Portuguese cities, and their contribution focused on collaboration effects for participants in a pre- and post-test experimental design. Yet the methodological formats to facilitate such a collaborative scenario process have not been in focus. In fact, Reed et al. [40] pointed out the importance of structured information flow as a success factor in multi-actor scenario studies. More precisely, structural guidance for eliciting and aggregating information from participants and the provision of information to participants is demanded [40]. However, a systematic procedure guiding communication intensity and format is missing, and thus one focus of our study. Our first research question is as follows:

(1) How can we integrate knowledge for regional scenario building in a collaborative research process among disparate actors from science and practice?[1]

Understanding regional transformation requires a profound system analysis before strategies can be defined, because urban regions are complex and dynamic systems *par excellence*. Within urban systems, we find a multiplicity of interrelated feedback loops [41], and their detection and interpretation allow for a better understanding of the adaptive potential and vulnerable impact structures in the case region [42]. Insights into system feedback loops to enable complex system understanding can be considered a "key component of sustainability learning" [18; p. 439]. Previous research provides evidence for the misperception of feedback principles as individuals tend to interpret contexts as causally linear [43]; however, individuals can learn to perceive and understand feedback loops. Meaningful representations of circular feedback loop models (e.g., verbal, graphical, numerical) can promote such learning processes [18,44]. Nevertheless, we did not find a case application that integrates the identification of regional feedback loops during scenario analysis. In fact, Burt [45] argued for further development of system analysis techniques within the scenario methodology to reveal systemic sources of discontinuities and disruptive events in future system states. We aim at a better understanding of the interdependent feedback relations in the case region, together with stakeholders. Thus, our second research question asks:

(2) How can we reveal major internal dynamics in the form of intraregional feedback loops in a collaborative scenario analysis?

Revealing feedback loops is one thing, but making the knowledge and insights from a scenario analysis accessible to all involved is another challenge. Providing adequate scenario formats for communication and interpretation is particularly

[1] Research question 1 refers to the methodological aspects of the scenario process. Thus, the developed process heuristic is presented within the methods section of this paper (Section 3.2).

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