



# Integrated research on land-use changes in the face of urban transformations – An analytic framework for further studies



Ellen Banzhaf<sup>a,\*</sup>, Sigrun Kabisch<sup>a</sup>, Sonja Knapp<sup>b</sup>, Dieter Rink<sup>a</sup>, Manuel Wolff<sup>a</sup>,  
Annegret Kindler<sup>a</sup>

<sup>a</sup> UFZ – Helmholtz Centre for Environmental Research, Department Urban and Environmental Sociology, Permoserstr. 15, D-04318 Leipzig, Germany

<sup>b</sup> UFZ – Helmholtz Centre for Environmental Research, Department of Community Ecology, Theodor-Lieser-Str. 4, D-06120 Halle, Germany

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## ABSTRACT

We state that land use is under constant pressure, no matter if land-use changes take place in growing or shrinking cities. Land-use changes witness multiple interdependencies between environmental, social and economic factors. In urban areas land is highly exposed to accelerating consumption which makes it a scarce and precious resource. Therefore we need transformative processes to deal with land use in a more sensible and responsible way. We define urban transformations as fundamental, multi-dimensional changes in urban land-use patterns, population developments, infrastructures, governance regimes as well as established values, norms and behaviours. A central focus is on land use and its changes to supply ecosystem services as key driver for quality of life. Most important for us is that transformative processes are highly dynamic and non-linear, thus affecting functions of urban land uses in different ways and with varying consequences. In this sense, governance research is a decisive component to implement our research in practice. With this viewpoint we want to contribute to a debate on land-use changes in alternating growing and shrinking cities to foster appropriate development responses for urban transformations towards sustainability.

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## 1. Introduction

Urban land-use changes have been under investigation for a very long time and serve as basic indicator for urban transformations. We define urban transformations as fundamental, multi-dimensional changes in urban land-use and land-consumption patterns, population developments and infrastructure provision, governance regimes as well as established values, and norms. Most important for us is that the processes related to these phenomena are highly dynamic and non-linear (Kabisch and Kuhlicke, 2014). Urban land-use changes affect functions of different types of urban land use in different ways and with varying consequences, even within the same urban area (Weeks, 2010). Hence, our research contributes to initiate and foster transformative urban land use towards sustainable urban development.

The expansion of residential, commercial, industrial, and infrastructural use is analysed as major component of increased land consumption and thus discussed as urban growth processes (Seto

et al., 2011). Moreover, during the last decades, land-use changes in urban areas have also been explored regarding various processes and effects of urban shrinkage including population decline (Haase et al., 2013). Both, urban growth and shrinkage shed light on the dynamics of land use as a scarce and contested resource in the context of ongoing global urbanisation. According to the United Nations' sustainable development goals (UN, 2016), land-use changes must be geared in a resource-efficient and resilient way. In the context of both, urban growth and shrinkage are urban transformations considered as indispensable to pursue these goals.

Since the turn of the millennium, intensified urbanisation advances globally. This observed process is closely linked to the consumption of land as a major challenge for a sustainable development (The European Environmental Agency – EEA, 2015, p. 30). The mass concentration of humans living in urban areas is expected to proceed and two-third of the world's population are projected to become urban dwellers by 2050 (United Nations 2014, 2010).

In our view, it is essential to shed light on the various characteristics of urban transformations from a socio-environmental perspective. This point of view draws particular attention to urban land consumption especially as land is a primary and limited resource, its use is of highest value with multiple functional options

\* Corresponding author.

E-mail address: [ellen.banzhaf@ufz.de](mailto:ellen.banzhaf@ufz.de) (E. Banzhaf).

(Seto and Reenberg, 2014). Priority setting herewith depends on power relations of urban stakeholders and on competing governance interests (Van den Dool et al., 2015, p. 218).

Hence, a sensitive issue hardly discussed in urban debates is land use in the light of alternating growth and shrinkage. Both form a paradigm as “a growing-shrinking spectrum on which all cities are positioned” (Herrmann et al., 2016, 1st page). These alternations can depend on changing concatenations of external factors such as economic upswing or political crisis which impact internal characteristics in terms of respective demographic development paths. The latter refer to population stagnation, increase or decline for various time spans that again can change in dynamic urban settings. Alternating urban development paths have implications on urban land use and its multiple functions with regard to its spatiotemporal changes. It is not as simple as assigning less land consumption to shrinking cities and higher land consumption to growing cities – there is evidence for opposing development paths of ongoing land consumption no matter which process is going on (Haase et al., 2016; Wolff et al., 2016). In this respect, pressures on urban land constantly exist.

From a socio-environmental science perspective, such pressures are the trigger to accelerate or slow down urban transformations towards a sustainable urban development. Despite being an essential issue in sustainable urban development, this perspective has rarely been exposed in scientific discourses. Against this background it is our intention to fuel this debate.

## 2. Land-use changes at different scales

Assuming that urban land use is a key component to develop urban areas in a sustainable way, our understanding is that urban transformations must include appropriate developmental responses to disruptions and novel challenges. In this sense, research on urban transformations is highly diverse depending on the disciplinary background of the respective researchers. It encompasses urban areas in different cultural contexts under the pressure of various land-use changes. Unsurprisingly, there is no single strand of academic inquiry that does justice to this diversity (e.g. Block and Paredis 2013; Burch et al., 2014; McCormick et al., 2013; Radywyl and Biggs, 2013; Pickett et al., 2013).

The hitherto known development paths that drive the evolution of urban areas – expressed as urban growth or urban shrinkage – can be interrupted or reinforced by external factors. Most studies dealing with urban transformations, however, focus either on growth or shrinkage, using population development as major indicator (Banzhaf et al., 2009; Bontje and Musterd 2012; Haase et al., 2013; Mavrakis et al., 2015; Sharifi et al., 2014). Against this backdrop it must be addressed that most studies do not refer to different spatiotemporal scales. Urban realities indicate that there is no linear trend of either growth or shrinkage and that they are no phenomena affecting merely population development or land-use changes alone. As implications of land consumption, densely built-up and perforated residential areas can exist in both, growing and shrinking cities. They may in turn impair the provision of ecosystem services; complying a downgrade of quality of life (The Global Development Research Center, 2016). Therefore a rather complex approach is necessary, embedding the various interdependencies as well as spatial and temporal considerations at several scales. Such entangled developments are especially challenging, as different transformation processes are linked to different forms of disruption that are both specific as well as subject to certain overlaps. We recognize that urban areas can be affected by various impacts disparately in temporal and spatial scales which trigger contrasting and non-linear developments. The interspersed processes of shrinkage and growth require careful analysis across

multiple scales, given that they can often be observed between different neighbourhoods within the same urban area, in different areas of the same city as well as between urban regions. Respectively, different temporal dimensions (from short-term to long-term) of these impacts require attention.

By examining paths of diverse urban dynamics, we gain a nuanced perspective on urban areas that allows us to apply our theories and field studies to the context of urban transformations.

### 2.1. Research focus

The focus of our research is on processes of urban land-use changes, their drivers, triggers, trade-offs and conflicts. It identifies options and limitations for a resource-efficient and resilient urban development to ensure appropriate quality of life to urban dwellers. Based on the interdisciplinary approach fed by natural and social sciences we analyse and assess past, ongoing and intended land-use changes and their consequences of (non)sustainable land-use strategies. These insights nourish our knowledge for further transformative urban land use.

Our key question is: *How can research on land-use changes further our understanding of processes of urban transformations towards resource efficient and resilient cities that offer an adequate quality of life?*

We investigate land-use alternatives for different land-use types such as residential areas, green spaces and brownfields on different spatial and temporal scales. Given that our ultimate aim is to find ways for sustainable land-use options and regulations, we also integrate governance issues into our research approach (see Fig. 1). In this context ‘governance’ refers to co-creating and co-designing land-use options in a transparent and participatory manner integrating decision makers from policy and planning, as well as representatives from civil society (Frantzeskaki et al., 2014).

To understand land-use processes extensively we apply quantitative and qualitative concepts in an integrated way: We lay our methodological foci on both, objectively measurable land-use patterns and conditions as well as on less tangible factors such as attitudes and perceptions of residents to better comprehend land-use structures and changes (Banzhaf et al., 2014). The first focus is of quantitative nature encompassing monitoring and modelling techniques as well as spatial statistics for which we combine remotely sensed data from satellite imageries, digital orthophotos and drones (big data) with population statistics. For the second, we apply long-term surveys, questionnaires, expert knowledge and smartphone apps. Both, the mix of methods and the combination of *traditional* with *advanced* data sources and methods require a multidisciplinary team. Hence we can underpin our spatially explicit knowledge by individual and subjective evaluation, and reflect public viewpoints in a participatory way. Especially smartphone apps are a mapping toolset that serve at local level with a global multiplier.

We share our research activities underpinned by empirical evidence with practitioners and decision-makers to enhance and to encourage transformative urban land use.

## 3. Urban land-use dynamics and their impacts

Urban land-use dynamics are of pivotal significance due to multiple interdependencies between various environmental, social and economic factors. The dynamics of urban areas give rise to either condensed or dispersed developments of built-up areas, a reduction of open spaces due to population growth or the demolition of buildings due to a lack of residents – all affecting urban land use (Banzhaf and Höfer, 2008). Land-use structures may be mono-functional or multifunctional and may be based on varying speeds and spatial

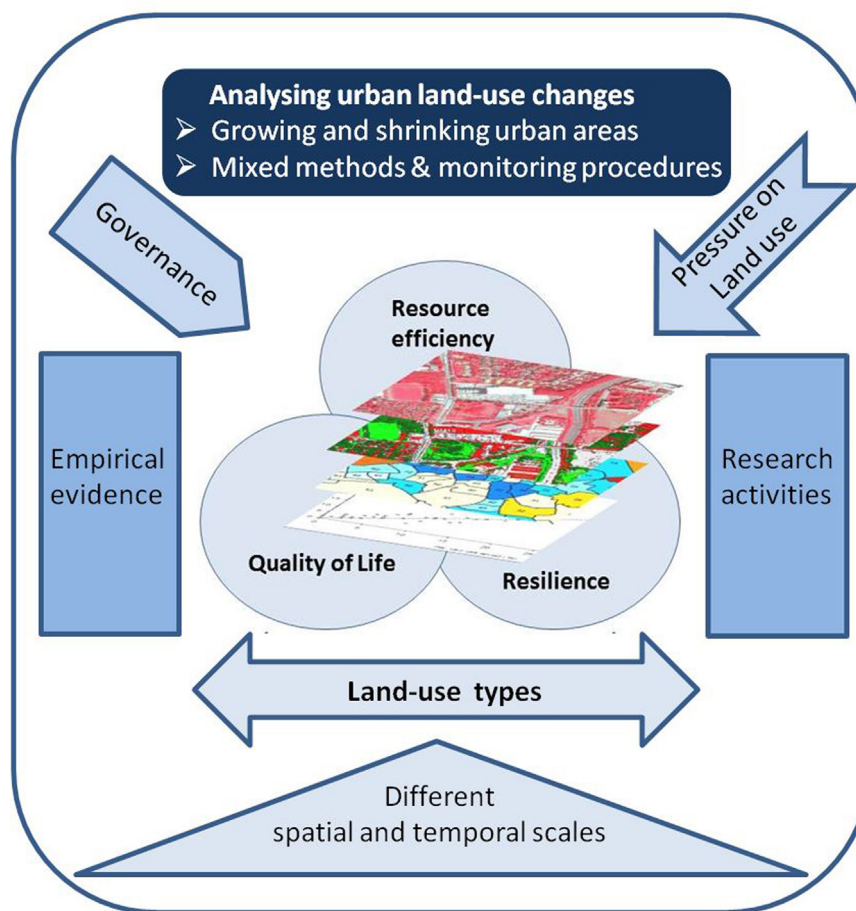


Fig. 1. Conceptual framework for integrated research on land-use changes in the face of urban transformations.

dimensions of change. An example for a mono-functional land-use type is a parking lot. In contrast, multifunctional spaces “perform several functions and provide several benefits on the same spatial area” (European Commission’s Directorate-General Environment, 2012, 1st page). A typical urban example is a park, which offers space for recreation and at the same time delivers a range of ecosystem services such as temperature regulation or flood retention.

In urban areas densification processes relating to construction are usually accompanied by a consumption of bare soils and green spaces (Banzhaf et al., 2013). A decrease in the amount of such open spaces indicates, for example, a loss of recreational spaces close to residential areas. Living close to green recreational spaces however, can decrease mental distress and increase the wellbeing of urban residents (White et al., 2013). Several other studies also illustrate that green spaces are crucial in determining the quality of life of urban residents through the provision of multiple ecosystem services (Dobbs et al., 2014; Elmqvist et al., 2015; Haslauer et al., 2015; Hubacek and Kronenberg 2013; Luederitz et al., 2015). In particular, selected types of urban green infrastructure (e.g. parks, urban forests, street trees or vegetated brownfields), their spatial layout and distribution govern the provision and accessibility of ecosystem services and therefore related aspects of quality of life. Jaganmohan et al. (2016) for example, showed that local temperature regulation in residential urban areas is affected by the size, shape and type of adjacent green spaces, with forests and large green spaces providing higher cooling effects in summer than parks and small green spaces, and the shape of green spaces interacting with their size. Beyond, there is also a link between the functional diversity (that is the diversity of e.g. morphological or physiological

features of organisms) and the ecosystem services of urban green spaces (e.g. tree canopy architecture affecting water capture on green roofs; Lundholm et al., 2010). It may however, not be forgotten that nature also produces so-called disservices (Von Döhren and Haase, 2015), e.g. health risks caused by ecosystem functions (Lyytimäki and Sipilä, 2009), that planners should consider.

Environmental aspects of quality of life also depend on residents’ socio-economic status which in turn influences residents’ behaviours and thus urban land use. Romero et al. (2012) used urban vegetation cover not only as an indicator for the provision of several ecosystem services. They also discuss the socio-spatial correspondence of vegetation cover to socio-economic classes and observe a much higher share of vegetation cover for richer classes and rather sparse furnishing for the lower middle class of a metropolitan area. Pressures arise for municipalities inhabited by citizens of low socioeconomic status, as limited financial resources decrease the chances to care for the configuration of public green spaces, and planted private land hardly exists (De la Barrera et al., 2016a). In contrast, in countries with high water prices only neighbourhoods with affluent citizens are able to water their private land and thus care for the provision of ecosystem services as benefit for their quality of life related to e.g. climate resilience against heat hazards (De la Barrera et al., 2016b).

On these grounds we stress the need for studies on urban transformations that integrate environmental, social and economic aspects in terms of resource efficiency, quality of life and resilience. Within our project, we investigate the resource urban land as a provisioner for ecosystem services which again is a key driver for environmental quality of life. Moreover, we investigate ecosys-

tem services and disservices derived from different land-use types regarding environmental justice. The latter is understood as the distribution and sharing of environmental *goods* (resources) and *bads* (harms and risks) and how therefore resilience can be enhanced for the urban population (Walker 2012; Franck et al., 2014; Schlink et al., 2014). Here, we concentrate on various relations between environmental conditions (especially air pollution), the beneficial potential of ecosystem services (mitigation of environmental burdens), improvements in quality of life and human well-being, the social situation of the exposed population, and, finally, their consequences for land-use planning and sustainable urban development.

The various functions of existing and changing land-use types serve as a pool of options and solutions for a sustainable urban development. This may be done by establishing long-term plans as well as short-term experiments which enhance physical, economic, social and environmental conditions. To implement these approaches, targeted and context-sensitive governance structures and instruments are necessary. Integrative investigations on governance within our research project on urban transformations contribute to improve existing measures and mechanisms.

#### 4. Governance of urban land use

Focusing on land-use changes involves a variety of policy and planning issues, mainly land-use plans and zoning and building codes. Generally they are elaborated by planning institutions and approved by municipal legislation, and sometimes these plans are added by landscape or regional planning (UN Habitat, 2009, p. 24 ff.). Often local authorities have to deal with interrelated issues from quite different perspectives and with differing aims, as well as with the concerns of a large number of actors, not least land owners with their powerful interests. Hence, the crucial point is that although interests are very different, all of them imply additional land consumption. During the many years in which unsustainable dynamics such as unplanned urbanisation or suburbanization spread far into the urban hinterland, governance did not yet have the goal to tackle the associated land-use problems. Moreover, due to overarching focus on growth additional land consumption was not seen as a problem at all.

It was only after the turn of the millennium that land use was identified as an environmental or sustainability problem (e.g. Rink and Banzhaf, 2011) and in several countries it became the subject matter of stricter regulations (United Nations, 2012, p. 15 ff.). In the 2000s, national and local governments introduced measures to restrict additional use of unsealed land (bare soils, green spaces, agricultural land). Land use was integrated within urban master plans and the reduction of new urban development was recognized as a central goal of the politics to develop land in a sustainable way (European Commission, 2007). This integrated urban development is also highlighted in the global megatrends elucidated by The European Environmental Agency – EEA: “Land-use planning and management are essential if we are to better reconcile land use with environmental concerns. It is a challenge that involves various policy levels and different sectors” (EEA, 2015, p. 1). At present, new governance structures and new politics have only been established in some countries that include policies and integrative planning capable of reducing land use, for instance brownfield redevelopment, re-densification, infill or protection of green spaces (Seto and Reenberg, 2014). From the viewpoint of political reality the success has remained modest and the reduction of urban land consumption constitutes a permanent challenge. Our research focus is to analyse how environmental and sustainable goals can be integrated in land-use planning and policy, and how traditional growth orientations can be overcome. Therefore governance comprises research on actor and power constellations, and on different interests, con-

cerns and goals of stakeholders as well as of citizens which needs to be performed in a participatory process.

#### 5. Conclusions

In this viewpoint paper we have argued that our research contributes to initiate and foster transformative urban land use towards sustainable urban development. Land-use changes and land consumption are under constant pressure. We assume that land-use dynamics are key to resolving tensions and strengthening trade-offs between the multiple interests, concerns and goals of stakeholders. Our argument refers to land use as it is imbedded in the concept of non-linear urban development processes. They are the foundation for our empirical evidence and analytic models using advanced quantitative and qualitative methods. We contribute to the discussion on drivers and impacts by investigating physically and socio-economically induced land-use structures as non-linear phenomena. Our results shed light on the interconnections between the complex and constantly changing land-use structures.

Being focussed on application, we support decision making, provide options and solutions, monitor and evaluate the respective implementation measures and mechanisms. When implementing our concept to different local and regional urban areas on different spatiotemporal scales, our analyses and results are mirrored in the respective cultural contexts. Options and solutions are in the focus of a decision-making process with practitioners, and citizens implying a participatory approach. Such objects of research are of local concern and of global interest.

Researchers should move their focus towards integrated investigations of different functions and their changes in different contexts. We are convinced that questions such as “what role do specific land-use types have under certain conditions?”, “how will they be changing?” or “how can such processes be scientifically shaped and politically steered?” will guide us in future research.

Much less important is to focus on one single land use or one function within one context such as growth. Beyond, we address the need for integrated governance of land-use dynamics from local to national and international scales to accomplish our integrative approach. Research emphasis should expand analyses towards an interdisciplinary comprehension of multidimensional and non-linear facets of urban transformations. Our aim is to make an innovative contribution to the present debate on environmental understanding of complex urban land-use dynamics as an important share of urban transformations towards sustainability.

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