



15th International scientific conference “Underground Urbanisation as a Prerequisite for Sustainable Development”

## Transitions to a high density urban underground space

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### Abstract

Urban Underground Space as a valuable resource, a space for placing structures and infrastructure, as well as a source of groundwater and geothermal energy. Development of Urban Underground Space has been accelerating rapidly in many major cities. Pressures of a changing global environment, including climate and increasingly limited land availability, place Urban Underground Space on the top of the innovative urban development agenda. However a strategy for an alternative to surface urban growth has not yet been duly elaborated or even discussed. This paper will explore plausible transitions in the use of underground space, discussing (1) changes in housing and infrastructure demand, and energy consumption over the next decades; (2) the functional, spatial and technological changes in Urban Underground Space; (3) the potential for Urban Underground Space to mitigate climate change by significantly reducing energy consumption and providing alternative locations for facilities at risk from climate change effects; (4) the status of Urban Underground Space as public space and an additional valuable spatial asset. Major challenges in the UUS transitions process have been identified and summarized as a UUS development agenda. The overarching goal in the urban and UUS development should be enabling a compact, liveable, sustainable, and resilient city while improving quality of life in it.

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## 1. Introduction

Urban Underground Space (UUS) has been used for many centuries; however understanding that it is a unique, precious, and in-demand resource has only emerged in recent years (Parriaux et al., 2006; Bobylev, 2009). UUS can be defined as a space beneath urban areas, including wider areas of UUS that provide direct services to a city, e.g. for groundwater supply of geothermal energy. UUS encompass geologically formed rocks and soils, and artificial structures, as well as caverns of various origins. Parriaux et al. (2006) have identified four basic UUS resources: space, materials, water, and energy. These resources have different degree of renewability, depending on their use and/or rate of extraction (Sterling et al., 2012).

Cities continue to sprawl both horizontally and upwards, but these development strategies have significant limitations (Jabareen, 2006) and fail to satisfy key contemporary challenges, e.g. biodiversity conservation, energy efficiency, minimizing green house gas emissions and sustainable transport modes. Most worryingly, consumption of land continues in the regions with falling populations, questioning success of developed countries in their sustainability efforts (Bobylev & Jefferson, 2014). Figure 1 shows built up area expansion at a rate exceeding populations' growth and falling average population densities (although in the core of urban centers densities continue to rise). It has been argued by many researchers (e.g. Bobylev, Parriaux, Ronka, Sterling) that this increased pressure on land use and urban expansion will result in the acceleration of UUS use. This can be observed in many cities, particularly those at an advanced stage of development (Evans et al, 2009). There is a consensus amongst scholars from a wide variety of disciplinary backgrounds (e.g. Williams, 2008; Zhao & Cao, 2011; Foster, 2011) that intensive UUS use is vital to maintain a good quality of life in dense urban environments. Hence, as the future brings more high density urban centers, ever greater use of UUS will be required (Jenks et al, 2000).

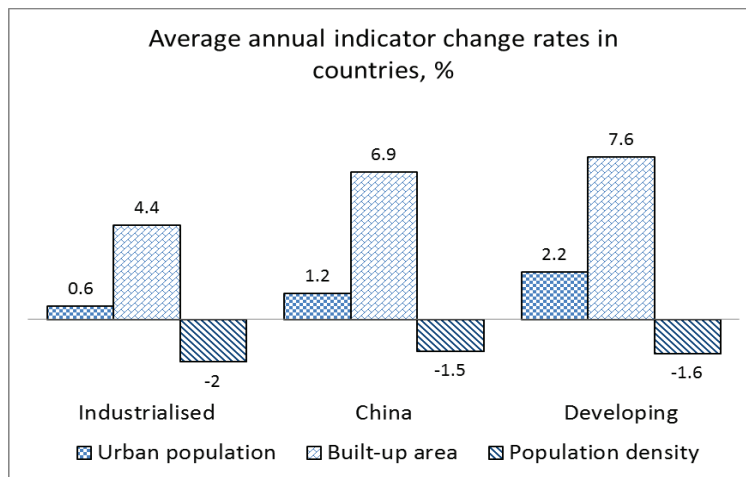


Fig. 1. Comparison of average global annual increase (decrease) rates in urban population, built-up area, and population density, %. Calculated using data from: China Urban Development Report, 2010; He et al, 2012; UN-Habitat, 2011; Angel et al, 2005; UN-Habitat, 2013.

This paper will examine urban transitions along with changes in UUS; how and why transitions to more active UUS use will be happening. This analysis will be done against a background of already happening transitions in UUS, for which a brisk state-of-the-art will be given. Greater questions are phase and necessity or inevitability of these transitions, their benefits and associated risks will be discussed, as well as a contemporary research agenda to address the whole complexity and challenges of UUS use.

## 2. The Driving Factors

The driving factors or pressures under which transitions in UUS use occurring are associated with urbanization and technological innovation process. Basically land use pressures and high urban densities provide a demand for an

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