University Alliance for Sustainability

Spring Campus, March 27-31, 2017
Research Workshop III: “Climate Change in Cities. Mitigation, Adaptation”

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Local Responses to the Global Environmental Change: Review of the Urban Underground Space Resource Use for Adaptation and Mitigation of Climate Change

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Overview

-Global Environmental Change

-Urban Underground Space Resources

-Urban Underground Space Resource Use for Adaptation and Mitigation of Climate Change

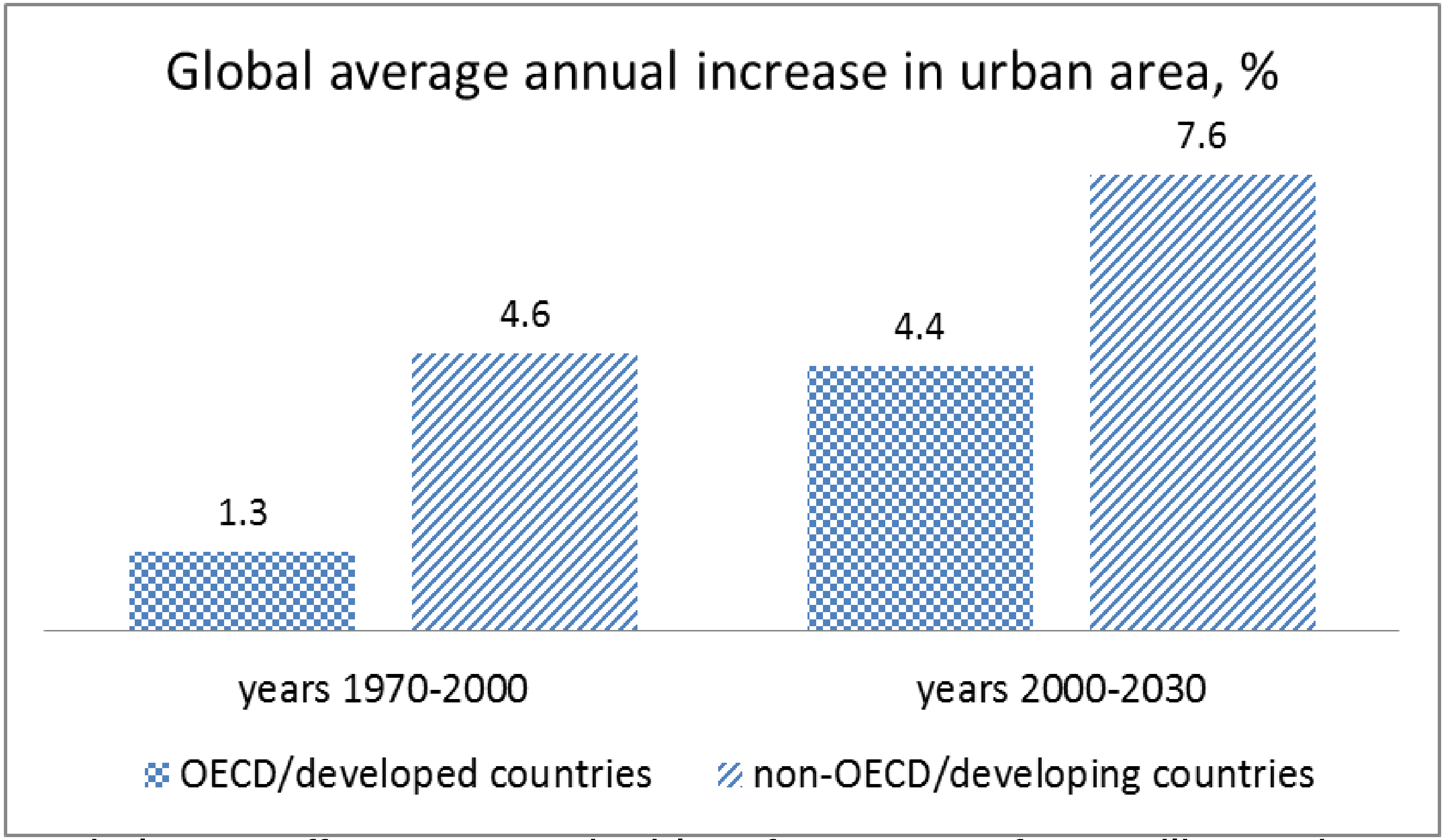
-Examples & discussion on environmentally friendly solutions (smart, resilient, carbon neutral, energy recovery, sound proof, liveable)

-Policy recommendations - Three-Dimensional Planning

-Tunnelling and Underground Space Technology, Elsevier. Special Issue Volume 55 – UUS Research & Development Agenda

Underlying drivers for contemporary UUS growth (urbanization, density, environment),

Facts = Land cover change!



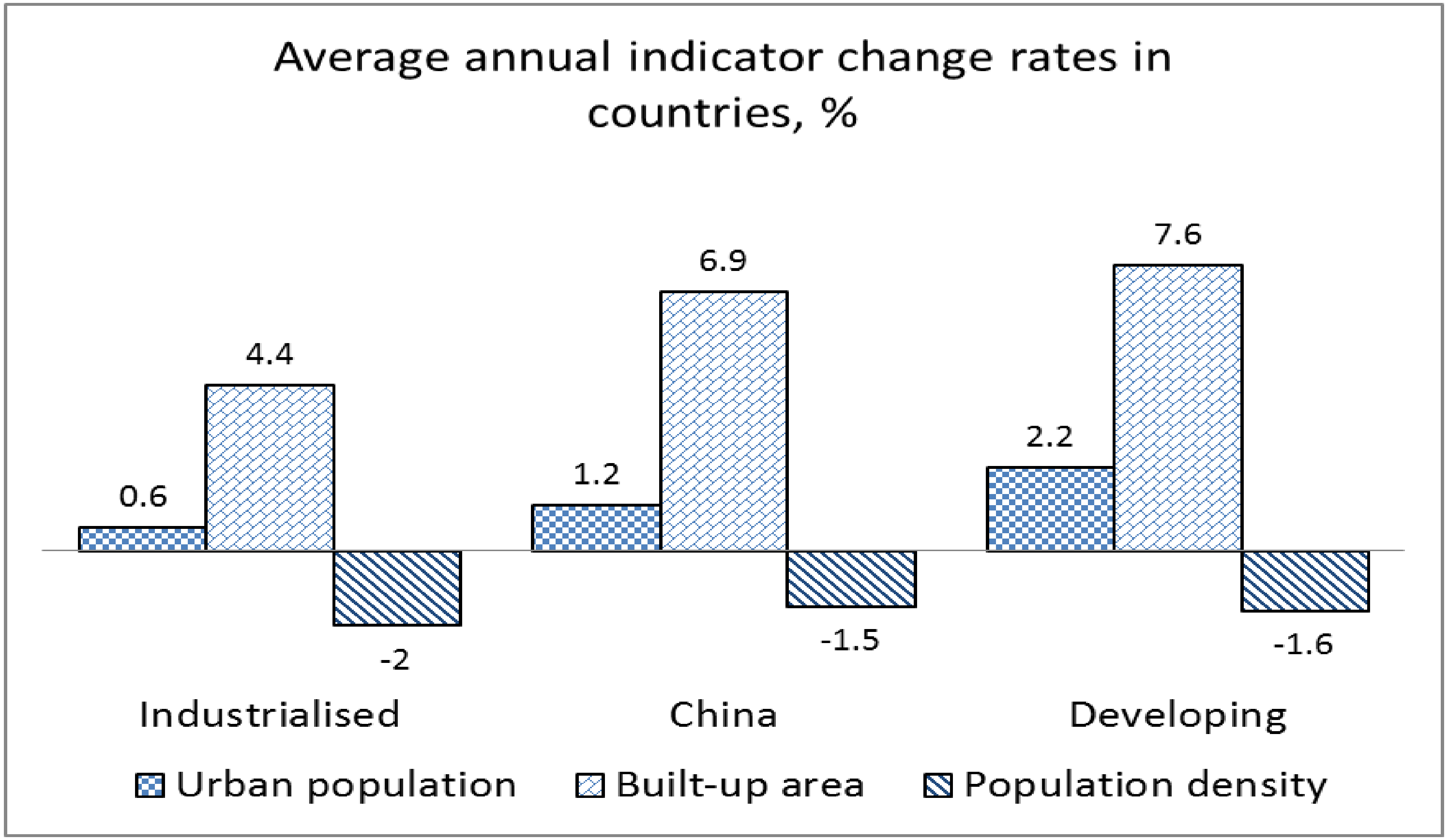
source: Bobylev & Jefferson, Sustainable Infrastructure for Resilient Urban Environments (SIRUE) 2012 – 2015

Data: Goldewijk K. and Van Drecht G., 2006; OECD 2008, Angel et al, 2005

*tolerances: built-up area equals urban area; OECD countries equals developed equals industrialised countries.

Underlying drivers for contemporary UUS growth (urbanization, density, environment)

Policy = Urban sprawl? A Compact city?

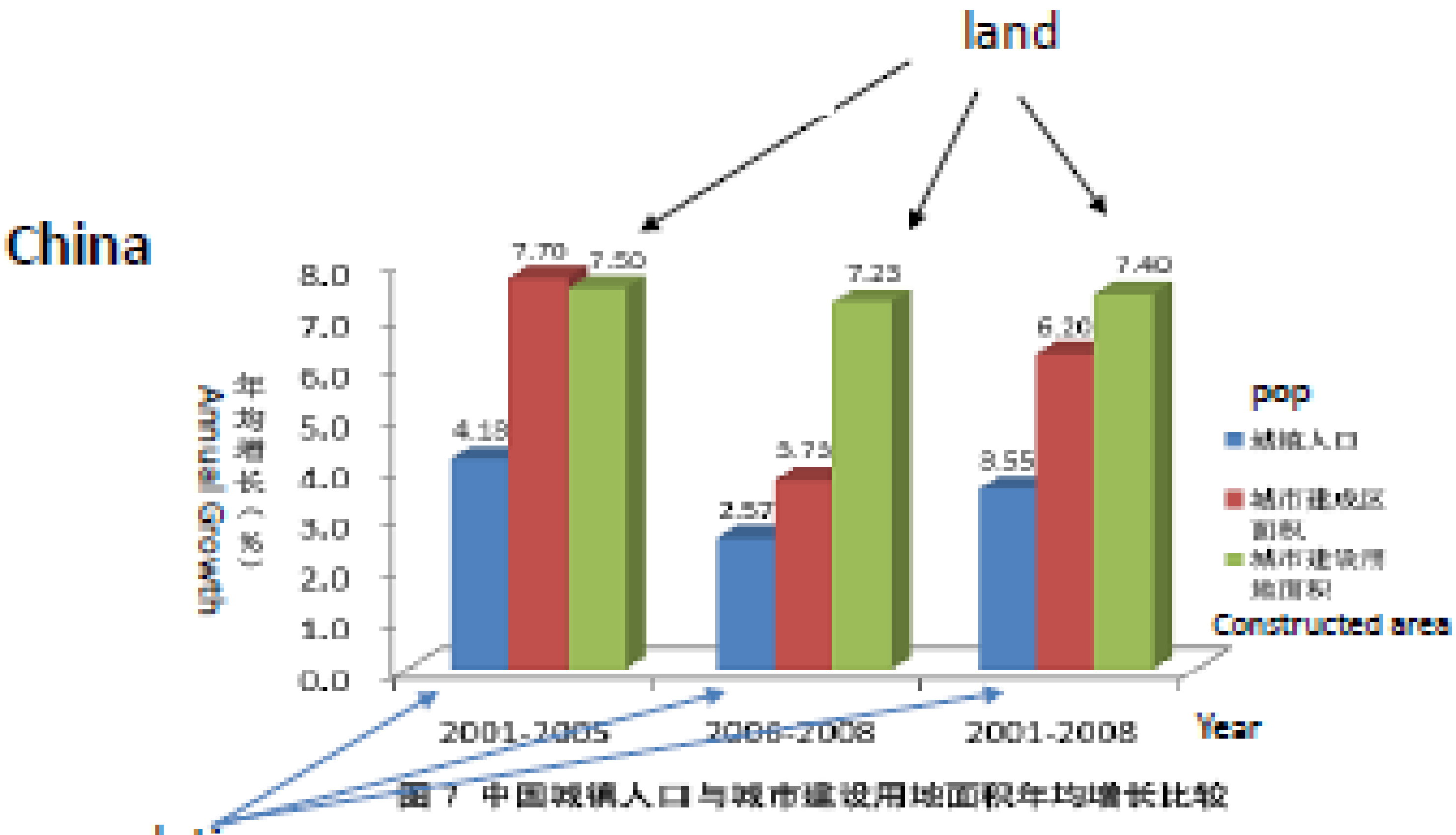


source: Bobylev & Jefferson, Sustainable Infrastructure for Resilient Urban Environments (SIRUE) 2012 – 2015

Calculated using data from: China Urban Development Report, 2010; He et al, 2012; UN-Habitat, 2011; Angel et al, 2005; UN-Habitat, 2013. *tolerances: built-up area equals urban area, excluding major green areas and water bodies; OECD countries equals to (1) developed (2) industrialised countries; data for China is for the years 2000 - 2009, data for the urban population is for the years 2010 - 2020, data for urban population density is for the years 1990 – 2000, the rest data is for 2000-2030.

Underlying drivers for contemporary UUS growth (urbanization, density, environment)

Facts = Land cover change!



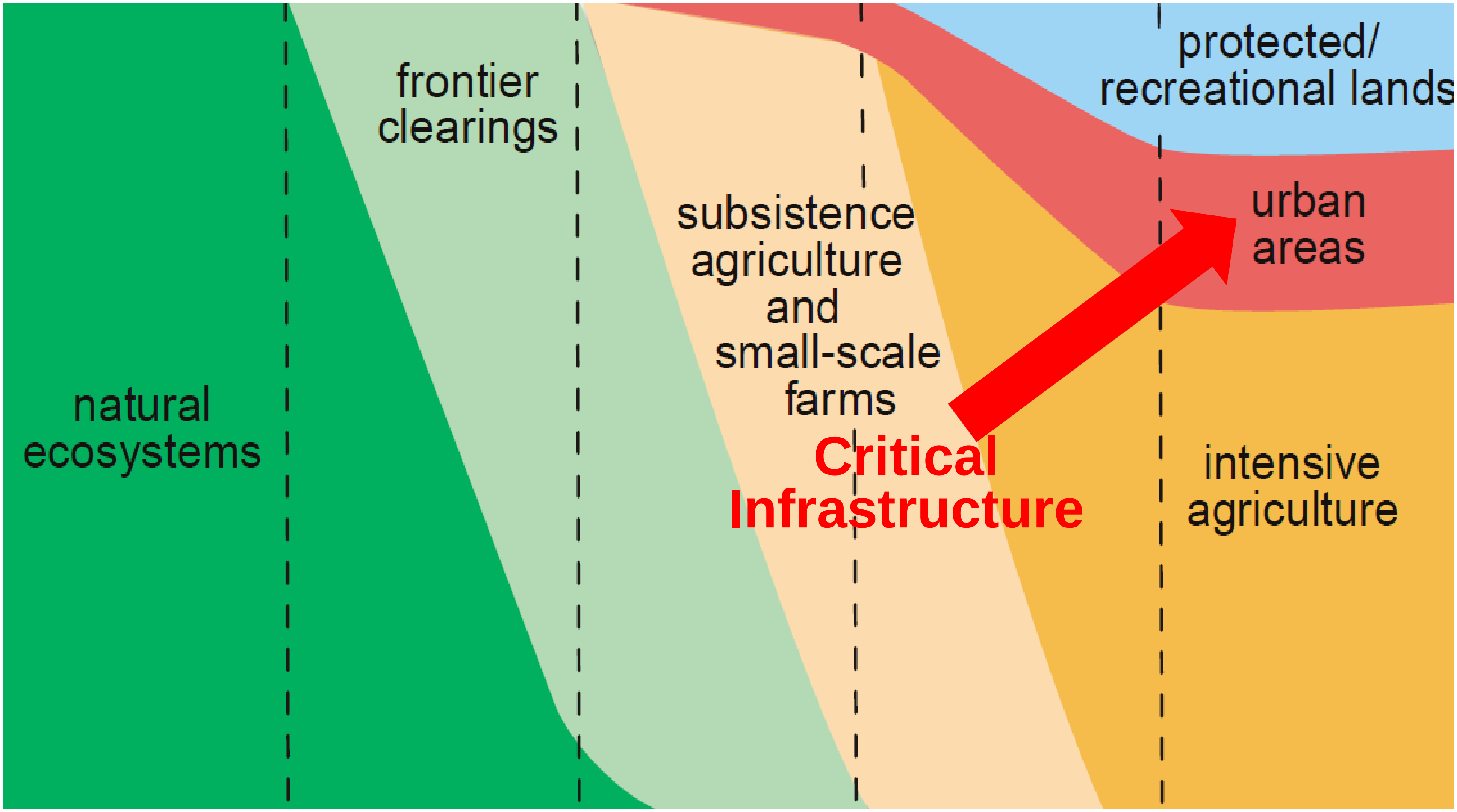
Contrast between Population and constructed area in China

Source: Dr. Ling Xue, Towards sustainability: 'new' urbanization, new planning. Spring Campus, April 11-15, 2016

Source: *HoukaiWei,* Contrast between Population and constructed area in China

Underlying drivers for contemporary UUS growth (urbanization, density, environment),

Land-use transitions

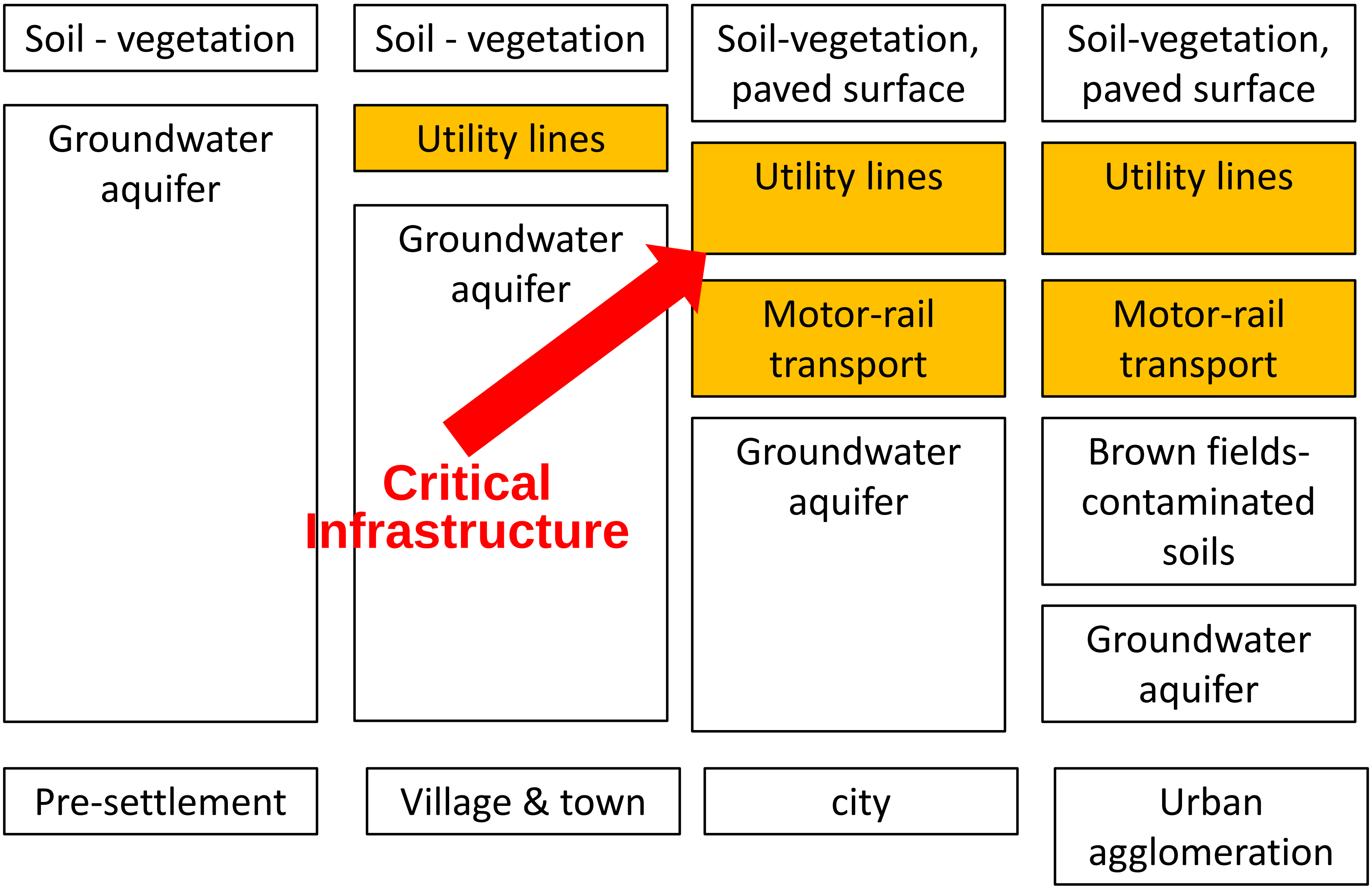


source: DeFries et al 2004

A sequence of different land-use regimes that may be experienced within a given region over time: from presettlement natural vegetation to frontier clearing, then to subsistence agriculture and small-scale farms, and finally to intensive agriculture, urban areas, and protected recreational lands.

Underlying drivers for contemporary UUS growth (urbanization, density, environment),

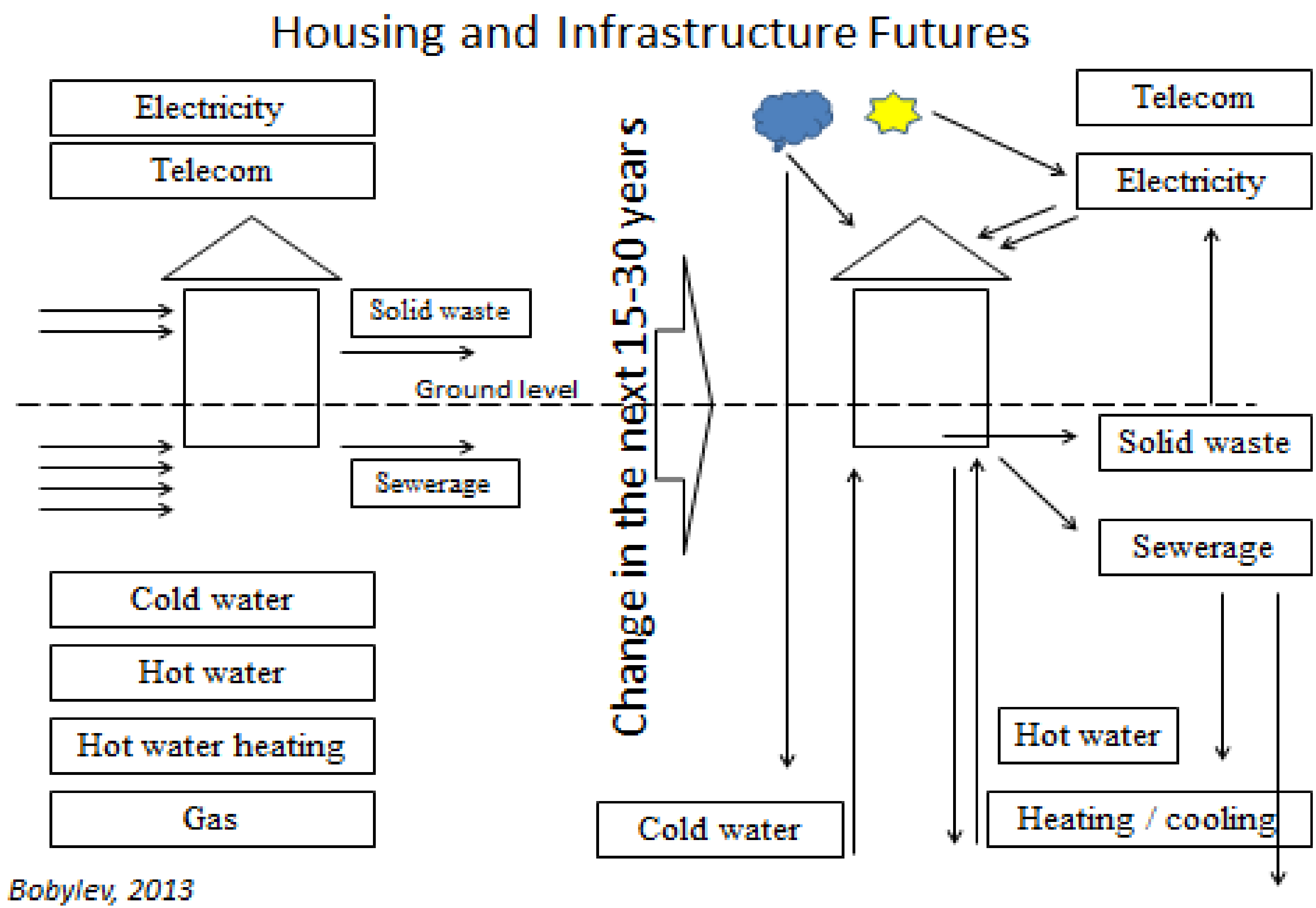
Urban Underground Space (UUS) use transitions



Bobylev & Jefferson, 2014

Urban Physical Infrastructure:

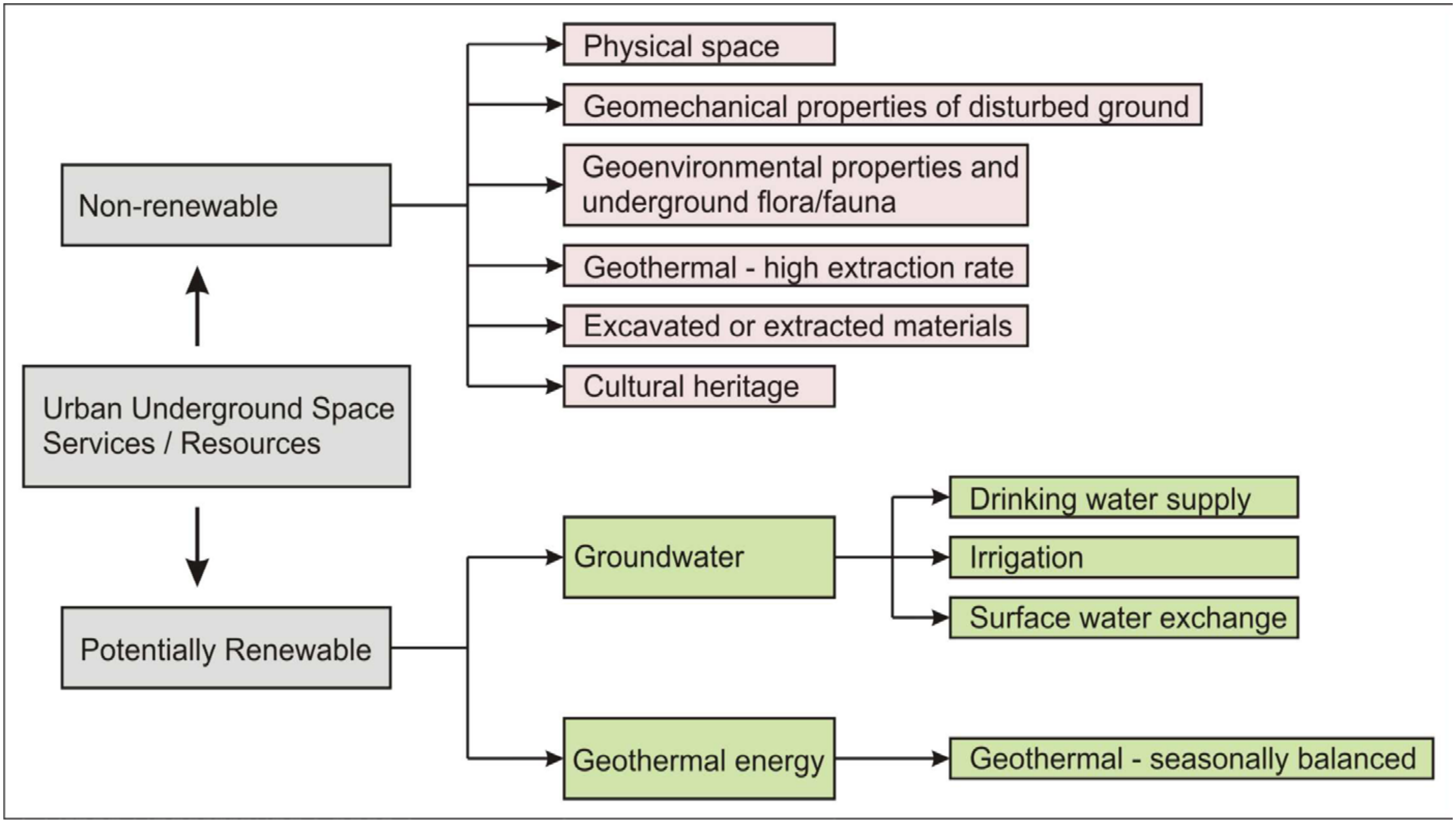
adaptation, transformation, transitions?



Housing support infrastructure development trends (from Bobylev, upcoming)

UUS resources (after Parriaux, Bobylev, Sterling)

Sustainability Issues for Underground Space in Urban Areas (2012) Sterling, R., Admiraal, H., Bobylev, N., Parker, H., Godard, J.P., Vähäaho, I., Rogers, C.D.F., Shi, X., Hanamura T. *Proceedings of the ICE - Urban Design and Planning*



Sustainability and resilience goals in urban development

Elements of resilience and sustainability related to urban development, Bobylev 2016

Urban challenges (liveability improvement)	**Resilience**	**Synergy or conflict; strong or moderate**	**Sustainability**
Utility services provisioning	Reliable provisioning of infrastructure services, backup infrastructure	Moderate conflict	Frugal resource use, reduced utility services consumption, saving energy while infrastructure operation
Infrastructure spatial arrangement	Wide, ample space for each infrastructure element to avoid disturbance in case of the other failure	Strong conflict	Tight, aimed at saving space, energy, and materials
Housing	Safe, adapted to withstand disasters	Moderate conflict	Liveable and energy efficient
Public spaces	Designed to have additional capacity for disaster response and reduction	Moderate conflict	Designed to encourage sustainable lifestyles
Transport	Reliable transport links, designed to withstand variety of stresses while maintaining services	Strong conflict	Minimal, aimed at consuming minimal energy
Green and recreational areas	Ample, to adsorb disaster shocks and provide refuge	Strong synergy	Ample, to provide quality of life
Optimal urban form	Polycentric, to diversify risks	Moderate synergy	Compact, to save energy
Society	Coherent and informed	Strong synergy	Coherent and informed
Population and building stock densities	Optimal, not too low to be able to organize common protection (flood management) and not too high to enable disaster response (proximity of emergency services)	Unknown/specific to location	Optimal, not too low to save land and energy and not too high to enable quality of life
Climate change	Increase industrial activities to be able to	Strong conflict	Decrease industrial activities to reduce

Urban Underground Space Resource Use for Adaptation and Mitigation of Climate Change

Mitigation issues	**Underground Space relevance**
Compact city, low energy for mobility	Enabler for compactness and densification
Compact city, low losses in energy infrastructure	Enabler for compactness and densification
Low energy use for indoor human optimal temperature	Underground buildings, premises
Local renewable energy	Geothermal, energy storage

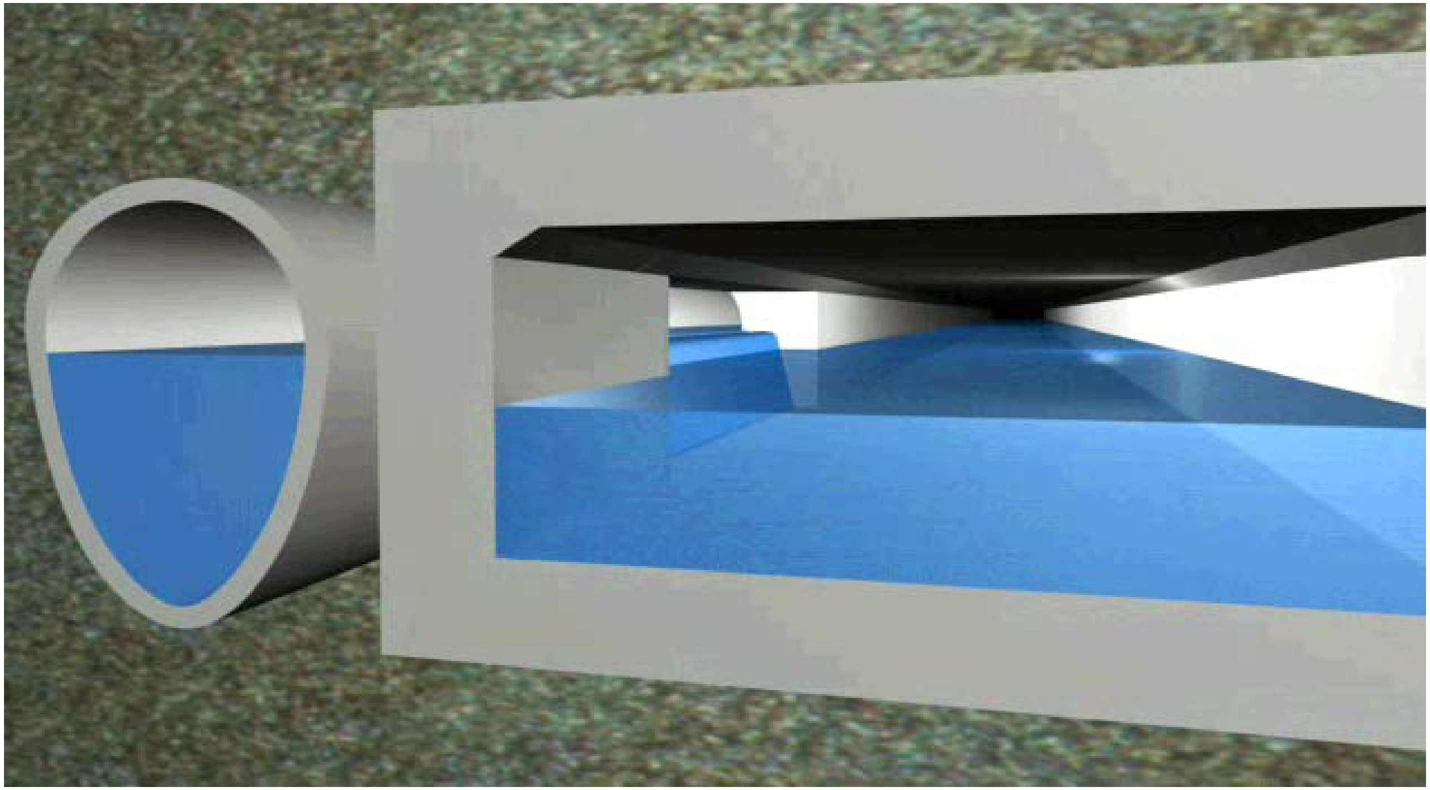
Urban Underground Space Resource Use for Adaptation and Mitigation of Climate Change

Adaptation issues	Underground Space relevance
Response to extreme weather events	Shelter provider
Urban heat island	Refuge provider, enabler for low energy premises
Changes in hydrogeological cycle	Underground buildings and infrastructure could be vulnerable

Climate change related threats to UUI and vulnerabilities

Climate-related threat	*Impacts on UUI*	*Vulnerability*	*Damage*
Floods, Extreme rainfall	Inundation of underground structures through open structural elements, like entrances, sewers or ventilation shafts	High	Structural damage is low; damage to equipment is high unless waterproofing doors are used
	Inundation of underground structures through leakages in retaining structure due to high water pressure	Low	Low if leakages are not continues
	Suffusion of surrounding soil due to change in water level during the flood	Low	Extremely high, up to structural collapse
	Sewers and rainwater collectors overcapacity operation, which might result in their structural damage	Medium	Medium
Sea level rise, and subsequent rise of surface and groundwater levels	Structural damage due to changing soil stress-strain condition, “floating up” of underground structures	Low	Medium. High in case of prolonged UUI maintenance neglect
Extreme atmospheric temperatures	Ventilation systems can become temporary not operational.	Low	Low
Extreme wind	Ventilation shafts can be structurally damaged	Low	Medium

UUI adaptation to climate change (to extreme weather events)



A storm water storage tank (right) adjacent to a sewer (left). Source: Berliner Wasserbetriebe and Department of Urban Water Management, Berlin Institute of Technology.

Adaptation versus Mitigation

and Resilience versus Sustainability

An example: Adaptation to climate change

A problem of urban water runoff after heavy rain:

climate change increases occurrence of extreme weather events (including urban flash floods)

Ensuing problems:

- Flooding and inundation
- Untreated water discharge into surface water bodies;
- Infrastructure damage;
- Disruption if critical (vital) urban services

Adaptation versus Mitigation
and Resilience versus Sustainability

An example: Adaptation to climate change

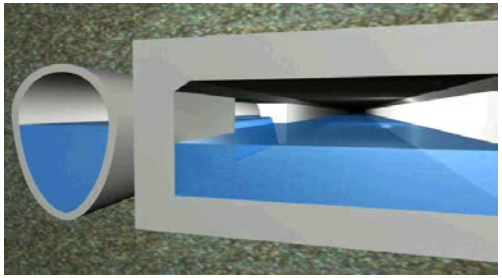
A problem of urban water runoff after heavy rain

Conventional solutions:

- Reduce runoff (trees, green zones); (resilient & sustainable)
- Increase capacity of drainage infrastructure (resilient & not sustainable)

Smart city solutions (resilient & sustainable)

- Manage runoff between city areas (valves, barriers, automated water management (smart grids)).
- Inform citizens to temporary cut domestic water use (e.g. for one-two hours).



Adaptation versus Mitigation
and Resilience versus Sustainability

A problem of urban water runoff after heavy rain

G-Cans Tokyo: resilient & not sustainable

- Resolves urgent problem
- Uses a lot of resources to build and operate
- Stems form an unsustainable land use decisions (unmanaged excessive runoff)
- De facto facilitates climate change

Max-Schmeling Halle, Berlin

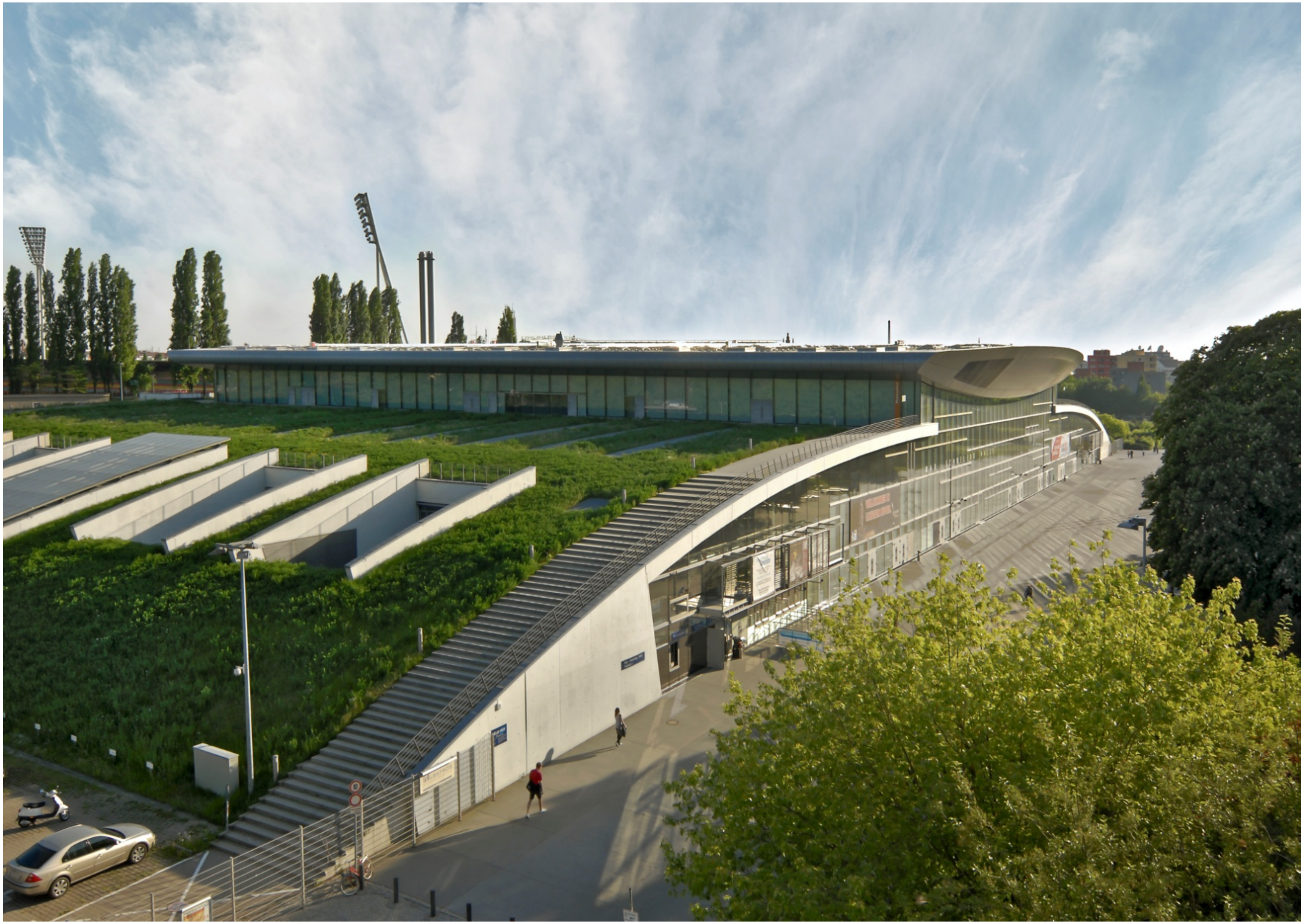
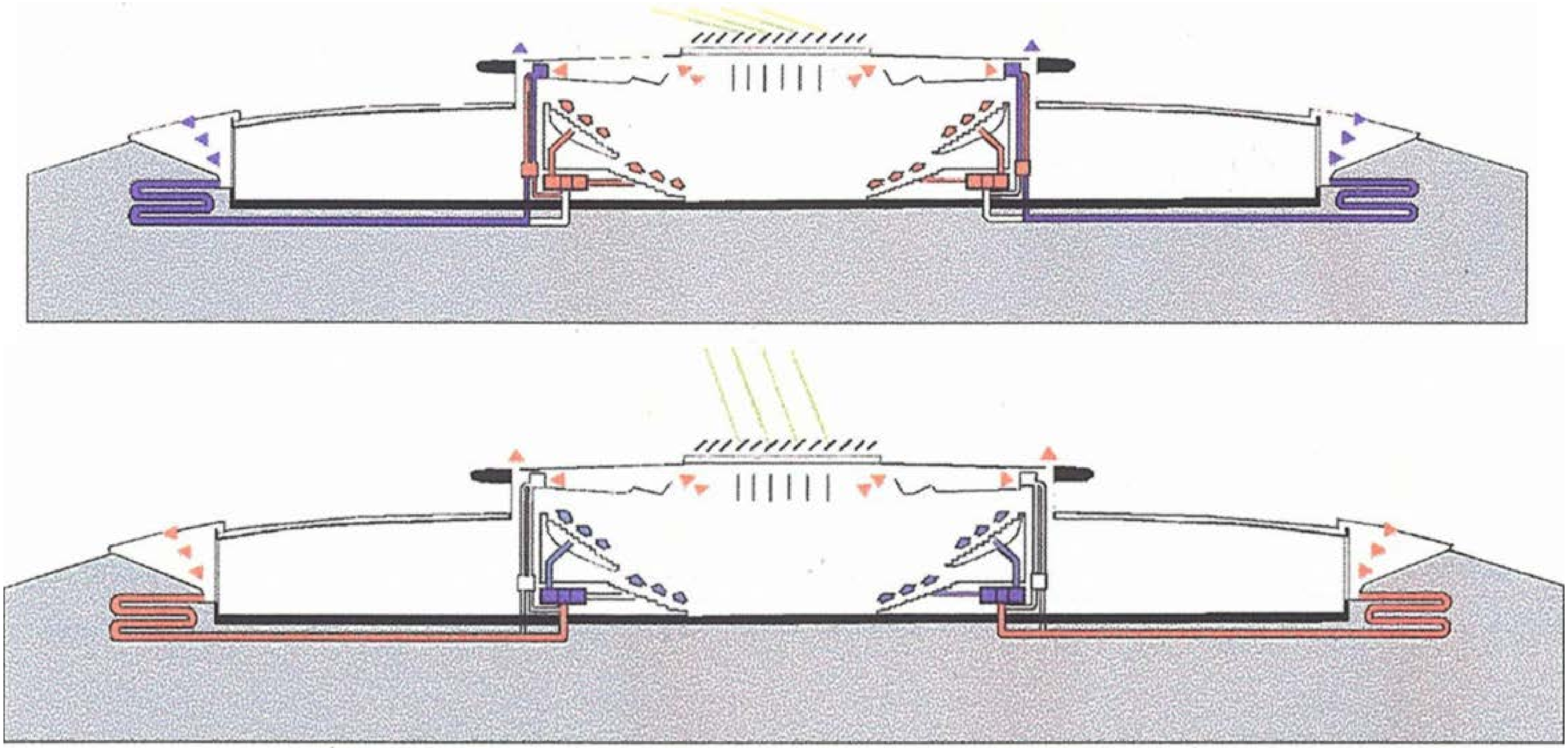


Photo: Sebastian Greuber – Max-Schmeling Halle, Berlin

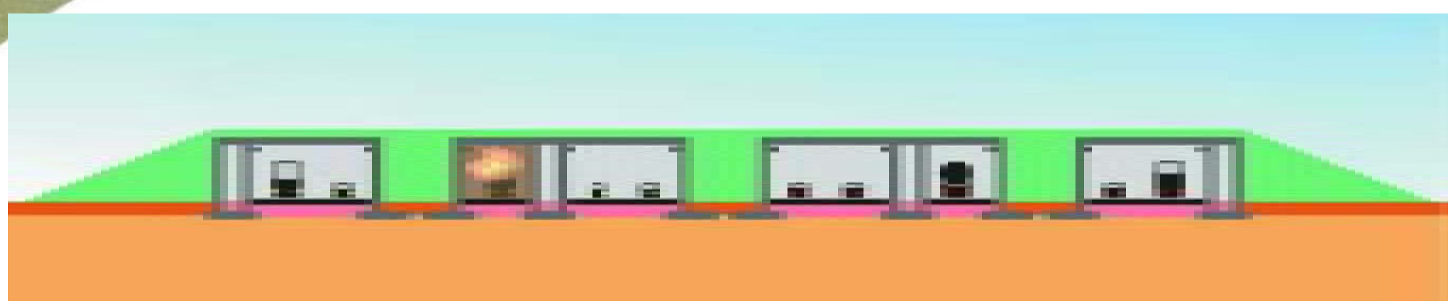
Max-Schmeling Halle, Berlin



Drawing: Jörg Joppien

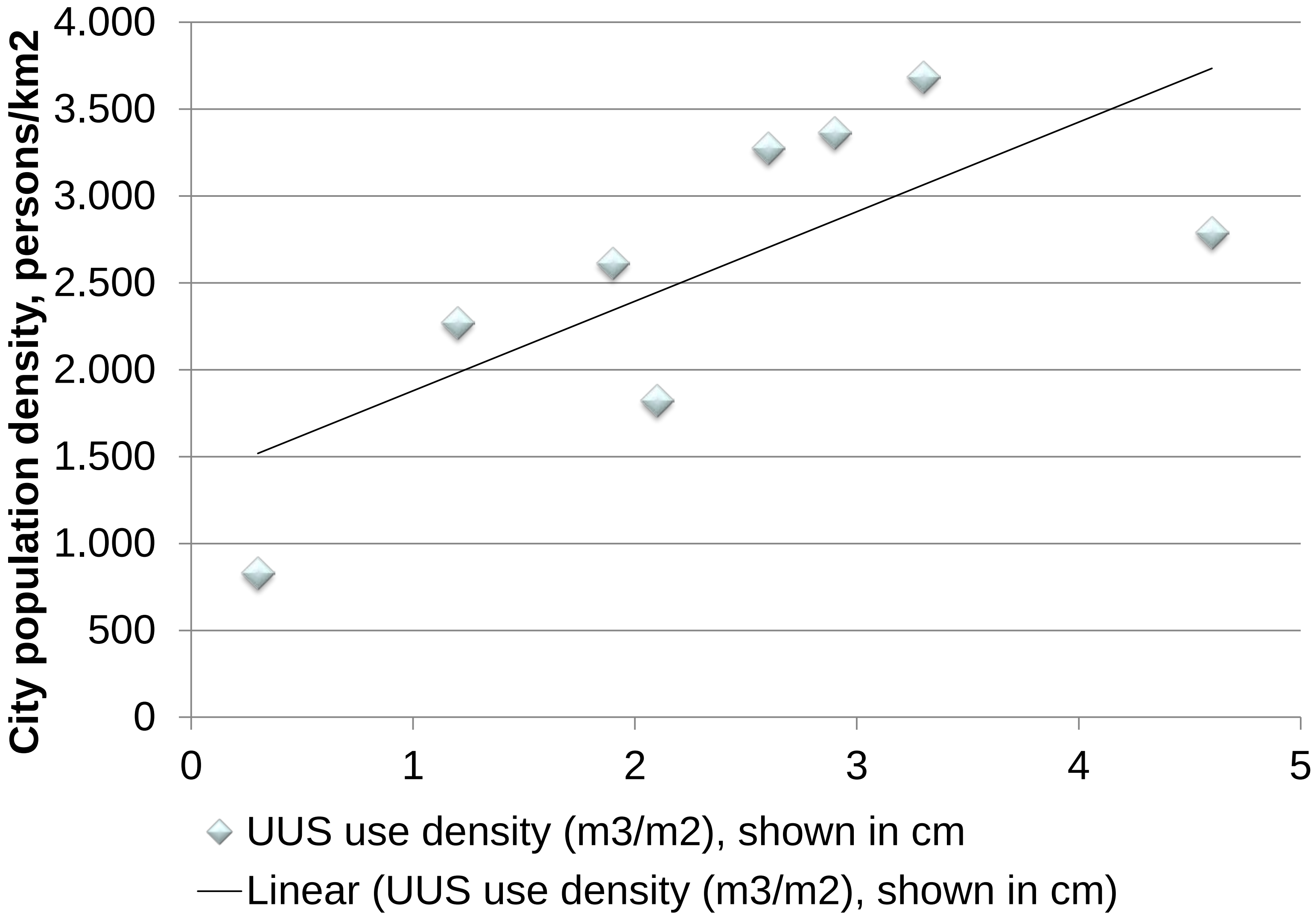
Urban Underground Space Resources Use for Mitigation of Climate Change

The Landtunnel Utrecht at Leidsche Rijn, Utrecht



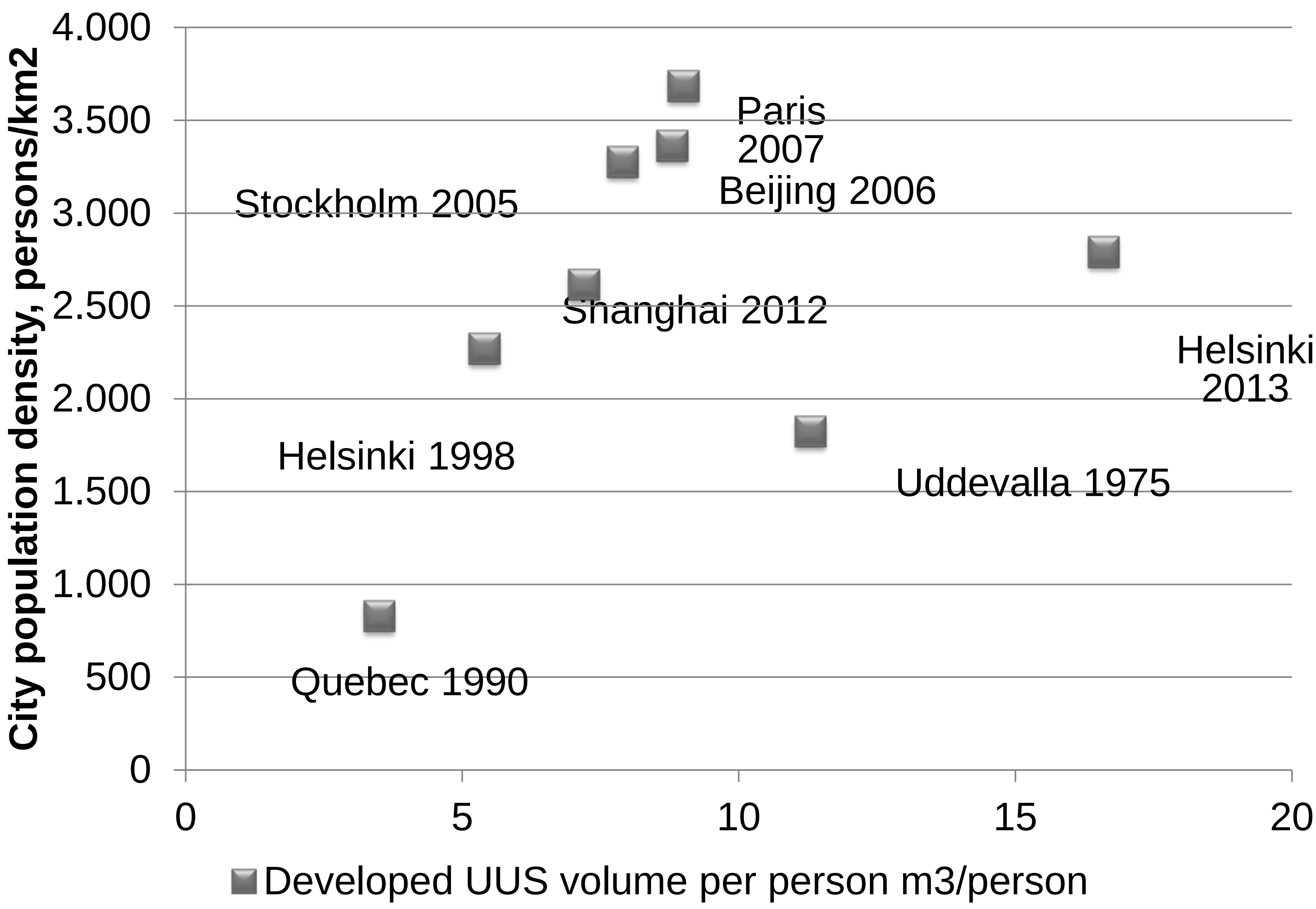
Source: Frank van der Hoeven, 2010. Landtunnel Utrecht at Leidsche Rijn: The conceptualisation of the Dutch multifunctional tunnel. Tunnelling and Underground Space Technology, Volume 25, Issue 5, September 2010, Pages 508-517

UUS statistics



Source: Bobylev, N (2016) Underground Space as an Urban Indicator: Measuring Use of Subsurface. Tunnelling and Underground Space Technology, Elsevier. Volume 55

UUS statistics



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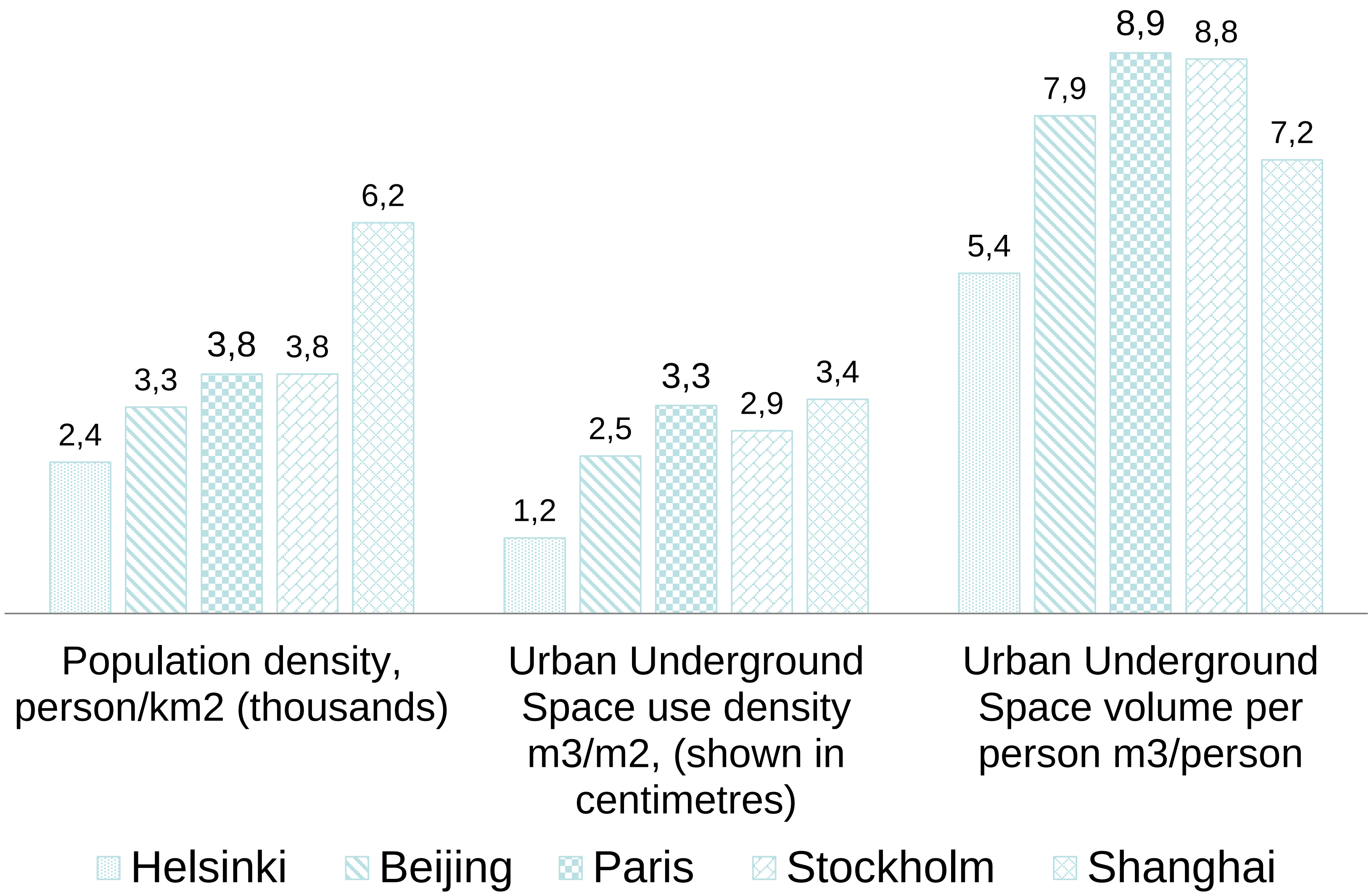

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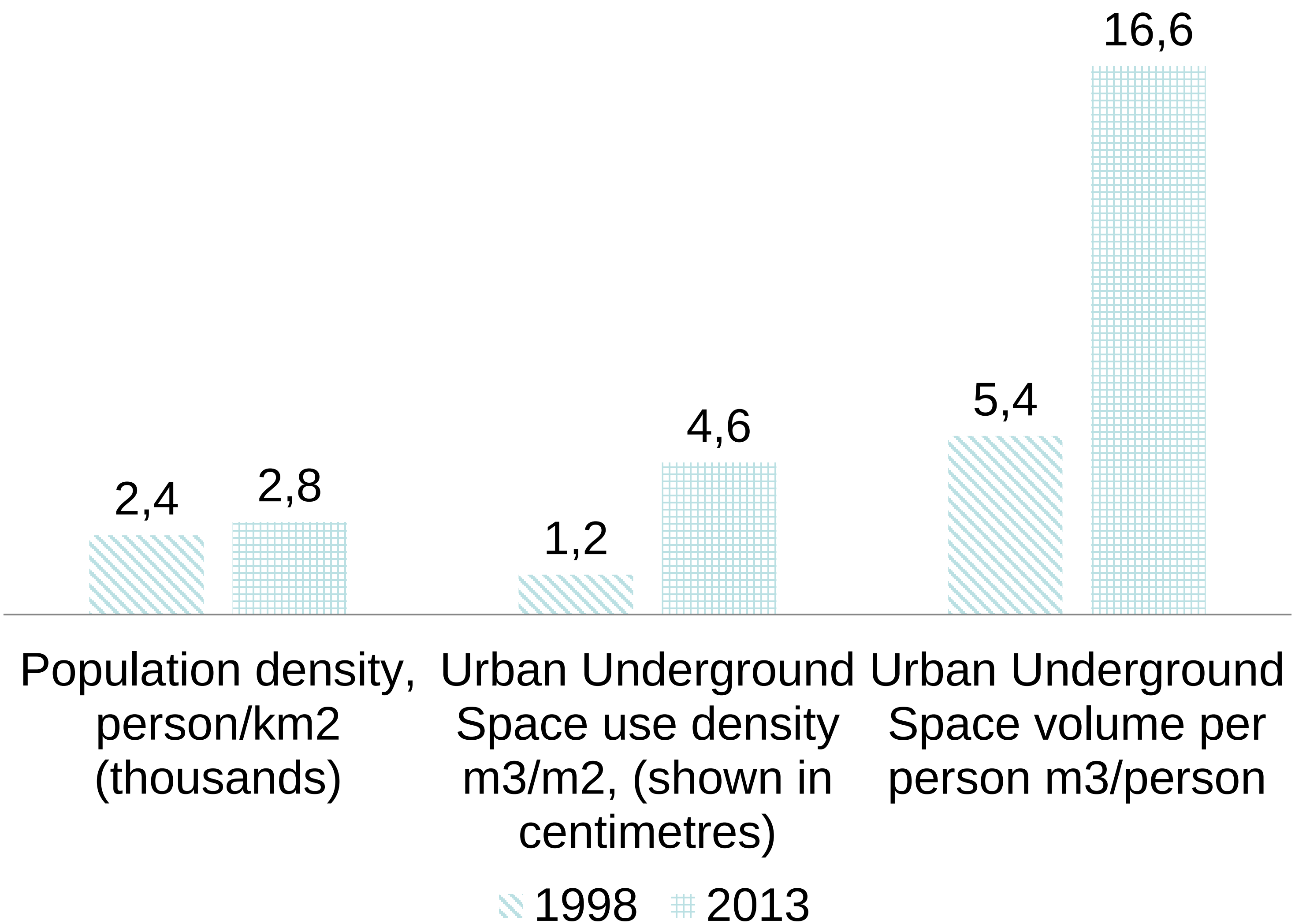

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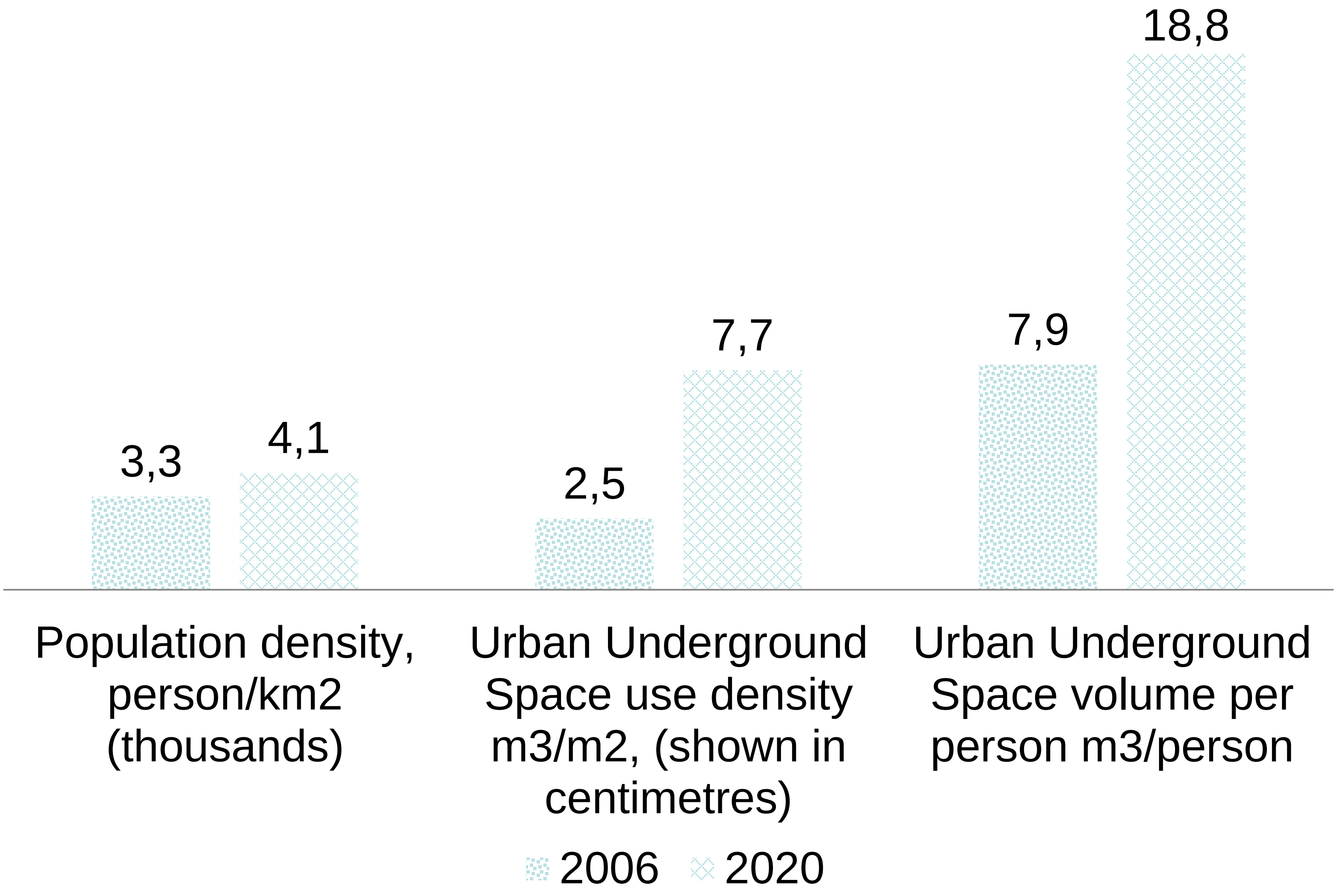

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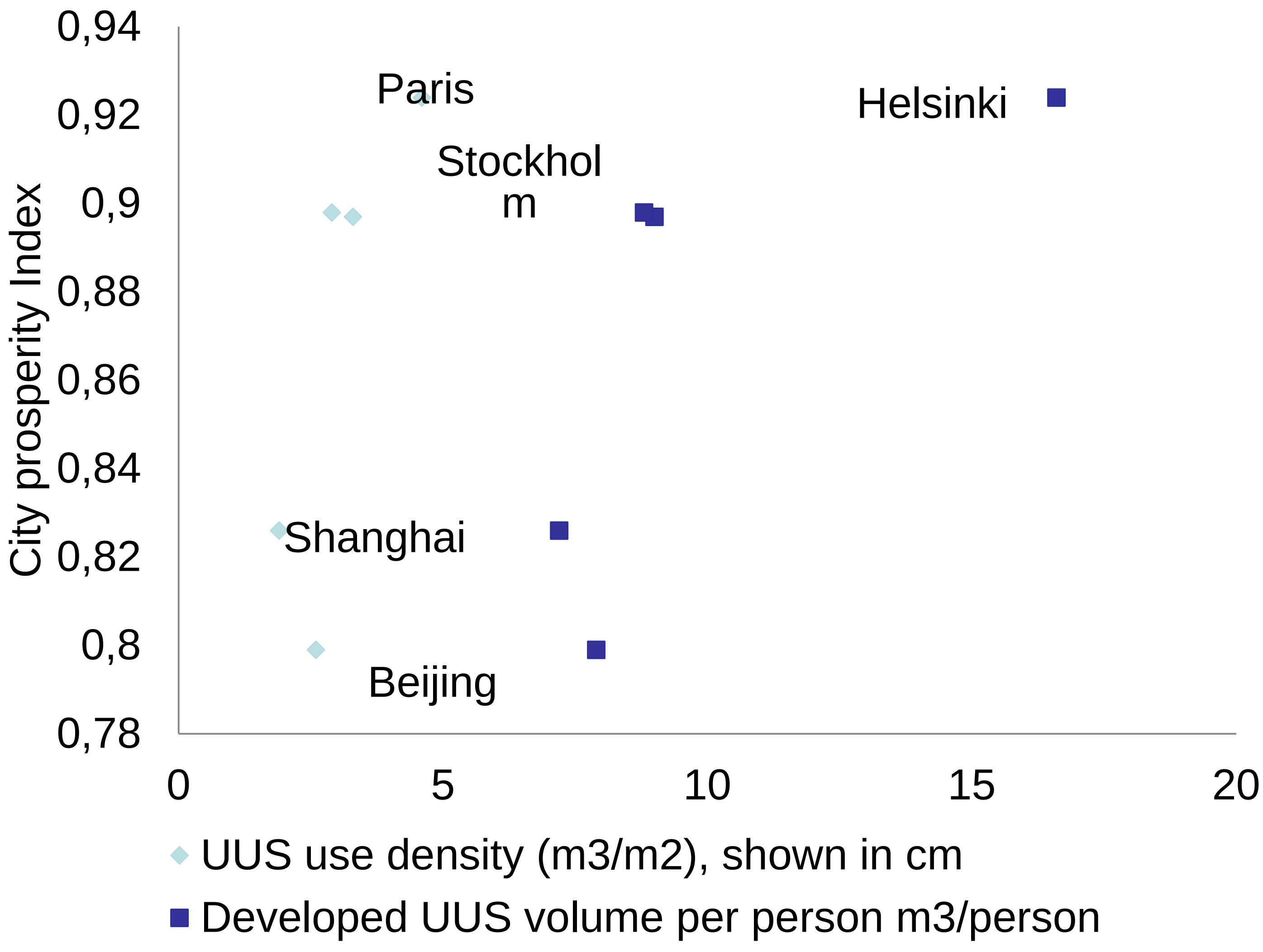

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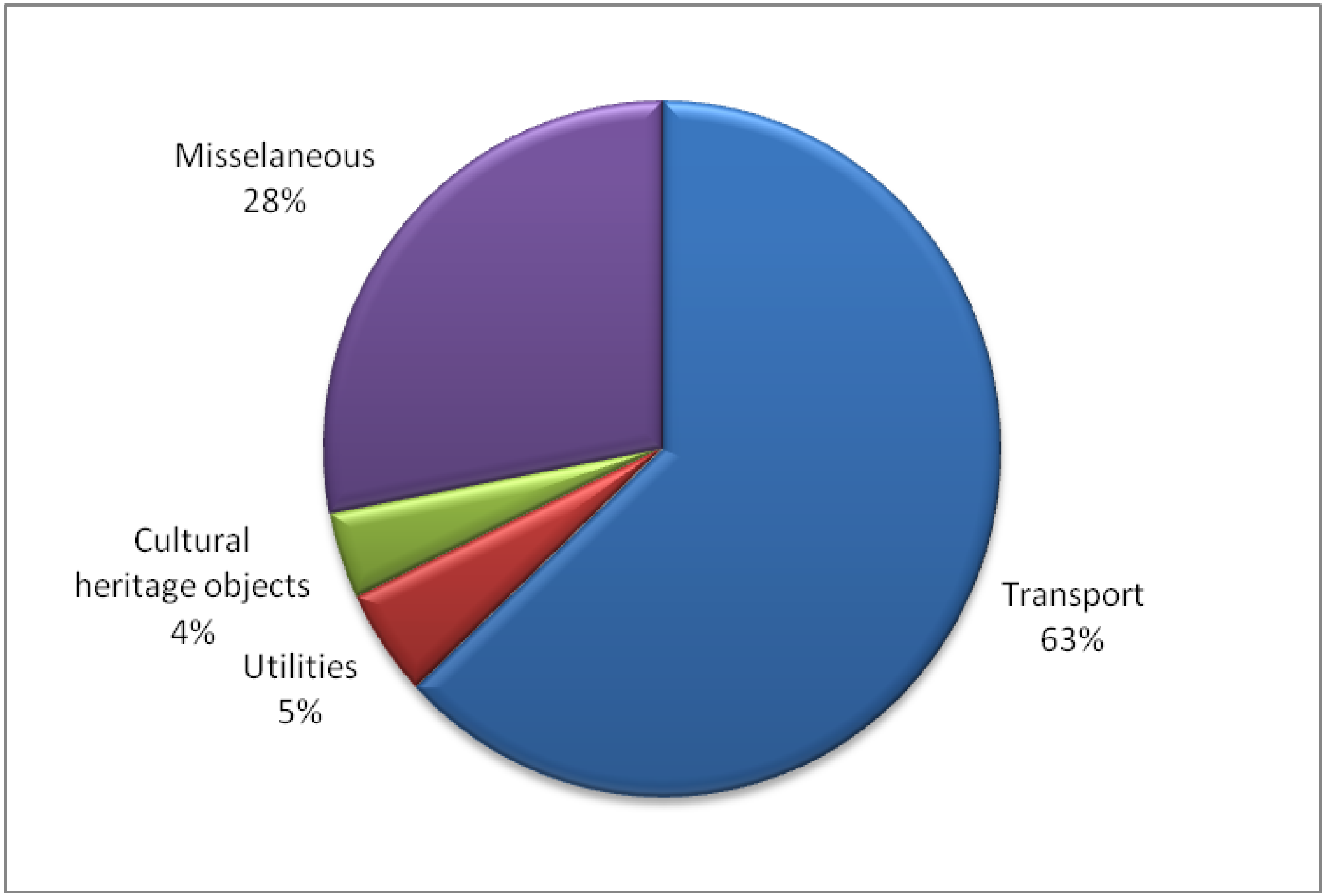
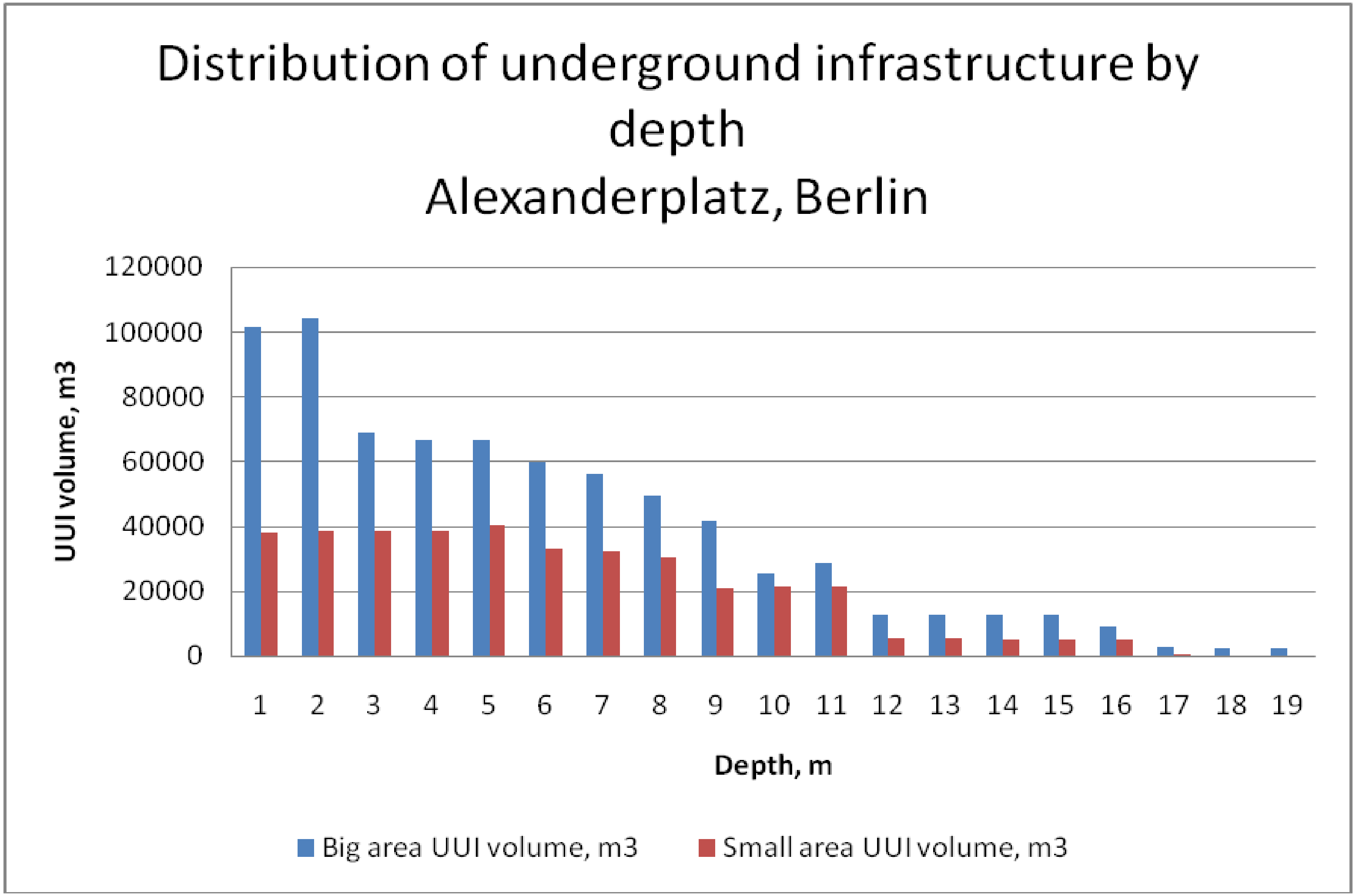
UUI state-of-the-art: Berlin

Analytical estimation of urban underground space use by function (Berlin, Alexanderplatz)



Source: Bobylev, Nikolai (2010) Underground Space Use in the Alexanderplatz Area, Berlin: research into the quantification of Urban Underground Space use. Tunnelling and Underground Space Technology, Elsevier, 31p

Quantification & statistics on UUI



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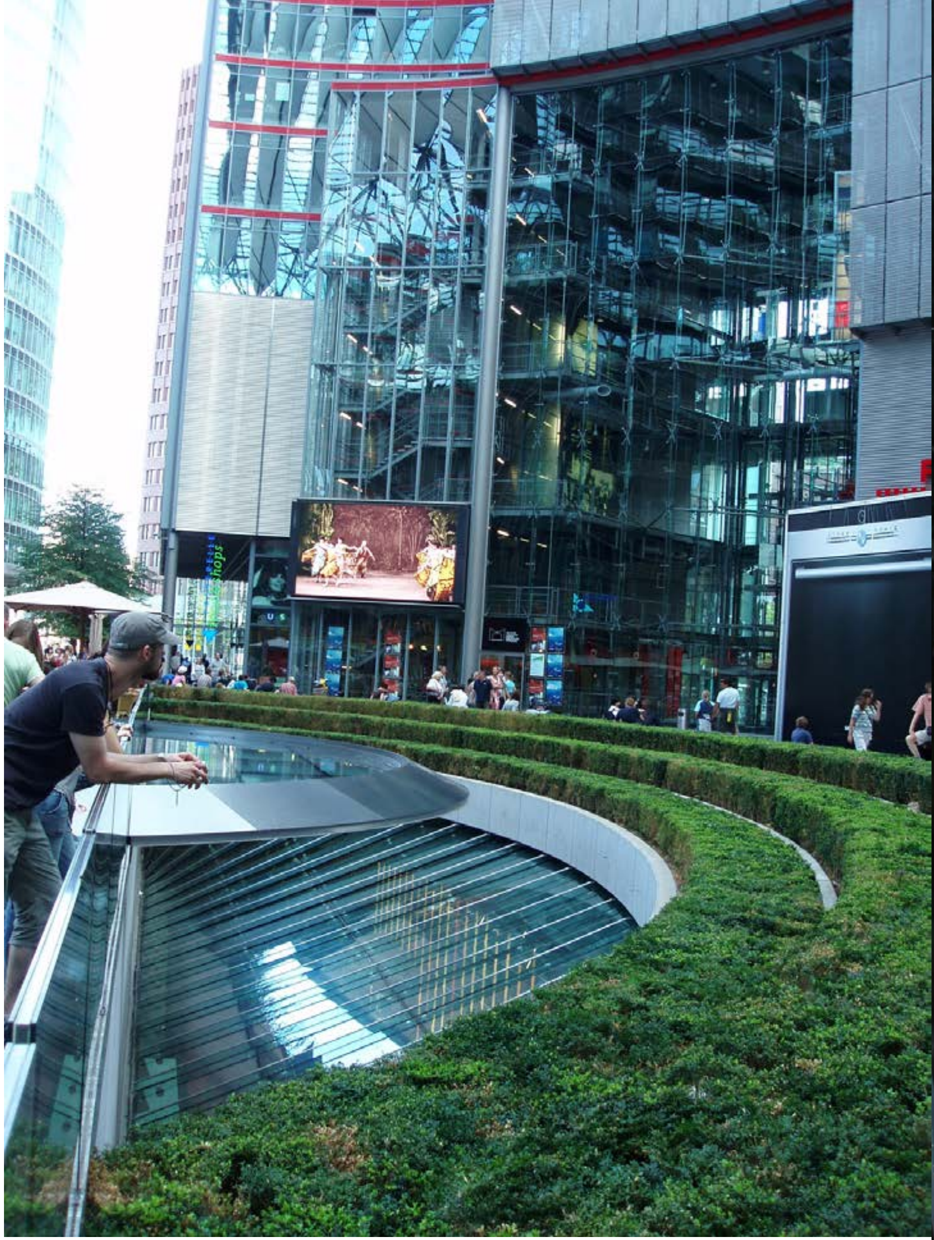


Berlin, Potzdamer Platz & Sony Centre;
Tokyo, Shiodome
Photo: Nikolai Bobylev

Policy Summary

Cities: addressing Sustainability, Resilience

Cities: addressing Global Environmental Change (and climate change)

Cities: Overarching goal: Quality of Life?

Cities: green, *sustainable, liveable, smart, climate-neutral, resilient*

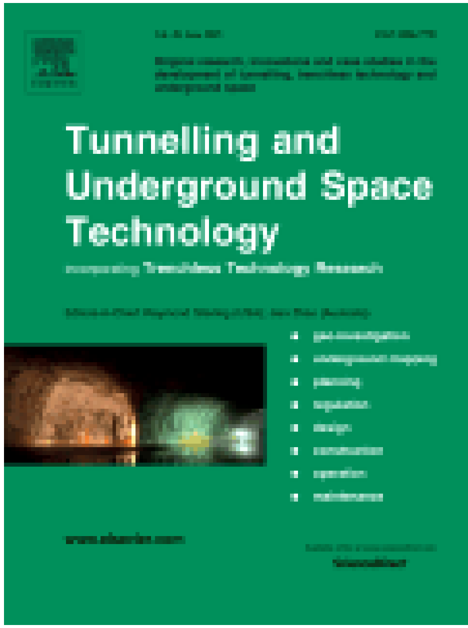
Key policies:

-urban density and efficiency

-master planning, 3D planning, democratic, expert-based, ~~political,~~ coherent with other policies

Tunnelling and Underground Space Technology, Elsevier
Special Issues 2015-2016

Tunnelling and Underground Space Technology
incorporating Trenchless Technology Research
Editor-in-Chief: Jian Zhao
5-Year Impact Factor: **1.833**



http://www.journals.elsevier.com/
tunnelling-and-underground-space-technology/

Special Issues

The Emergence of Underground Space Use Planning and Design
Virtual Special Issue from Underground Space (1976—1985)

Improvements in Underground Space Utilization and Planning
Virtual Special Issue (1986 – 2014)

Urban Underground Space: A Growing Imperative
Perspectives and Current Research in Planning and Design for Underground Space Use (2016)

Main themes 2016

Urban Underground Space: A Growing Imperative. Perspectives and Current Research in Planning and Design for Underground Space Use

Sustainability, Resilience, Livability, Urbanization, Futures, Urban development concepts

Resources use, energy, land use, user competition, conflicts of interest

City planning, master plans, zoning, functional use, city case studies

Social sciences perspective: governance, administration, management, institutions, stakeholders, professionals, education, disciplines, policy and legal

Data, analysis, and tools: statistics, quantification, valuation, 3-dimentional mapping, GIS, decision analysis, economics

Human perspective: Architecture, interior design, health, ergonomics, psychology

Special and distinct issues: civil defense, disaster reduction, renewal, rehabilitation, redevelopment, environmental protection

Tunnelling and Underground Space Technology, Elsevier
Special Issues 2015-2016

Cities in UUS research

references

Projects:

Bobylev & Jefferson: Sustainable Infrastructure for Resilient Urban Environments (SIRUE) 2012 – 2015. European Comission FP7 PIIF-GA-2010-273861 http://cordis.europa.eu/projects/rcn/100003_en.html

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Photo credits:

Nikolai Bobylev;

Berliner Wasserbetriebe and Berlin Institute of Technology;

G-Cans, Tokyo (http://www.g-cans.jp/).

Alexander von Humboldt Stiftung/Foundation

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ITA global perspective
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