






Sustainability Assessment of Urban Systems

(ENV-461) – BS 170

2: Sustainability issues in urban systems

Lecturers:

Prof. Dr. Claudia R. Binder

Dr. Matthias Heinrich

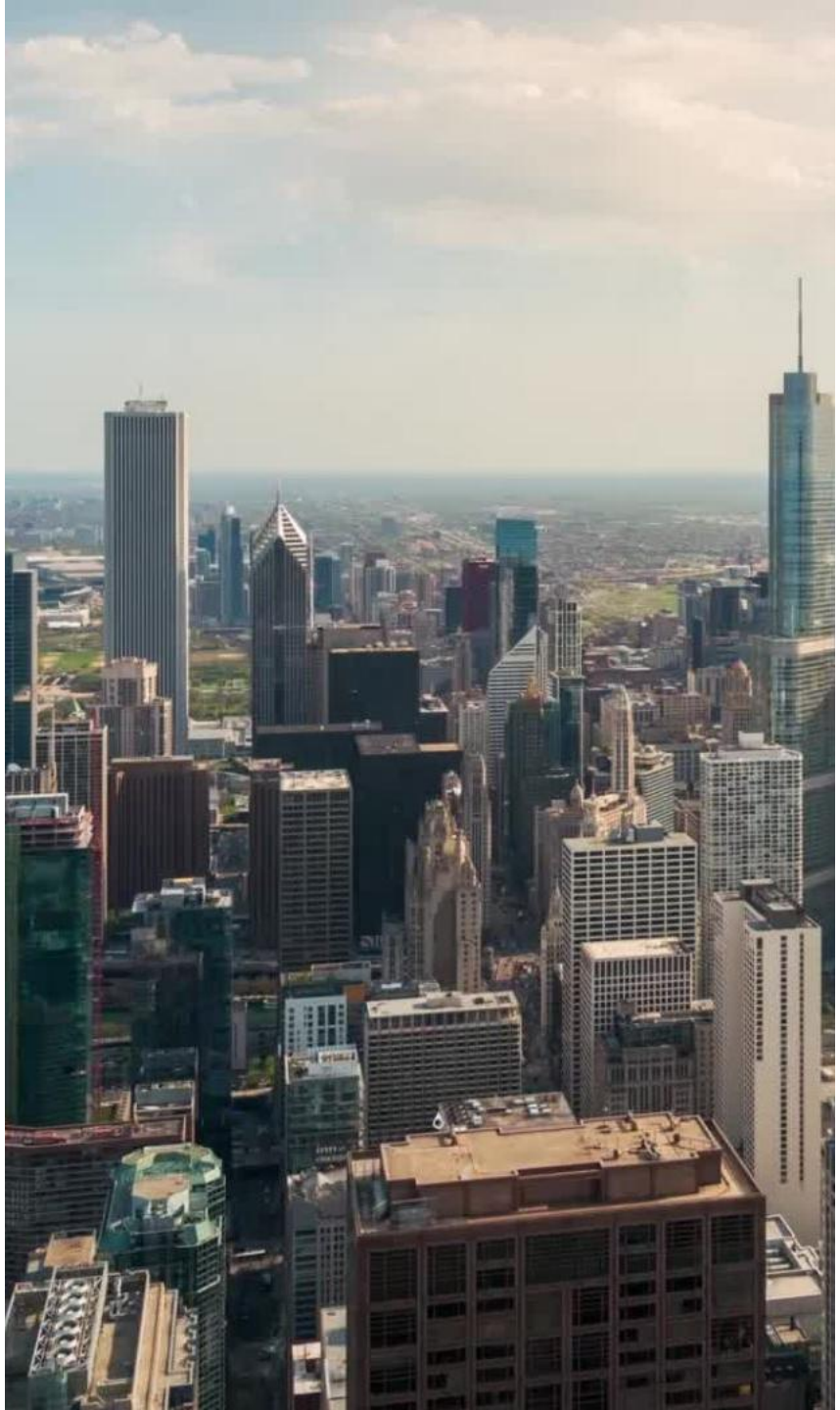
Assistants:

Ankita Singhvi, Giulia Frigo, Simon Ladino Cano, Hanbit Lee

Thank you for your expectations!

- From this course I would like to learn **how to use properly different sustainable models** in applied cases. In addition I would like to have an **overview of the environmental regulations** in Europe and Switzerland
- Learning **how to apply sustainability assessment methods to urban systems**, focusing on analytical tools, interdisciplinary collaboration, and policy recommendations to address sustainability challenges in cities.
- **Learning more about sustainable potential in urban areas**
- I expect to learn **the steps to create a complete sustainability assessment** and **be able to use** them in different scenarios

Short feedback on the last lecture



Goals of this lecture

- To get an understanding of the group project
- To understand what a city is, and which elements are necessary for its definition
- To get insights into the key problem areas of cities

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Group project

In a few words…

- Each group will (i) evaluate and compare the sustainability of **4 cities**; and (ii) report the results of their assessment in the form of an **oral presentation** AND a **poster.**

- The students will utilize the **concepts and tools presented during the lectures**

- Group size: 3-4 students

The project steps

Step 1: Group formation

Due on 05.03.2025

Step 2: Outline submission

Due on 19.03.2025 before 13:00

Step 3: Poster submission

Due on 16.05.2025 before 18:00

Step 4: Poster presentation

In-class 21 **and** 28.05.2025

Step 5: Critical assessment

Due on **30.05.2025 before 18:00**

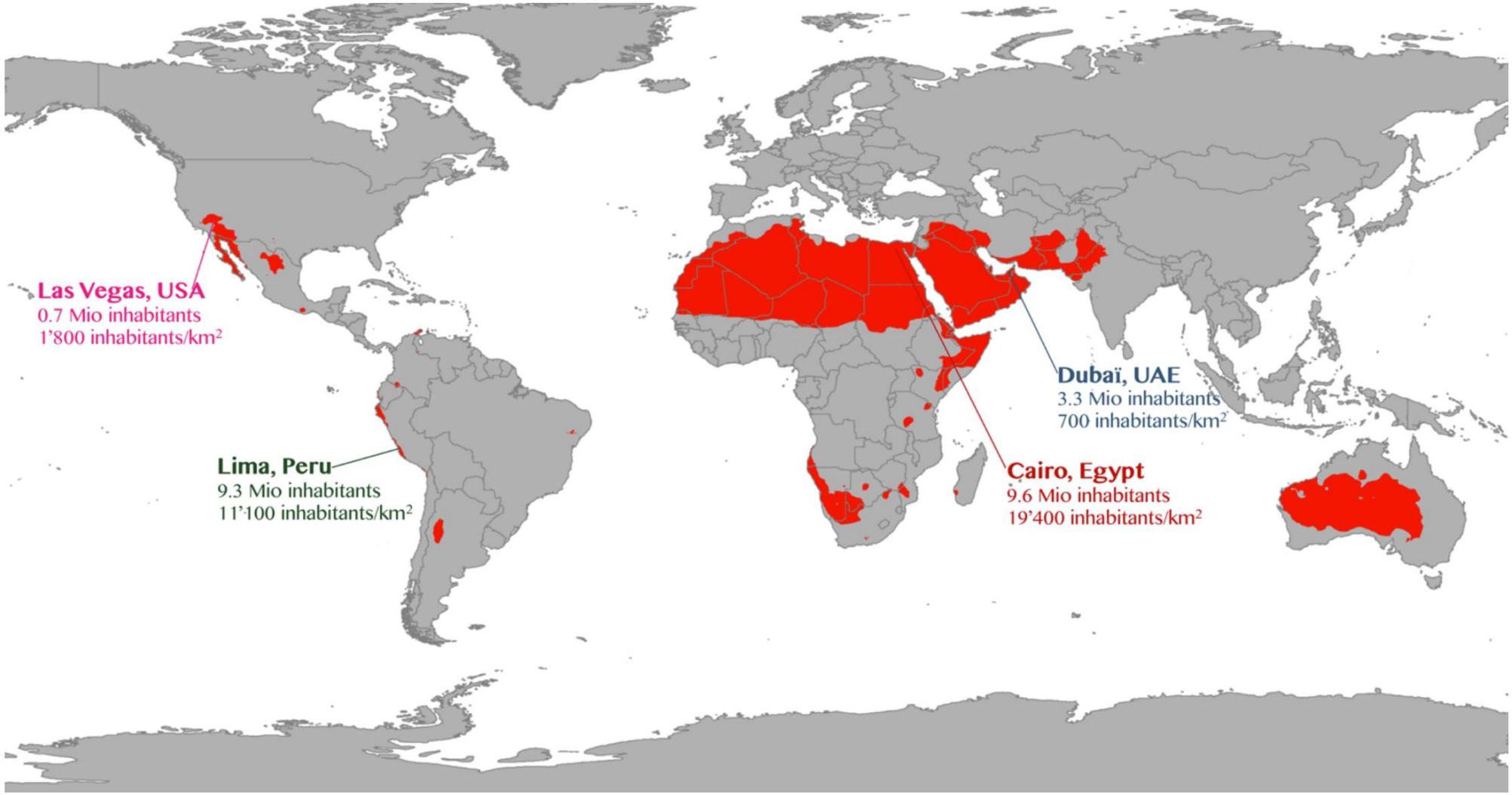
Key tasks expected from students

- **select** 4 cities with common characteristics / problems;

- Examples :

Examples

… cities characterized by hot and dry climate



Source: student project 2020

Examples

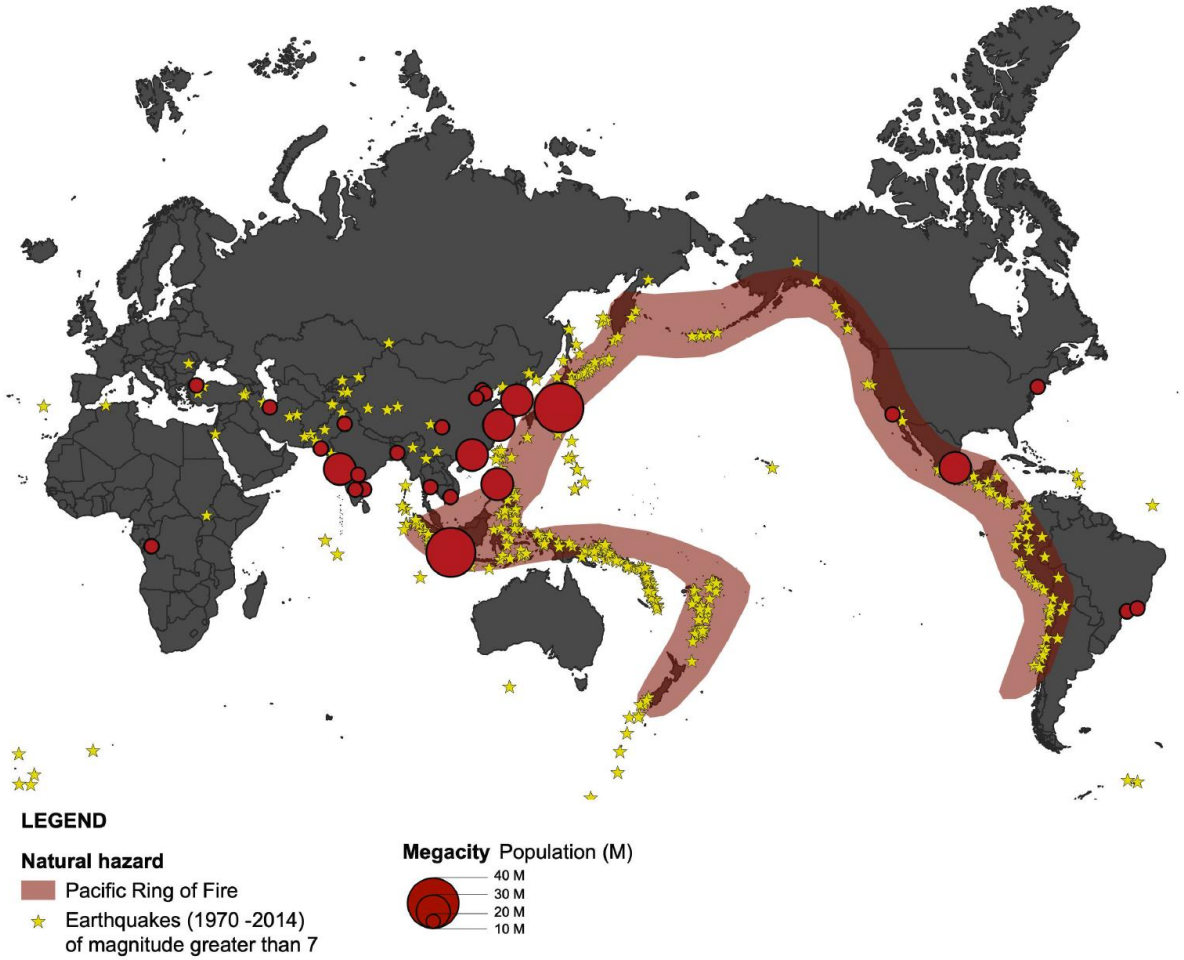


Figure 1: Map of the Ring of Fire, worldwide megacities and historical earthquakes' epicenter.

Source: student project 2021

Examples

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SAUS - 2021

Cold Cities G-7

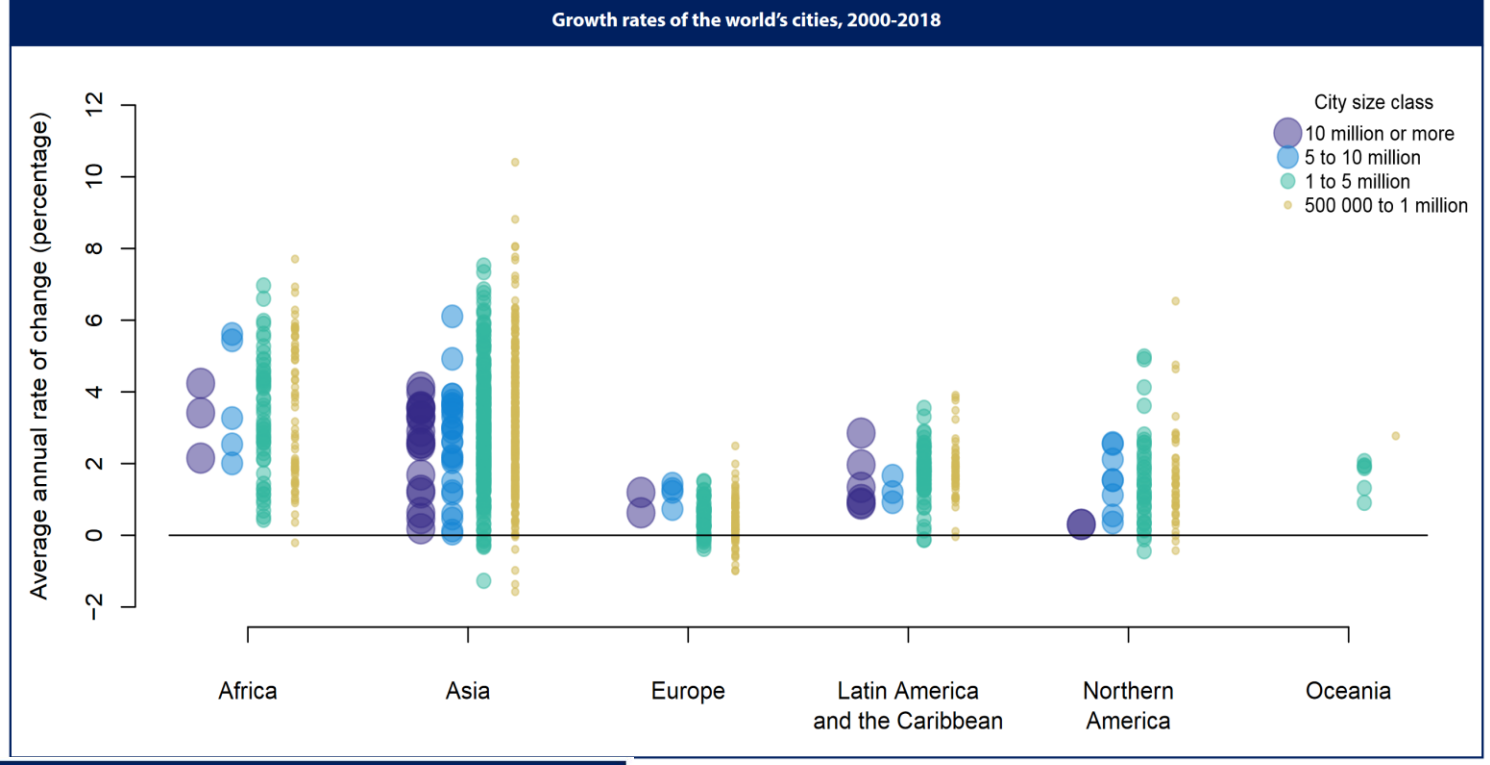
Cold Cities : Selection

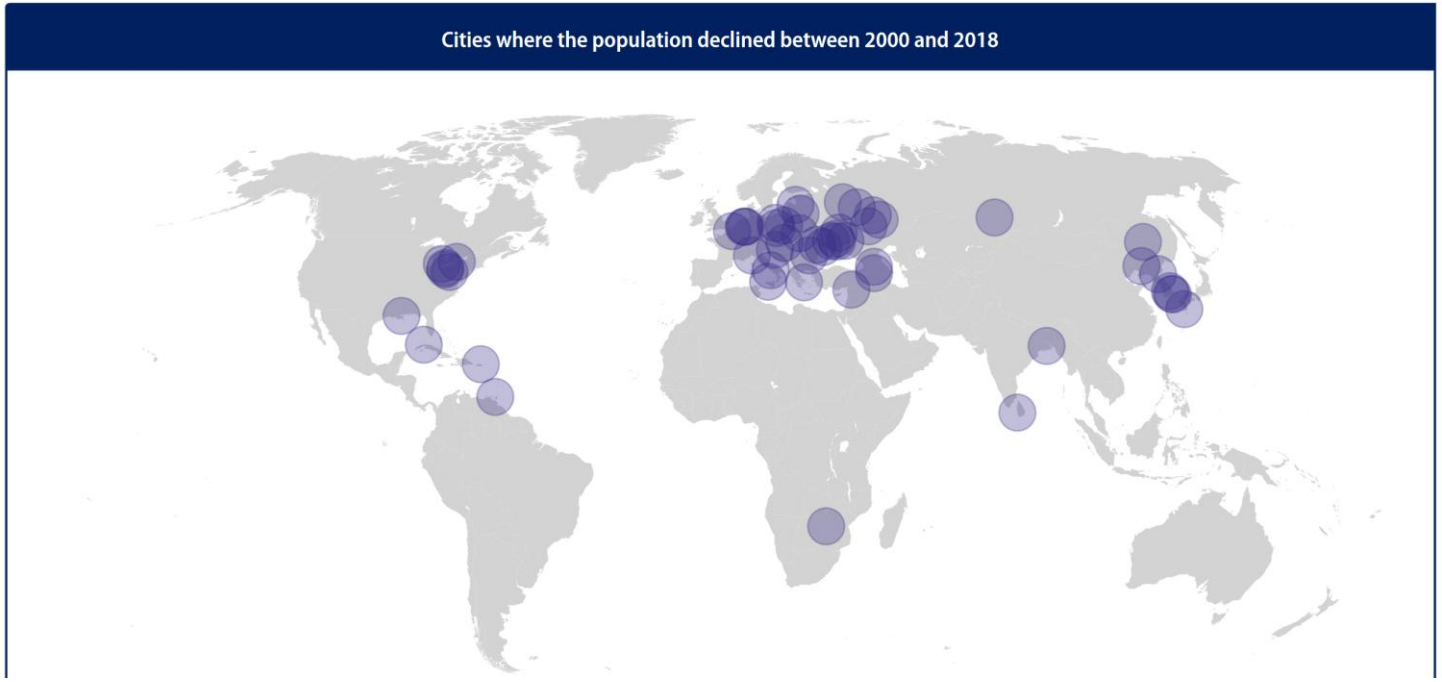
Country	Canada		Iceland		Russia		China	
Climat	Warm-summer humid continental climate		Subpolar Oceanic Climate		Borderline Subarctic Climate		Humid continental climate	
Population	727 500 hab.		131 136 hab.		623 562 hab.		10 635 971 hab.	
Size	464,08 km2		274 km2		301 km2		609 km2	
Altitude	+ 239 m		+ 0 m		+ 440 m		+ 150 m	
Main activity	Agriculture production		Tertiary activity		Agriculture production		Agriculture production	
Temperatures	Min m : −17.9°C Max m : 26.7°C	Min : -47.8°C Max : 42.2°C	Min m : -3°C Max m : 14.2°C	Min : -19.7°C Max : 25.7°C	Min m : −21,8°C Max m : 24,8°C	Min : −49.7°C Max : 37.2°C	Min m : −22.9°C Max m : 27.8°C	Min : −38.1°C Max : 39.2°C

Source: student project 2021

Examples

Fast growing cities …





… or shrinking cities

Source: UN 2018

Key tasks expected from students

- **select** 4 cities with common characteristics / problems;
- **identify** the key sustainability issues in the selected cities;
- **formulate** a *research question* that the assessment will provide an answer to;
- **select a definition of sustainability** and translate it to the study context;
- **develop a conceptual framework** that translates the identified issues into goals, organised according to the identified dimensions of sustainability;

Key tasks expected from students

- …
- **identify a list of potential indicators** relevant for the sustainability issues present
- **display the interrelationships** between the selected indicators;
- **collect data** for the selected indicators using and enriching the SA course database;
- **apply a multicriteria approach** to compare the cities;
- **perform** a **sensitivity analysis**;
- **interpret the results** and make recommendations to policy makers and/or scientists working in the field of sustainability

Lecture programme

Lecture 1	• Introduction
Lecture 2	• Sustainability in urban systems
Lecture 3	• Key dimensions in SA #1: Procedural
Lecture 4	• Key dimensions in SA #2: Normative
Lecture 5	• Key dimensions in SA #3: Systemic
Lecture 6	• Deriving indicators
Lecture 7	• Mid-Term Exam
Lecture 8	• Influence matrix
Lecture 9	• Multi-Criteria Analysis
Lecture 10	• SA in practice
Lecture 11	• Policy implications
Lecture 12	• Working session
Lecture 13	• Group presentations (projects)
Lecture 14	• Group presentations (projects)

Elements of sustainability assessment

Understanding sustainability	• How do we conceptualize sustainability? • What are different sustainability issues?
Research problematique	• What is the problem? • What is the context of the problem? • What do we want to achieve?
Planning the phases	• What steps are required in the SA? • Who is involved in the process, how, and at which stage?
System analysis	• What are the boundaries of the system? • What are the components and (causal) connections within the system?
Derivation of indicators	• Derive indicators for the system model • Design an influence matrix
Performing the assessment	• Find, analyze and evaluate data • Analyze trade-offs with multi-criteria assessment
Critical reflection	• Reflect on your process, choices, results and potential for practice • Get feedback from experts

Outline writing

- Each group must submit a 2-page outline (excluding the bibliography) for review by supervisors
- **General motivation for the study**
- **Selection of cities for comparison**
- **Research question**
- **Definition of a "sustainable city" assumed for the study**
- **Conceptual framework**
- **Bibliography**

➔Guidelines are provided on Moodle

➔Submission format : **GroupX_outline.pdf**

Milestones for group projects

- **Formation of groups: 05.03.2025 before 13:00**
  - Form groups (4 students per group)
  - Choose the type of cities (common characteristic) you want to assess
  - Select four cities representing the type of cities chosen

→ **Fill in the excel sheet ON MOODLE**

- **Outline: 19.03.2025**
- **Submission of posters 16.05.2025**
- **Presentation: 21.05.2025 - 28.05.2025**

Objectives of Week 2

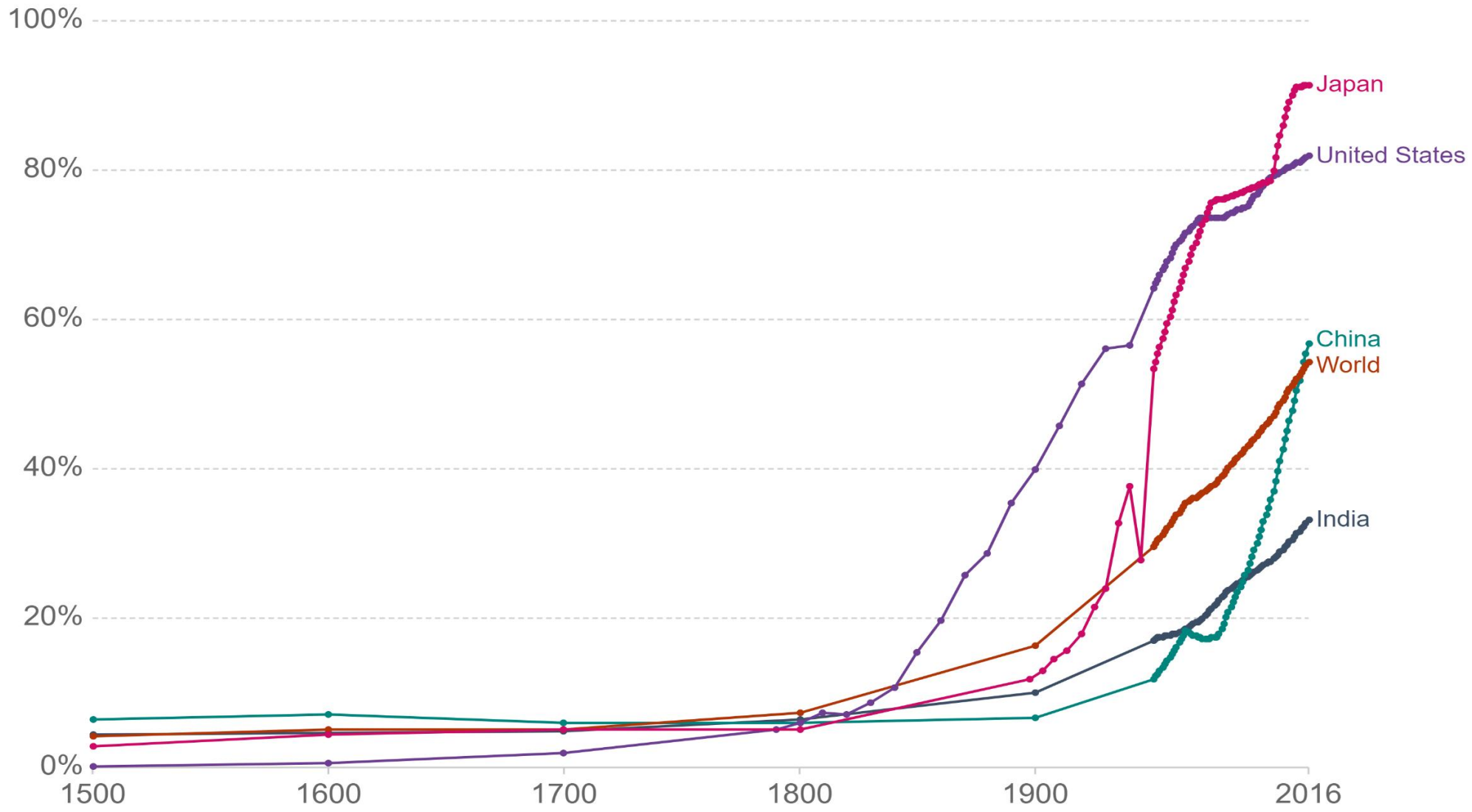
- Learning about
  - **city definitions** and different **types** of cities
  - **city characteristics**
  - cities' **impact** on **climate**
  - various **sustainability issues** in cities

Defining cities

- **How do we define a city ?**
- **What are the trends of urbanization ?**
- **How does the definition of the cities impact their sustainability assessment ?**
- What are the sustainability issues affecting cities ?

Urbanization over the past 500 years, 1500 to 2016

Share of the total population living in urban areas.



Source: OWID based on UN World Urbanization Prospects 2018 and historical sources (see Sources) OurWorldInData.org/urbanization • CC BY
Note: Urban areas are based on national definitions and may vary by country.

Defining cities : An intuitive approach

Torino, 1674

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An intuitive definition of cities

What are the key characteristics of a city ?

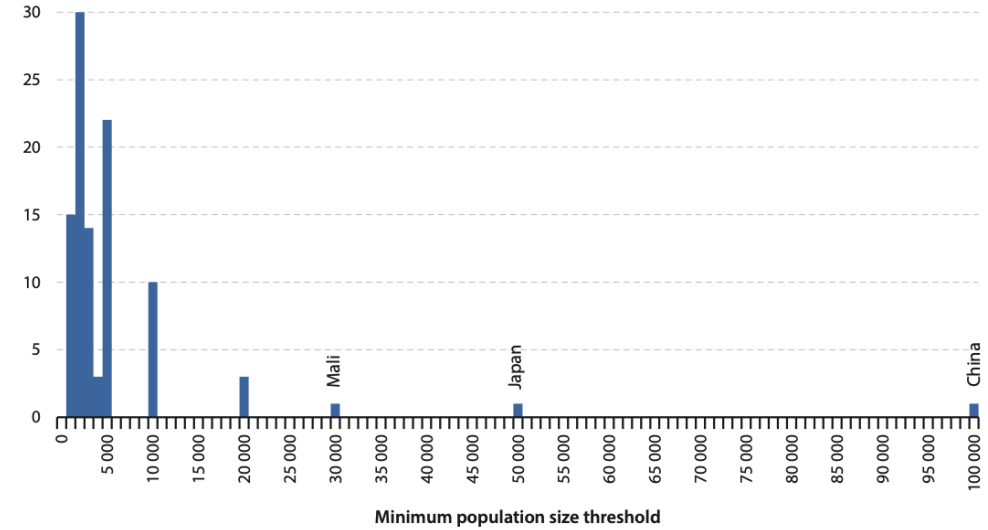
An intuitive definition of cities

- At first sight defining a city may be easy :
- **There are densely populated areas !**

Defining city with a statistical perspective

Statistical-administrative concept:
cities are determined using an inhabitant threshold value, i. e. a

- **minimum number of inhabitants**, and relates to the population within certain administrative boundaries (Fassmann, 2009: 43 and Gaebe, 2004: 19); threshold varies between countries, e.g.
  - 200 inhabitants (Iceland)
  - 2,000 inhabitants (Germany)
  - 10,000 inhabitants (Switzerland)
  - 50,000 inhabitants (Japan)
  - 100,000 (China)
  - …



Source: UN World Urbanization Prospects

- **minimum density**, for example, more than 1,500 inhabitants per km2 (UN Statistical Commission, 2020)

Defining cities : Toward a multifaceted approach

Torino, 1674

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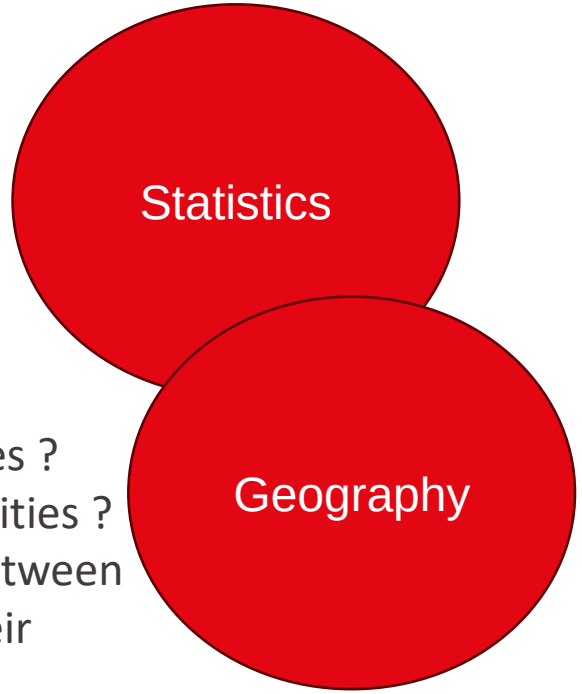
The multifaceted definition of cities

How many inhabitants ?
Which density ?

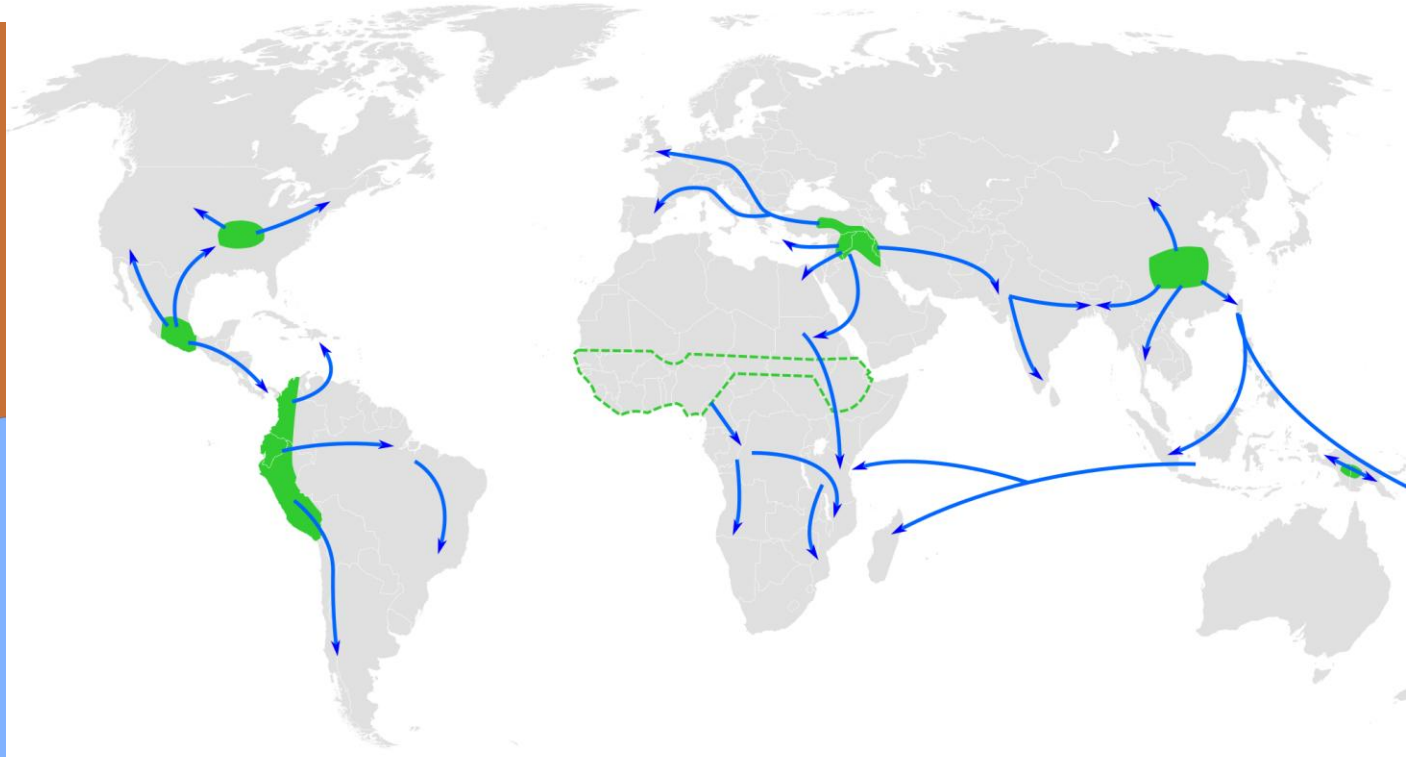


What are the legal boundaries ?
What are the natural specificities ?
What are the connections between the so called «cities» and their envionment ?

Geography of cities : Cities as key locations

The growth of cities worldwide is (…) influenced by **the natural location, the availability of resources,** demographic structures, local or national economies, political systems and infrastructures. (WBGU, 2016)

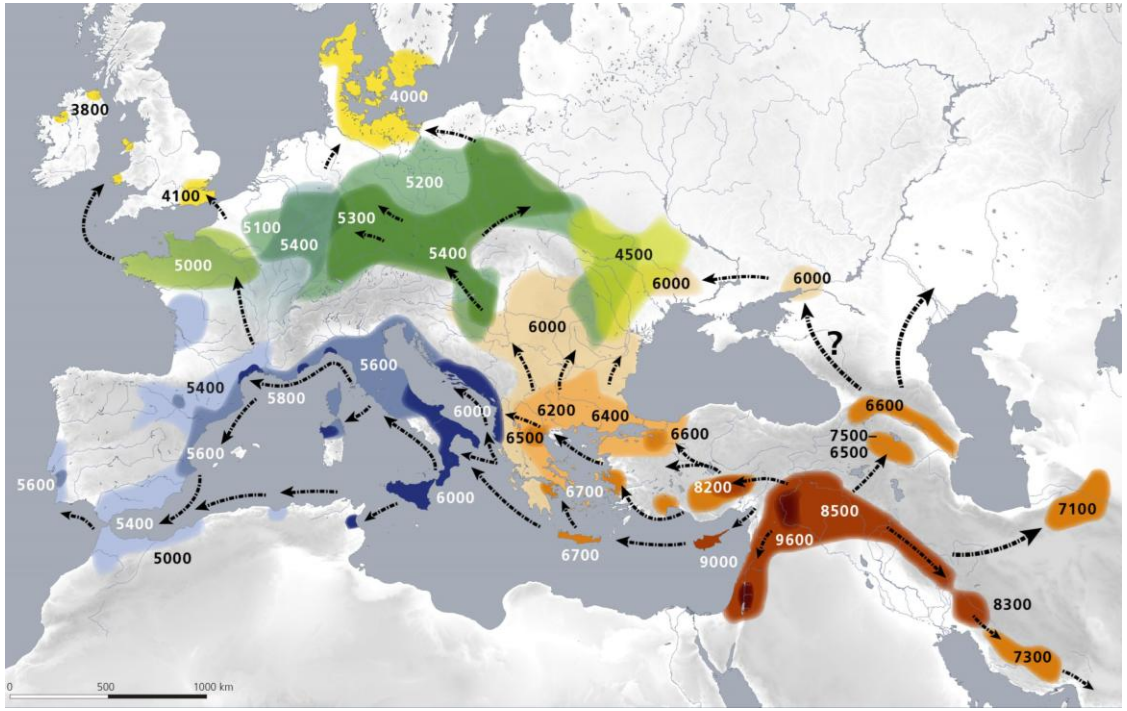
The Fertile Crescent
(Wikipedia, Astroskiandhike)



Approximate **centres of origin of agriculture** and its spread in prehistory
(Wikipedia, Joe Roe)

Geography of cities : Cities as marketplaces

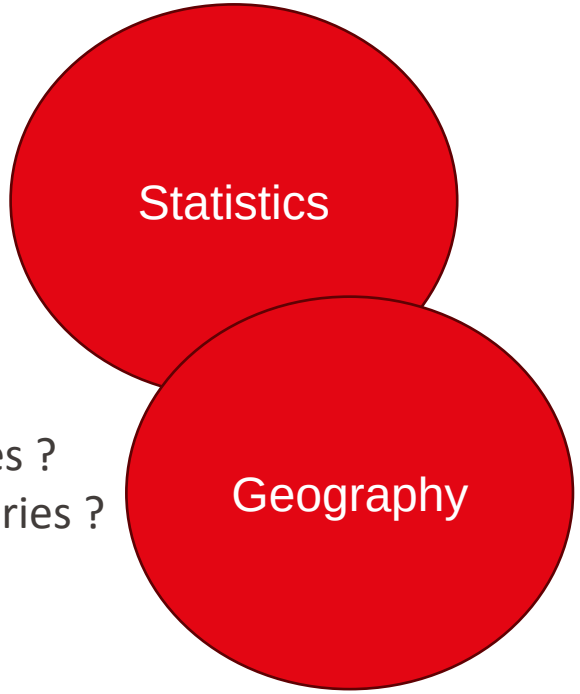
"This involved not only the possibility of practicing agriculture to meet basic needs. **Cities were marketplaces, nodes for the exchange of goods, and places of payment".** (Benevolo, 2010)



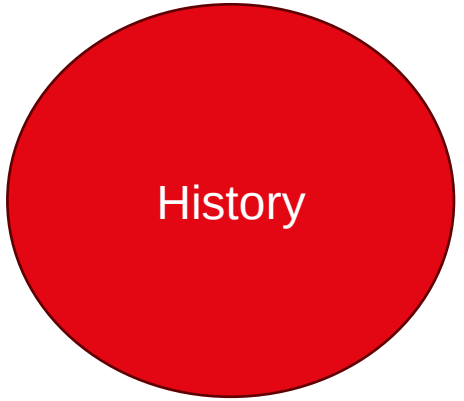
Spread of agriculture to Europe, between 9600 and 3800 BCE
(Horejs, Gronenborn, 2023)

The multifaceted definition of cities

How many inhabitants ?
Which density ?



What are the legal boundaries ?
What are the natural boundaries ?
How does the geographical context influence the city ?



What civilisations, cultures, events have influenced the development ?

Cities as places of social interactions

In the European context, we could highlight the **social innovation of inter-city trade,** and the "understanding of the city and urbanity as characterized **by the polis, with the agora or forum".** (WBGU, 2016)

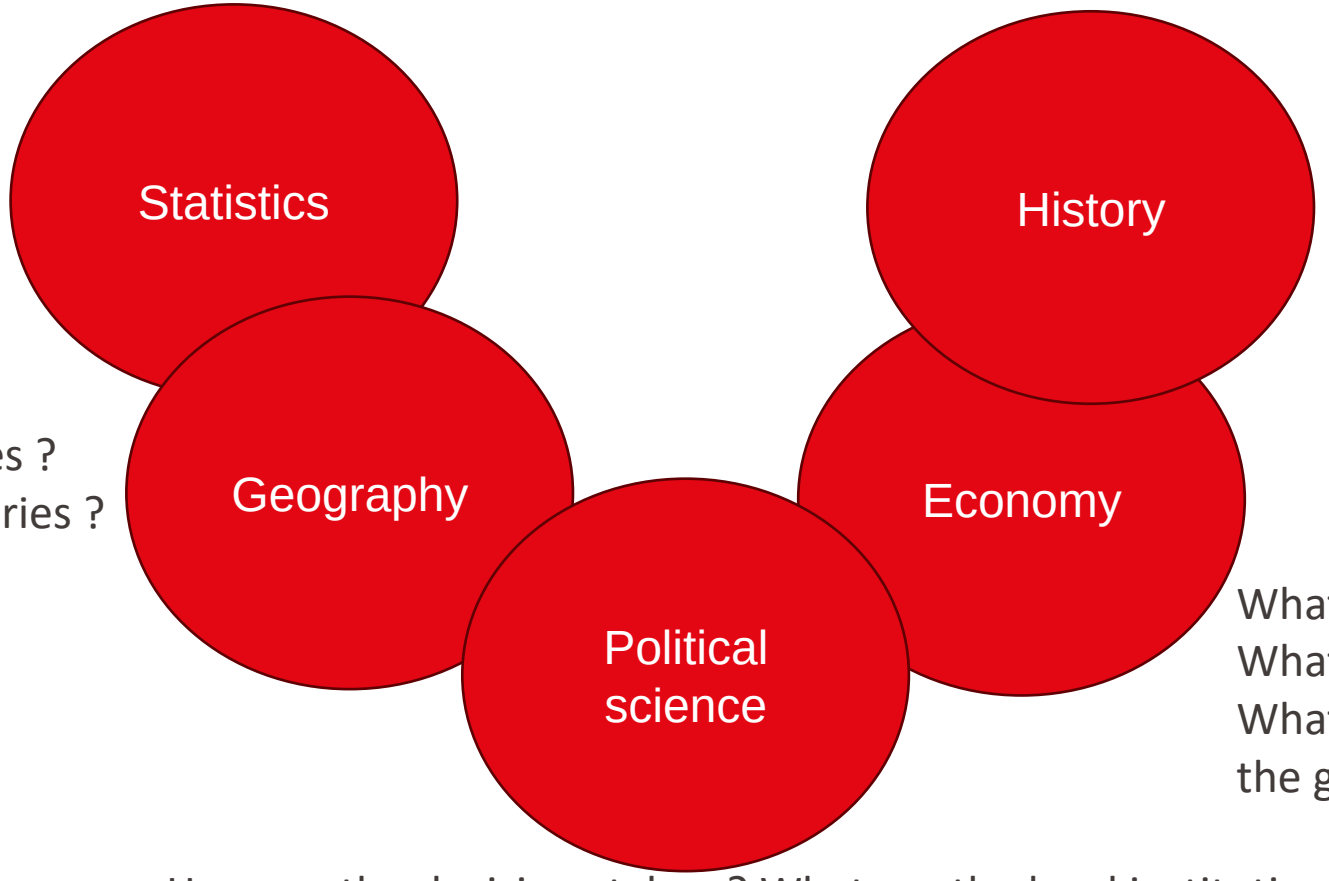
Merchant in Pompeii
(the-athenaeum.org)

the Forum, Pompeii
(Wikipedia, Giorgio Sommer)

Cities as places for infrastructures

The multifaceted definition of cities

How many inhabitants ?
Which density ?



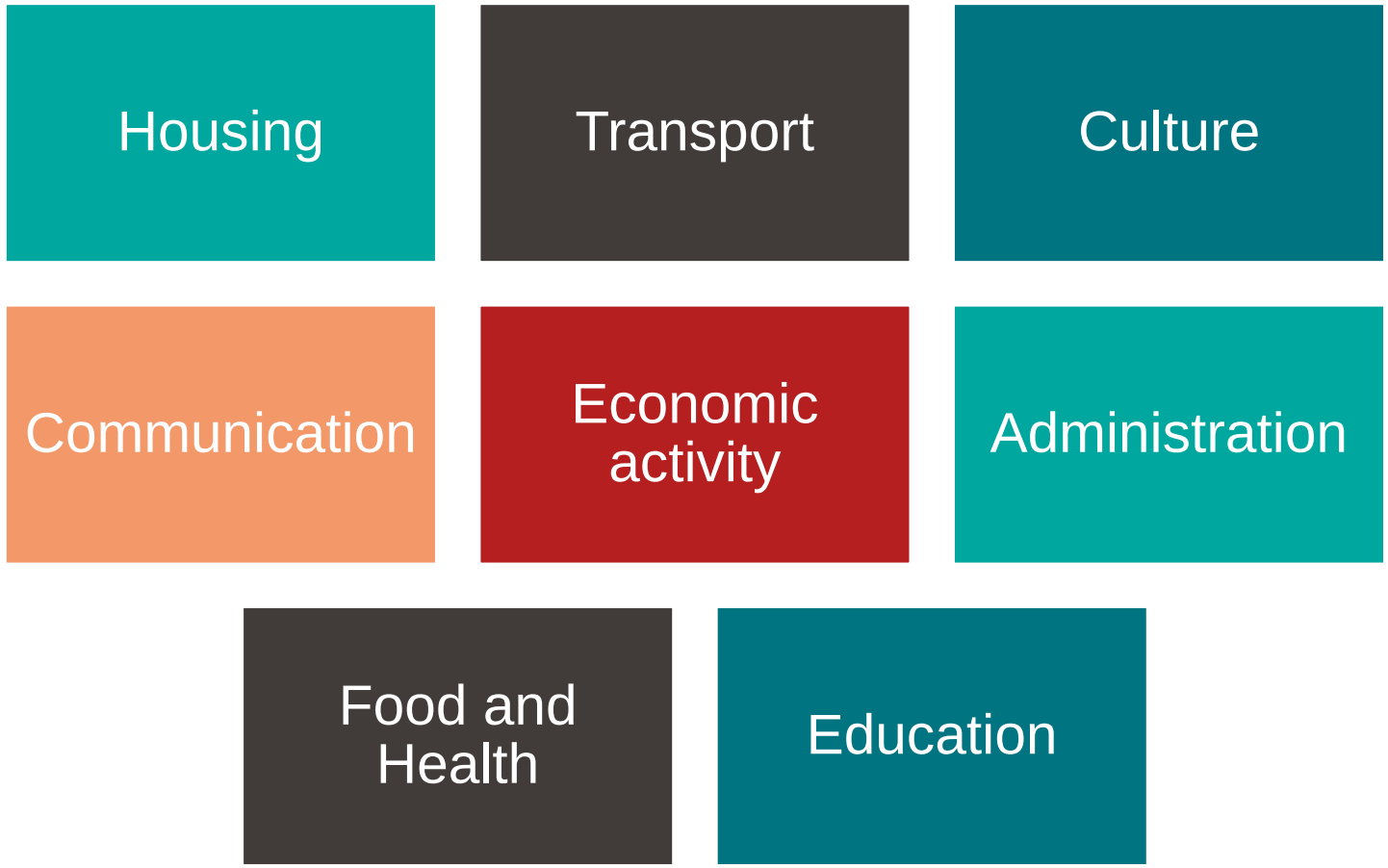
What civilisations, cultures, events have influenced the development of the city?

What are the legal boundaries ?
What are the natural boundaries ?
How does the geographical context influence the city ?

What are the main activities ?
What is produced and where ?
What is the place of the «city» in the global economy ?

How are the decisions taken ? What are the local institutions ?
How is the local power integrated within broader power networks?

Cities as places of functions

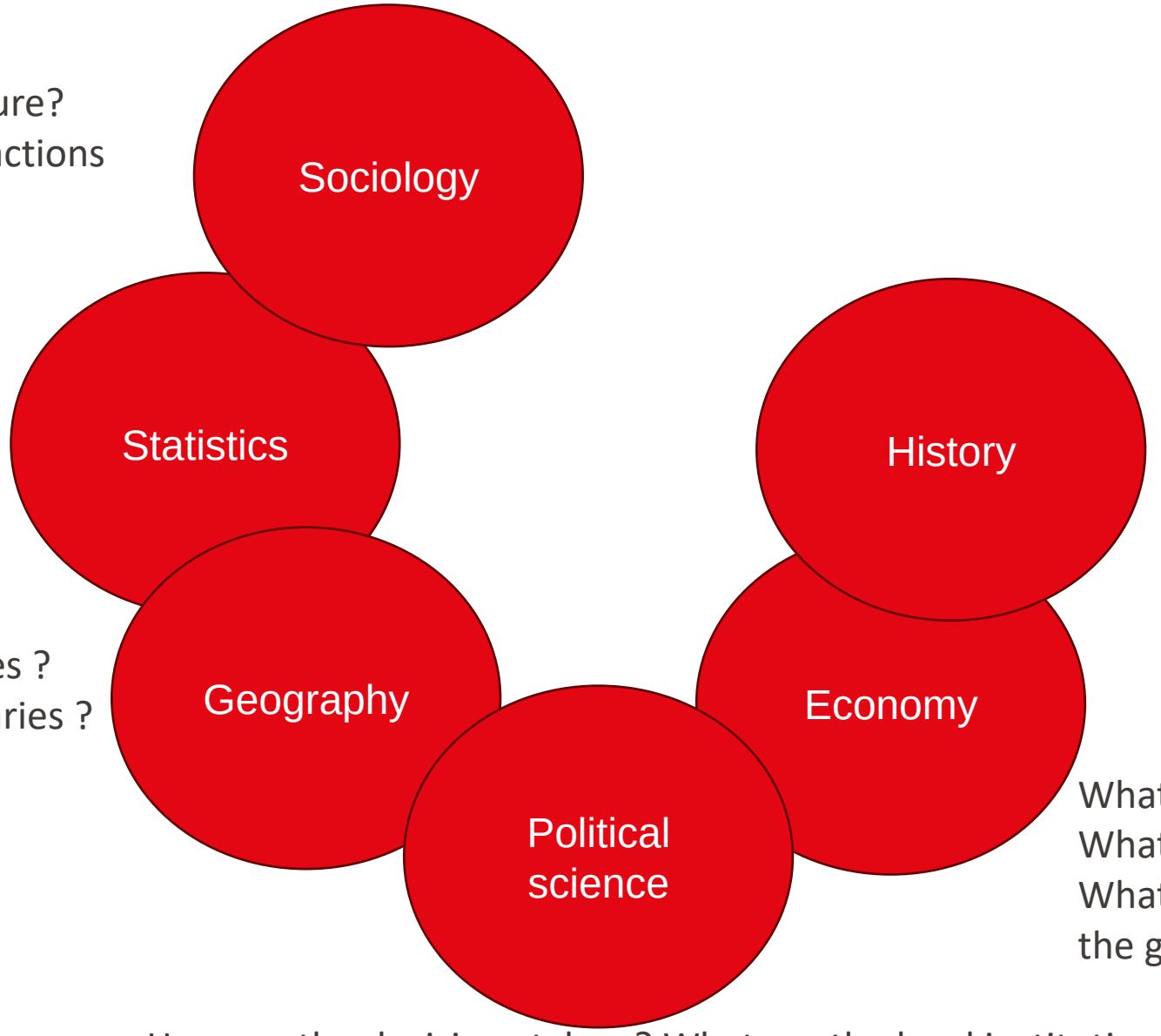


The multifaceted definition of cities

What is the social structure?
How are the social interactions organized ?

How many inhabitants ?
Which density ?

What are the legal boundaries ?
What are the natural boundaries ?
How does the geographical context influence the city ?



What civilisations, cultures, events have influenced the development of the city?

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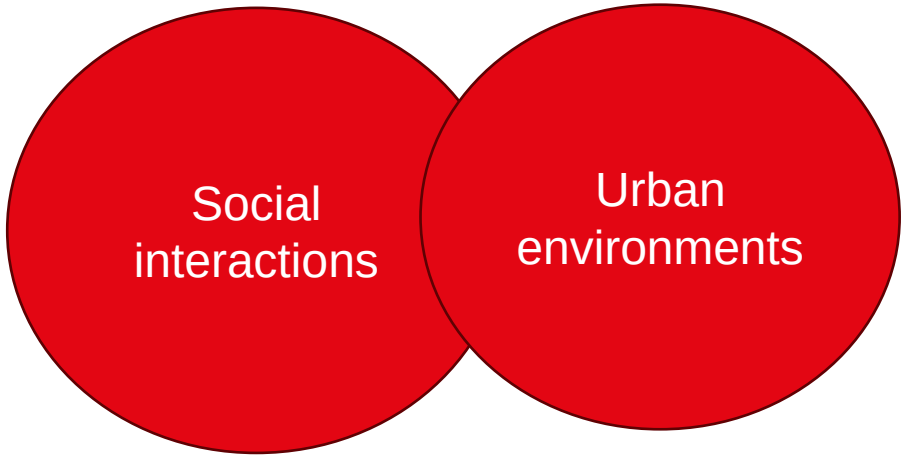
Cities as places of social structuration

A city may be considered as a particular form of human association

Specific phenomenon occur :

City ≠ community (Weber, 1921)

City as a space of rationalization (Weber, 1921)



Cities as places of social structuration

A city may be considered as a particular form of human association

Specific phenomenon occur :

City ≠ community (Weber, 1921)

City as a space of rationalization (Weber, 1921)

Residential segregation (Ex. Suburbs in India)

Lifestyle homogenization → “The Right to the City” (Lefebvre, 1968)

Urban criminality (Chicago school)

Gentrification

…

The multifaceted definition of cities

What is the social structure?
How are the social interactions organized ?

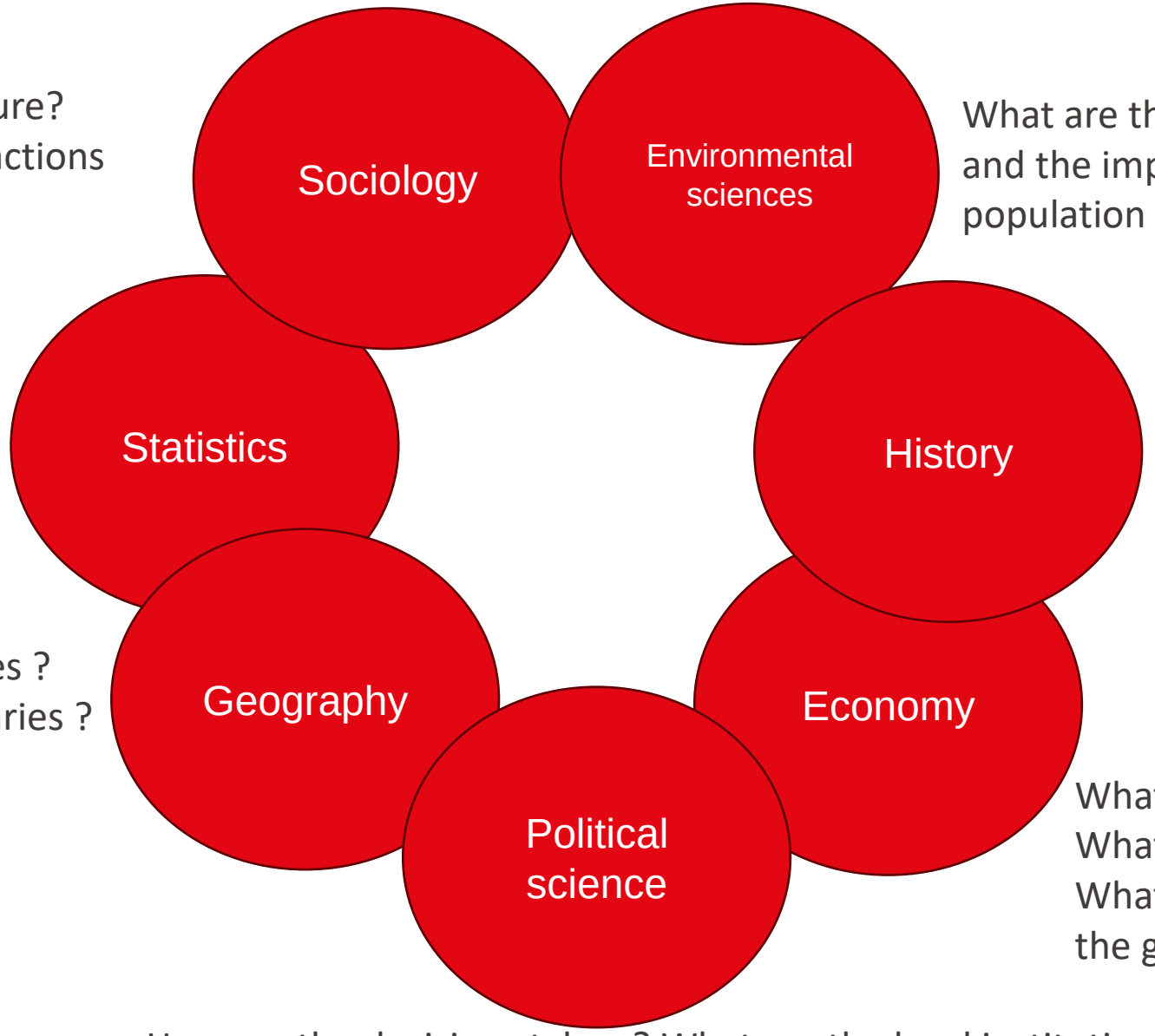
What are the environmental challenges and the impacts of the activities and the population ?

How many inhabitants ?
Which density ?

What civilisations, cultures, events have influenced the development of the city?

What are the legal boundaries ?
What are the natural boundaries ?
How does the geographical context influence the city ?

What are the main activities ?
What is produced and where ?
What is the place of the «city» in the global economy ?



How are the decisions taken ? What are the local institutions ?
How is the local power integrated within broader power networks?

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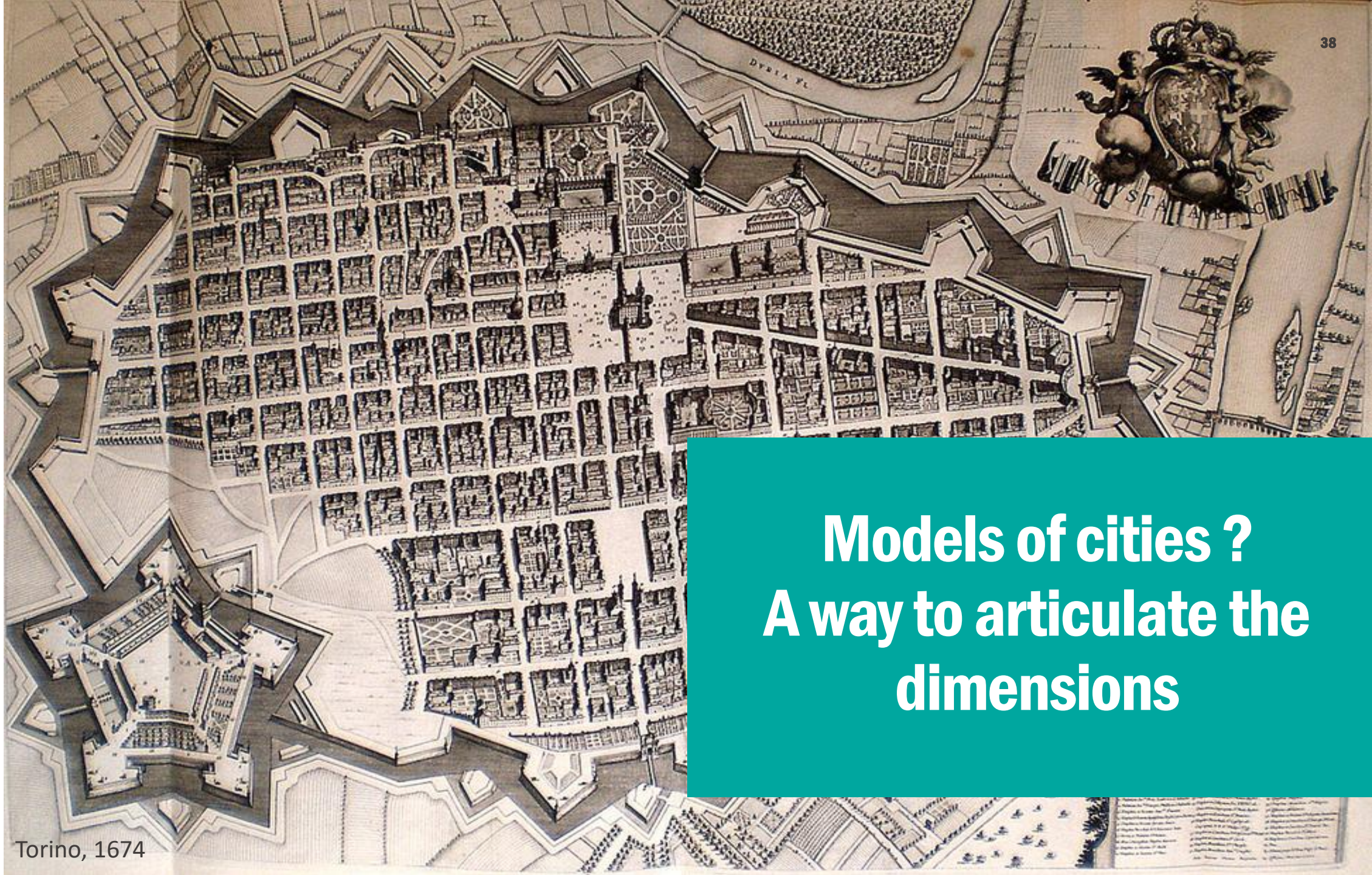


Models of cities ?
A way to articulate the dimensions

Torino, 1674

A «model» of a city ?

- **A city model is a**
  - Simplified and abstract representation of a city
  - It enables its functioning to be analysed, understood and predicted.
  - It can include physical, social, economic and environmental aspects.

- **Interaction analysis**: Models enable us to study how different elements of a city (population, economy, infrastructure) interact with each other.

- **Identifying trends**: such as population growth, urban sprawl or gentrification
  - Urban planning, prospective, resource management (…)

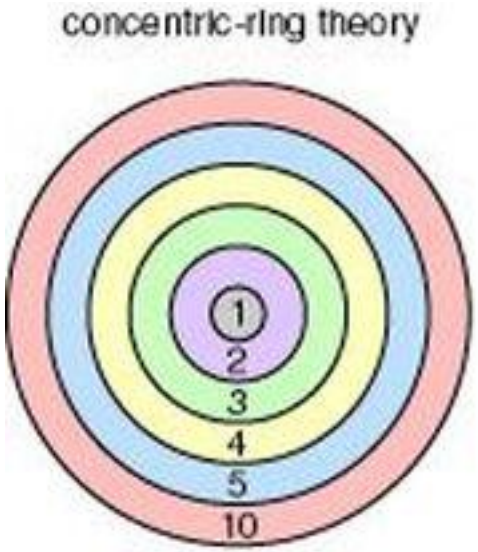
A «model» of a city ?

- **A city model is a**
  - Simplified and abstract representation of a city
  - It enables its functioning to be analysed, understood and predicted.
  - It can include physical, social, economic and environmental aspects.

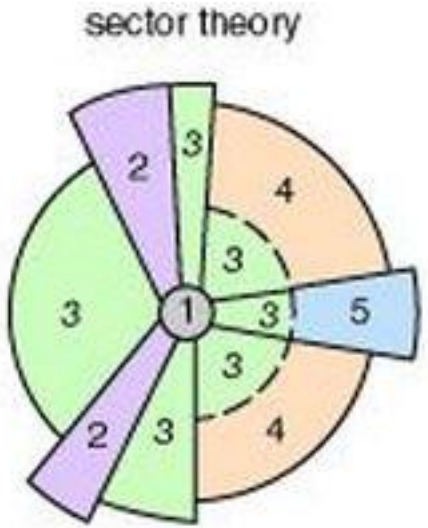
- **Any example ?**

A «model» of a city ?

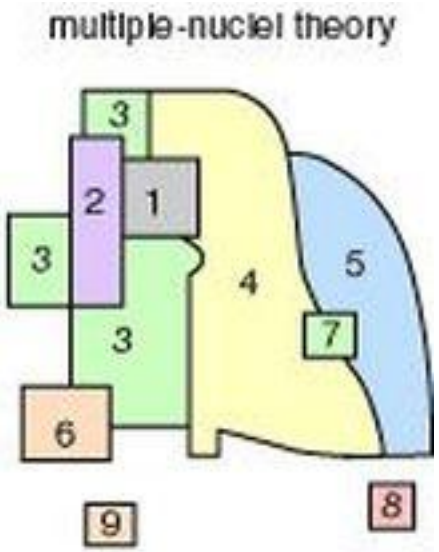
Burgess model (1925)



Hoyt model (1925)



Harris and Ullman model (1945)



1 central business district (CBD)
2 wholesale light manufacturing
3 low-cost housing
4 medium-cost housing
5 high-cost housing
6 heavy manufacturing
7 outlying business district
8 residential suburb
9 industrial suburb
10 commuter zone

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Defining cities : a synthesis

Torino, 1674

City characteristics (I)

Minimum size and population density:

- Compact settlement area

Functional structure:

- Functions are spatially separated

Urban-rural linkages:
Cities usually have an ‘excess significance ’ vis-à-vis rural settlements.

- Imbalances in the fields of jobs, housing and services.
- Functions can radiate internationally, cultural and financial centers.
- Centers of innovation where new political and societal ideas evolve

(Heineberg, 2014; Fassmann, 2009; Zehner, 2001; Gaebe, 2004, WBGU, 2016).

City characteristics (II)

Societal plurality:

- Social, religious and ethnic diversity

Socio-economic disparities:

- Disparities between socio-economic groups, which can also be reflected geographically by differences in inner-city design and the structure of land and rental prices

Artificial environmental design:

- Cities are landscapes - reshaped and changed by people
- Ecological problems are often externalized as a result of the city's resource-dependence on the hinterland
- The city environments have an ecological compensation function.

WBGU, 2017

Some institutionnal definitions

A city is a social, ecological, and economic system within a defined geographic territory. (UNEP, 2011)

Cities are places where large numbers of people live and work; they are hubs of government, commerce and transportation. (UN, 2018)

They are associated with:

- a functional or administrative region,
- a critical mass and density of people,
- man-made structures and activities
  (OECD and China Development Research Foundation 2010).

Cities are differentiated from other settlements by their population size and functional complexity (Fellmann et al. 1996).

A synthesis to set up boundaries

Methods for delineating a city (IPCC, 2014; UN, 2018)

1. Political-administrative boundary
   - Based on area under jurisdiction of relevant governmental entity
   - Often reflecting historical status
2. Statistical-administrative concept
   - Delimitation based on population size and/or density
3. Functional boundary
   - Economic connections, mobility patterns, etc.
4. Morphological boundaries
   - Presence of paved streets, buildings, water supply systems, etc.

Sustainability assessment sensitivity to city definition

Torino, 1674

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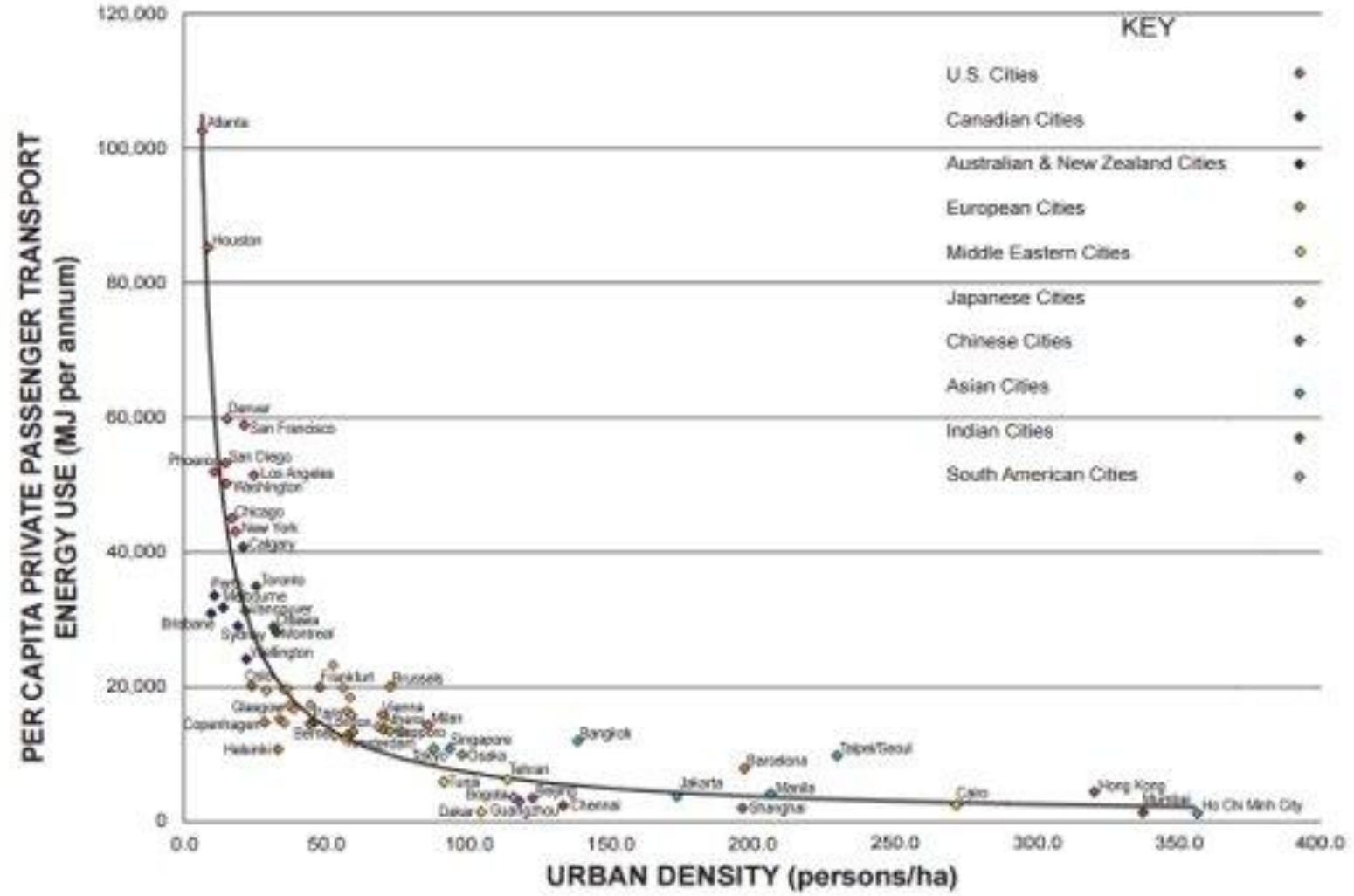
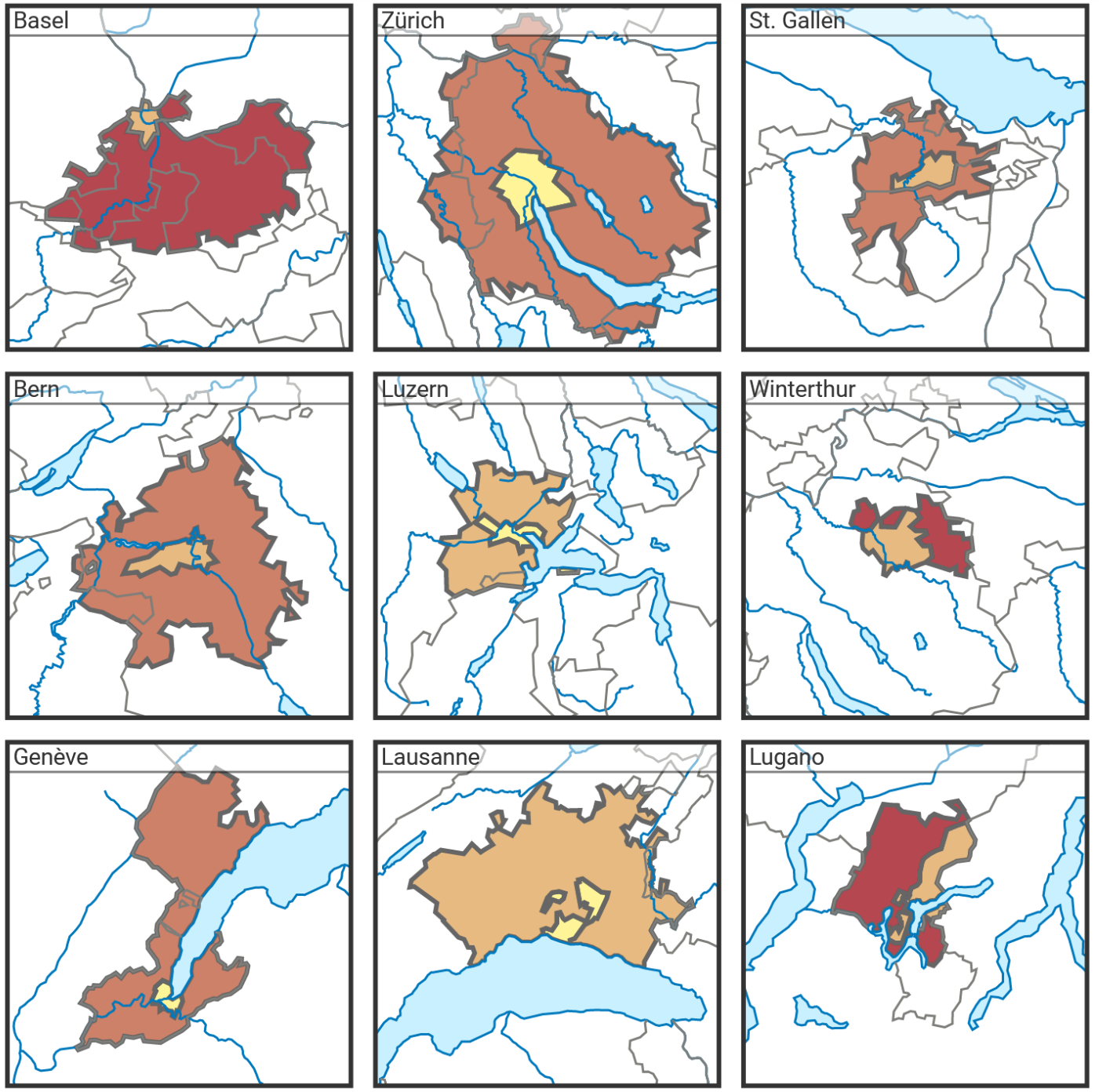
Delineating city boundaries



Source: Newman and Kenworthy 2015

Delineating city boundaries



Nombre de maisons individuelles pour 100 appartements*

≥	50,0
25,0 –	49,9
5,0 –	24,9
<	5,0

* Logements au 31.12.2018

Source: FSO City Atlas, https://www.atlas.bfs.admin.ch/maps/162/de/15784_12162_12161_12154/24686.html

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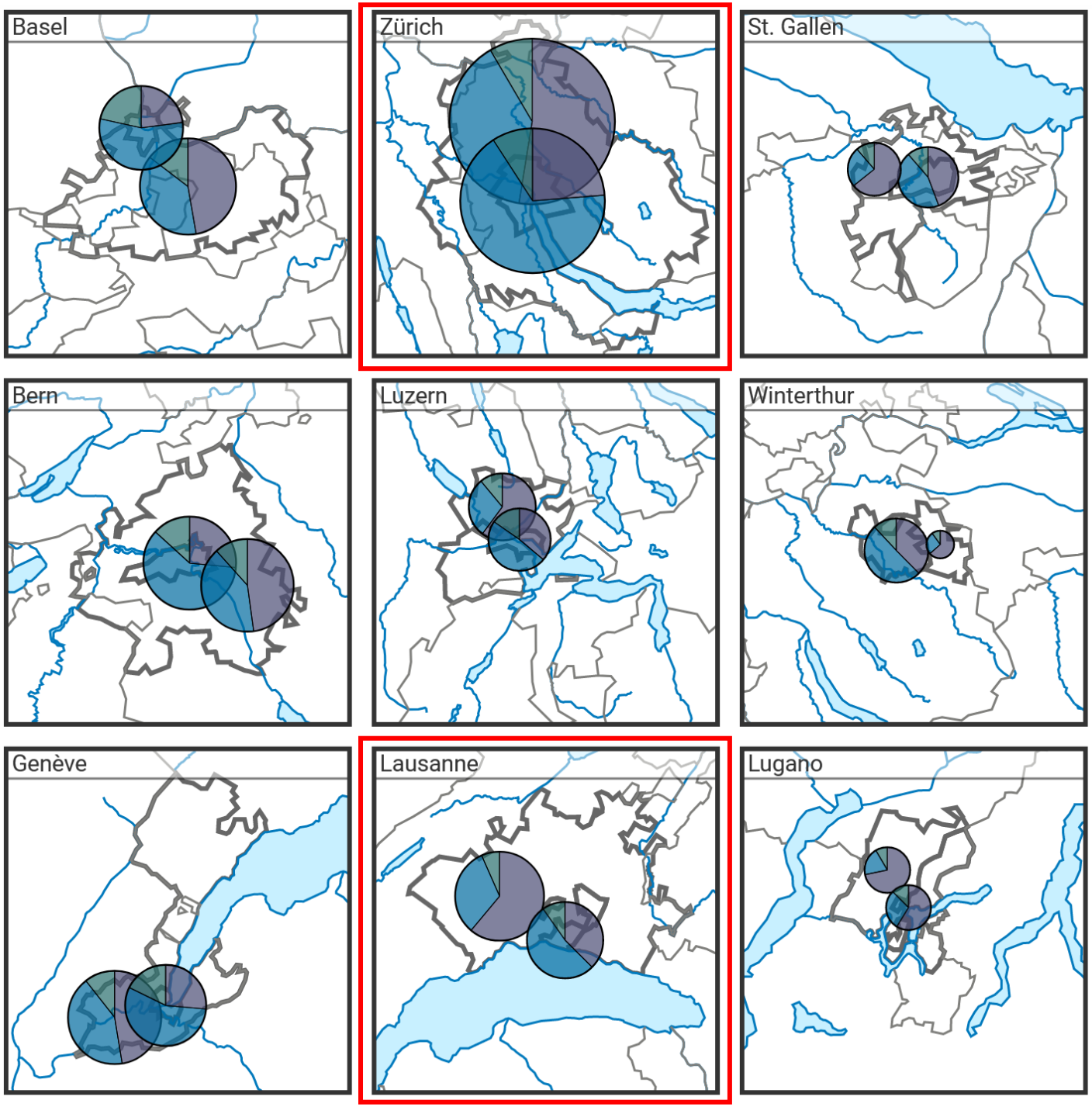
Delineating city boundaries



Transport* lors du déplacement domicile-travail

- Transport individuel motorisé
- Transports publics
- Mobilité douce

* Mode de transport principal des personnes actives occupées; relevé structurel du 31.12.2017

Source: FSO
https://www.atlas.bfs.admin.ch/maps/162/de/15794_12174_12171_12154/24704.html

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Heterogeneity of cities

- Despite these common characteristics, cities around the globe are diverse and heterogeneous
- Different *types of cities* vary for example in terms of:
  - **Geographical conditions,** for example desert cities vs coastal cities vs mountain cities
  - **Functional specialization,** for example (post-) industrial cities vs university cities
  - **Development paths,** for example rapidly growing cities in terms of population, or GDP vs shrinking cities

Heterogeneity of cities

- Different *types of cities* are likely to face different kinds of sustainability challenges (and to prioritize different sustainability goals)
- Sustainability assessment needs to be tailored to the type of city under investigation

- **Environmental issues** (air pollution, waste...)
- **Social issues** (adequate housing, segregation, declining population...)
- **Structural features** (urban heat islands, traffic jams, transport system issues...)
- **Geographical conditions** (prone to natural disasters, floods, earthquakes, heatwaves...)
- Sustainability challenges are interlinked

Defining cities

- How do we define a city ?
- What are the trends of urbanization ?
- How does the definition of the cities impact their sustainability assessment ?
- **What are the sustainability issues affecting cities ?**

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Urban Development and Sustainability Challenges

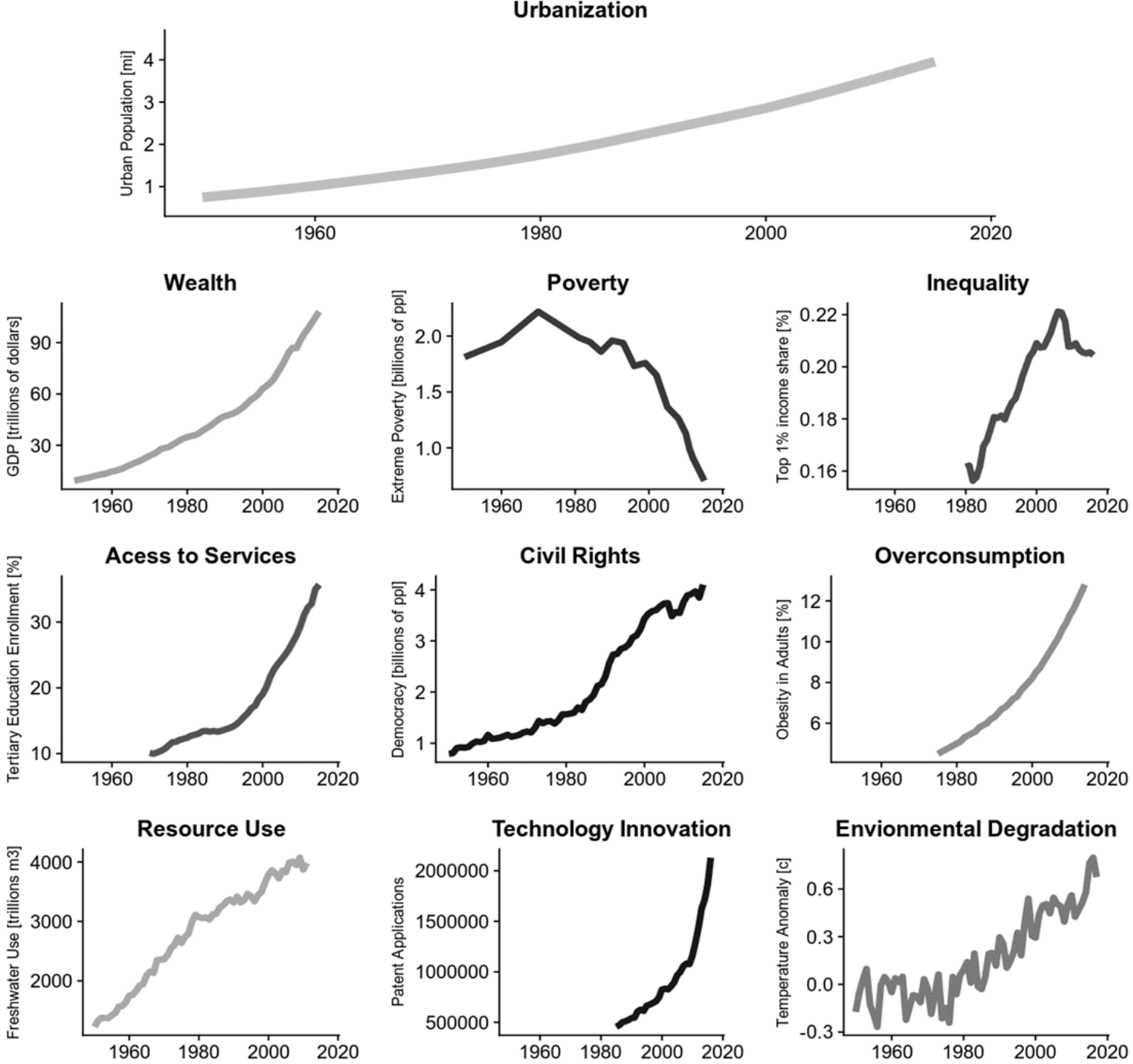
What do you think are key challenges of cities?

What do you think are benefits of cities?

Urbanisation in short

- **Cities** account for about **3%** of the land on Earth
- Account for about **80%** of the **global GDP** but also
- **60-80%** of global **energy consumption** and **75%** of **GHG emissions**

Effects of urbanization



Source: Meirelles et al., 2020

Most important issues as perceived by cities

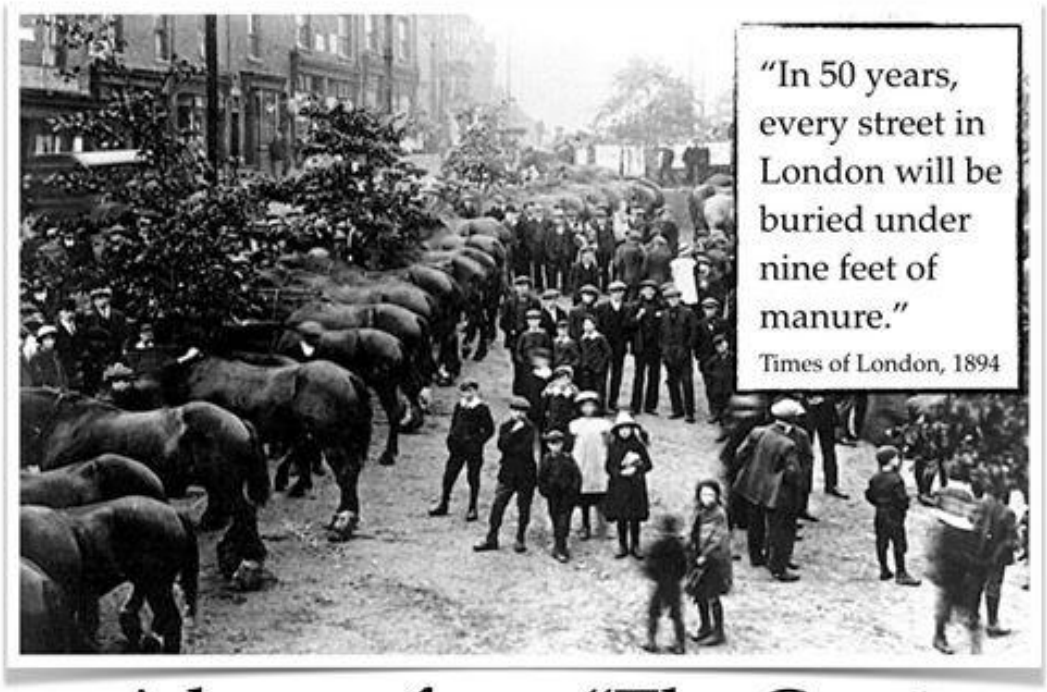
Most important issue	Highest rating	(%)	Second highest rating	(%)	Third highest rating	(%)
Education and training	Oulu (FI)	60	Wien (AT) and Belfast (UK)	58	Aalborg (DK), Hamburg (DE) and Zürich (CH)	55
Health services	Budapest (HU)	67	Belfast (UK) and Reykjavik (IS)	66	Bialystok, Gdansk and Warszawa (all PL)	63
Social services	Leipzig (DE), Vilnius (LT) and Groningen (NL)	31	Rostock (DE), Rīga (LV) and Budapest (HU)	29	Dortmund (DE) and Zürich (CH)	28
Unemployment	Napoli (IT)	73	Ostrava (CZ)	71	Miskolc (HU)	70
Housing	Stockholm (SE)	61	München (DE)	56	Geneva and Zürich (both CH)	51
Road infrastructure	Tallinn (EE)	52	Irakleio (EL)	50	Praha (CZ)	49
Public transport	Helsinki (FI)	49	Oslo (NO)	45	Istanbul (TR)	42
Air pollution	Ostrava (CZ)	76	Burgas (BG)	62	Krakow (PL)	60
Noise	Praha (CZ)	35	Valletta (MT)	28	Burgas (BG)	20
Urban safety	Marseille (FR)	52	Liège (BE)	47	Rotterdam (NL)	44
Least important issue	**Third lowest rating**	**(%)**	**Second lowest rating**	**(%)**	**Lowest rating**	**(%)**
Education and training	Praha (CZ)	13	Miskolc (HU)	11	Ostrava (CZ)	4
Health services	München (DE)	21	Praha (CZ)	17	Ostrava (CZ)	7
Social services	Bruxelles/Brussel (BE) and Napoli (IT)	12	Paris (FR), Malmo (SE) and Istanbul (TR)	11	Krakow (PL)	10
Unemployment	Reykjavik (IS)	15	München (DE)	14	Valletta (MT)	5
Housing	Sofia (BG) and Napoli (IT)	5	Palermo (IT)	4	Burgas (BG)	3
Road infrastructure	Barcelona (ES)	9	Paris (FR)	8	Madrid (ES) and Malmo (SE)	7
Public transport	Tallinn (EE)	8	Ostrava (CZ)	5	Burgas (BG)	4
Air pollution	Dublin (IE) and Tyneside (UK)	7	Belfast (UK)	6	Bialystok (PL)	5
Noise	Roma (IT), Stockholm (SE), Belfast (UK) and Oslo (NO)	4	Helsinki (FI) and London (UK)	3	Dublin (IE), Rīga (LV), Oulu (FI), Malmo (SE) and Glasgow (UK)	2
Urban safety	Burgas (BG), Rostock (DE), Tallinn (EE) and Bialystok (PL)	16	Stockholm (SE)	14	Cluj (RO)	12

(*) Athina (Greece), Paris (France), Lisboa (Portugal), London, Manchester and Tyneside conurbation (all United Kingdom): greater city.

Source: Eurostat, 2015

Environmental issues in cities

Horse manure



A lesson from "The Great Horse Manure Crisis of 1894"

"*Streets were "literally carpeted with a warm, brown matting . . . smelling to heaven." So-called "crossing sweepers" would offer their services to pedestrians, clearing out paths for walking, but when it rained, the streets turned to muck. And when it was dry, wind whipped up the manure dust and choked the citizenry*."

Kohlstedt, 2017

Horse manure

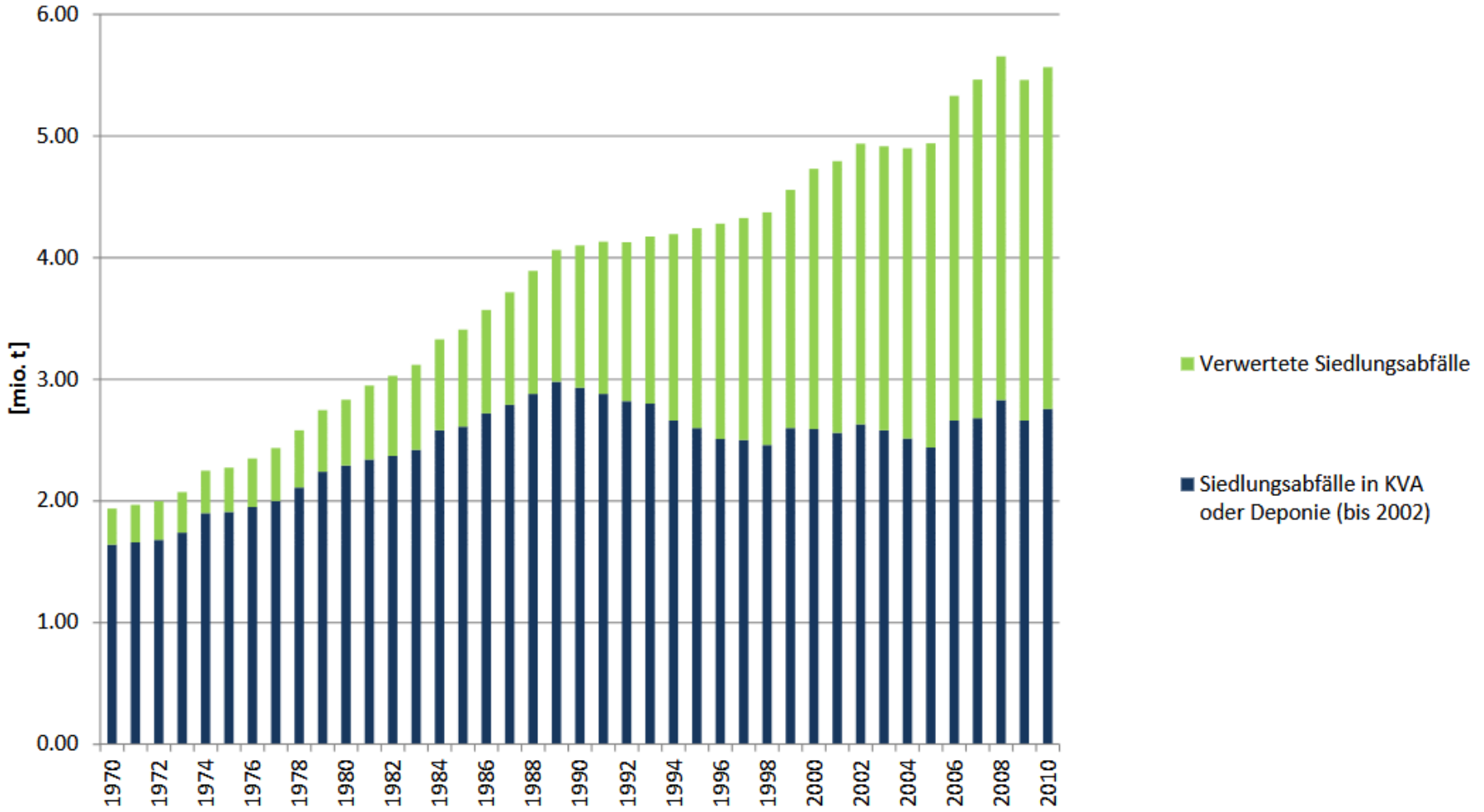
- By 1870s, New Yorkers were taking over 100 million horsecar trips per year
- By 1880 there were at least 150,000 horses in the city.
- At a rate of 22 pounds per horse per day, equine manure added up to over a 100,000 tons per year
- In 1900, 200 people were killed in horse related accidents in NYC. In 2003 there were 344 auto related fatalities; the per capita fatalities in 1900 were about 75% higher

https://99percentinvisible.org/article/cities-paved-dung-urban-design-great-horse-manure-crisis-1894/

Waste

https://edition.cnn.com/2016/02/24/middleeast

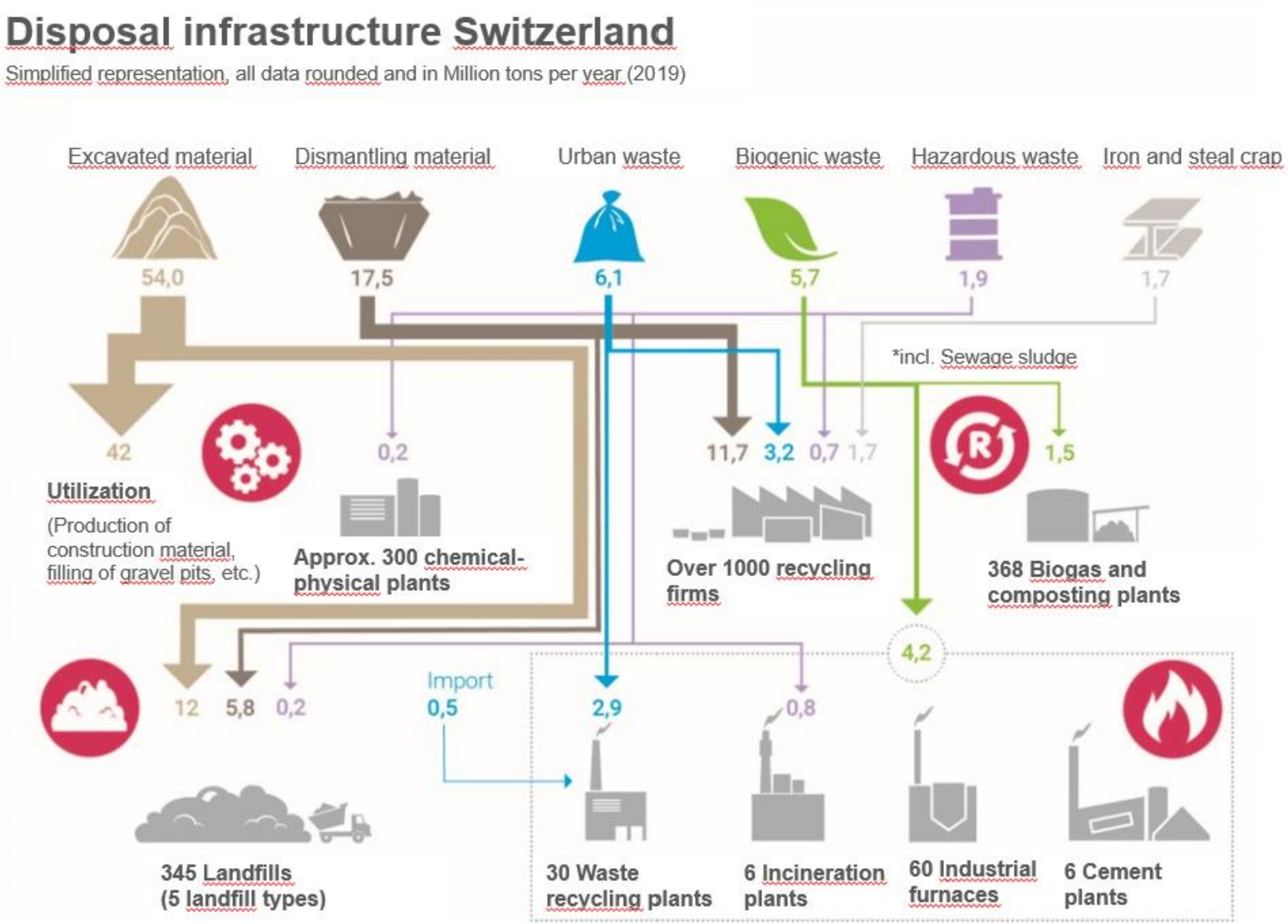
Recycled & non-recycled waste in CH 1970-2010



Federal Office of the Environment, 2011

Recycled municipal solid waste

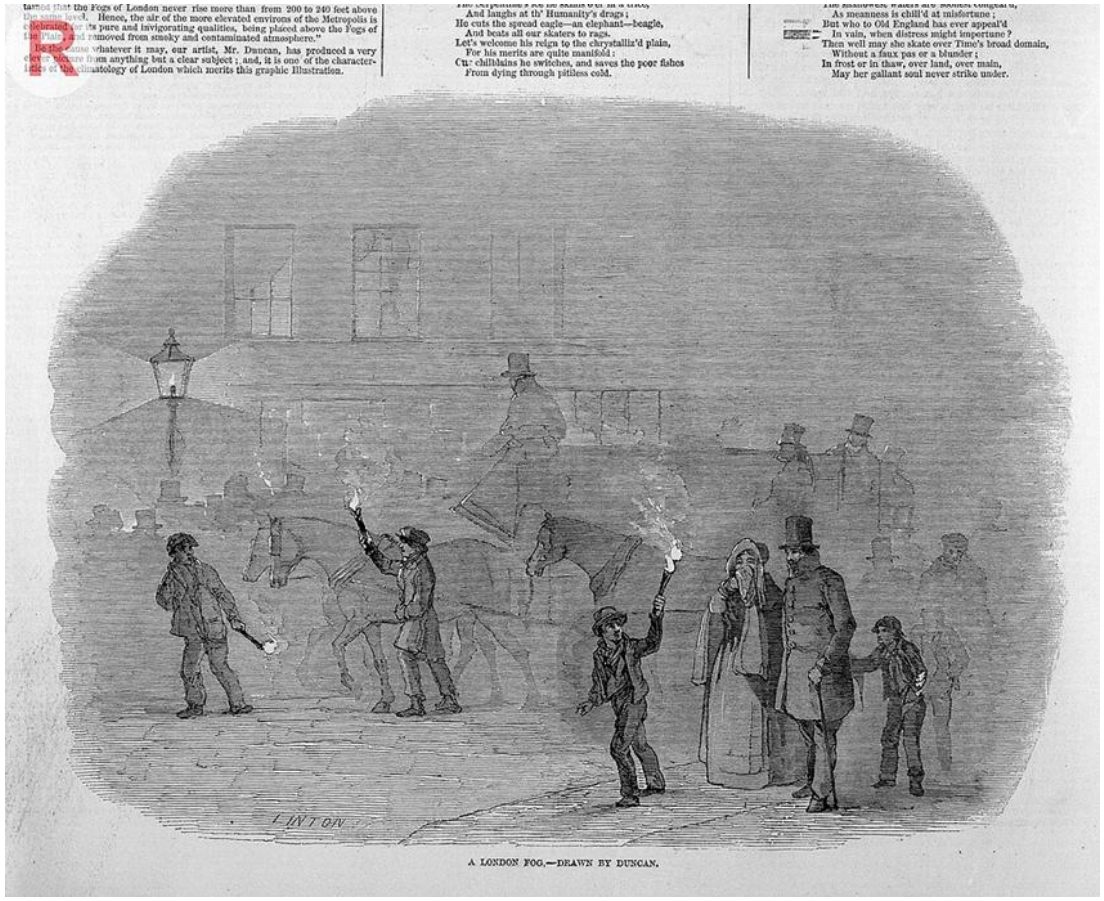
Infrastructure is key for "circularity"



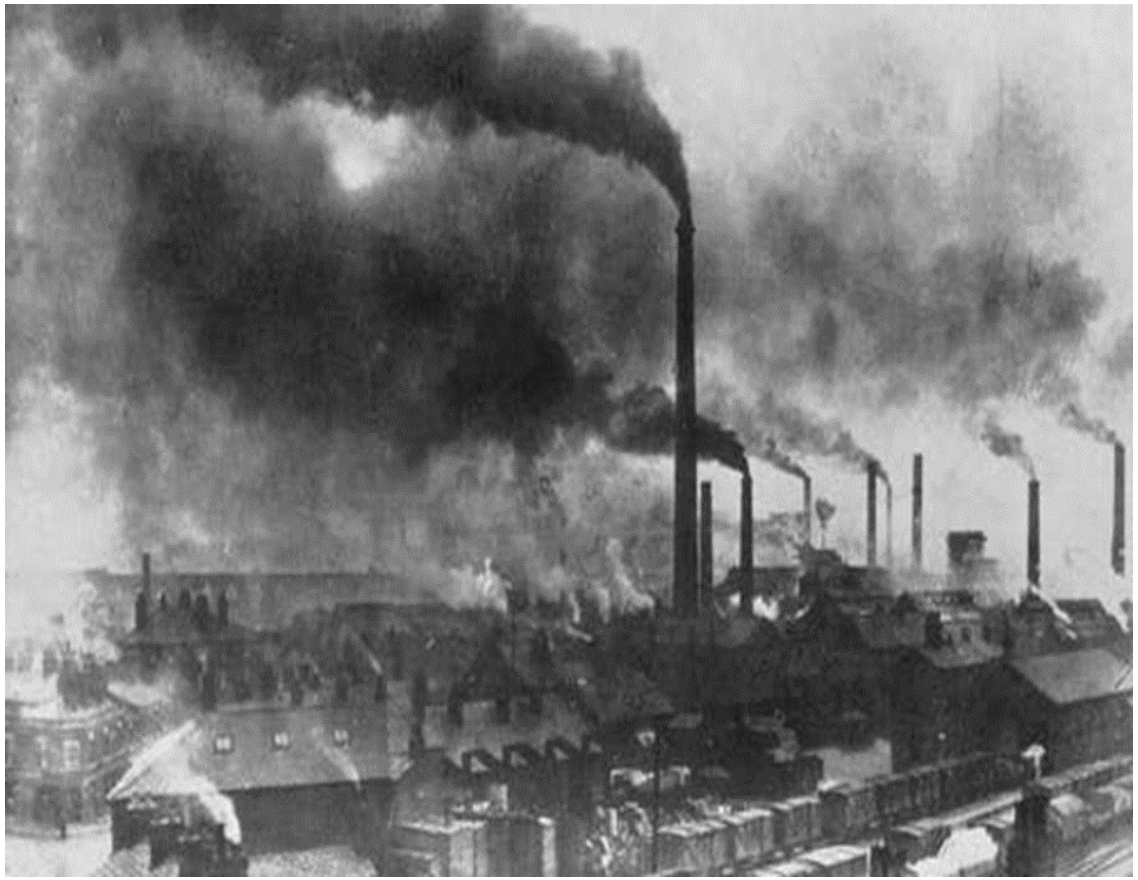
Air Pollution: Silent Killer

WHO estimates **7 million people** die prematurely **every year** due to **air pollution!**

Smog



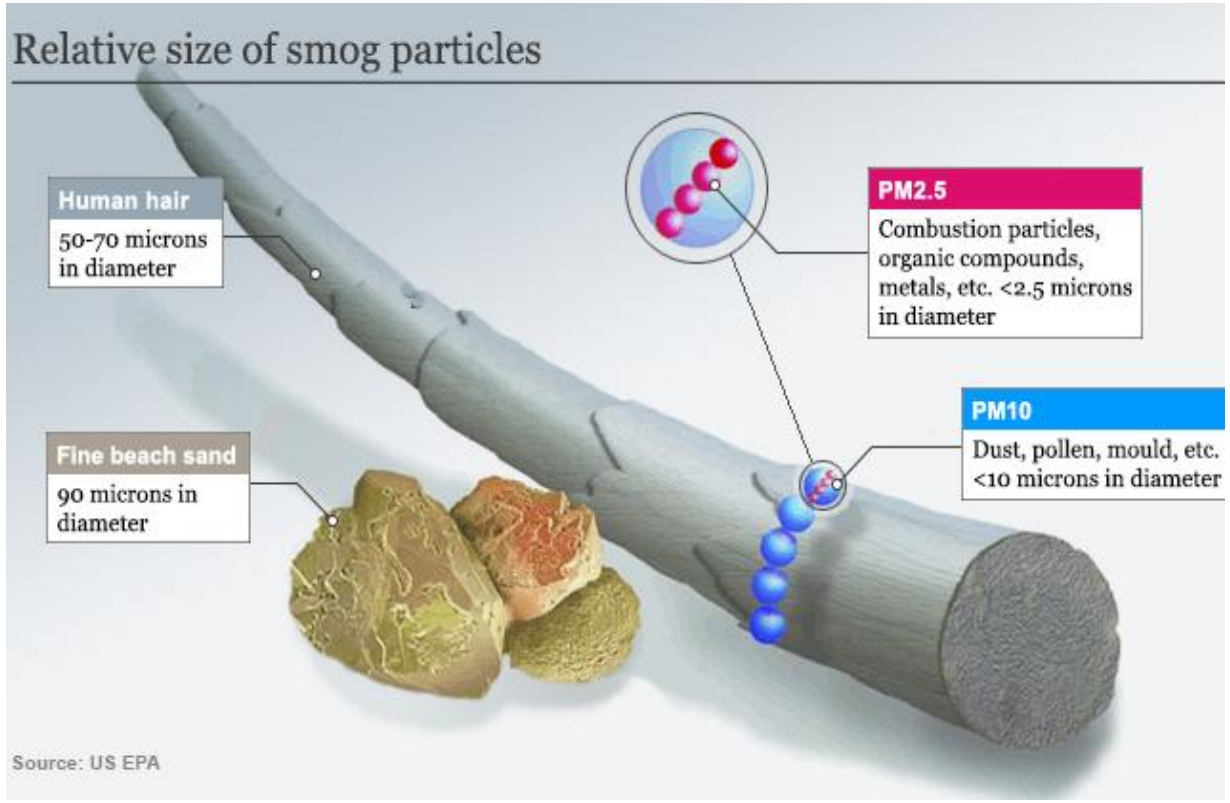
A LONDON FOG.—DRAWN BY DUNCAN.



https://commons.wikimedia.org/wiki/File:Widnes_Smoke.jpg

"During the continuance of a real London fog—which may be black, or grey, or more probably orange-coloured—the happiest man is he who can stay at home...Nothing could be more deleterious to the lungs and the air-passages than the wholesale inhalation of the foul air and floating carbon which, combined, form a London fog." (Charles Dickens, Dicken's Dictionary of London, 1879).

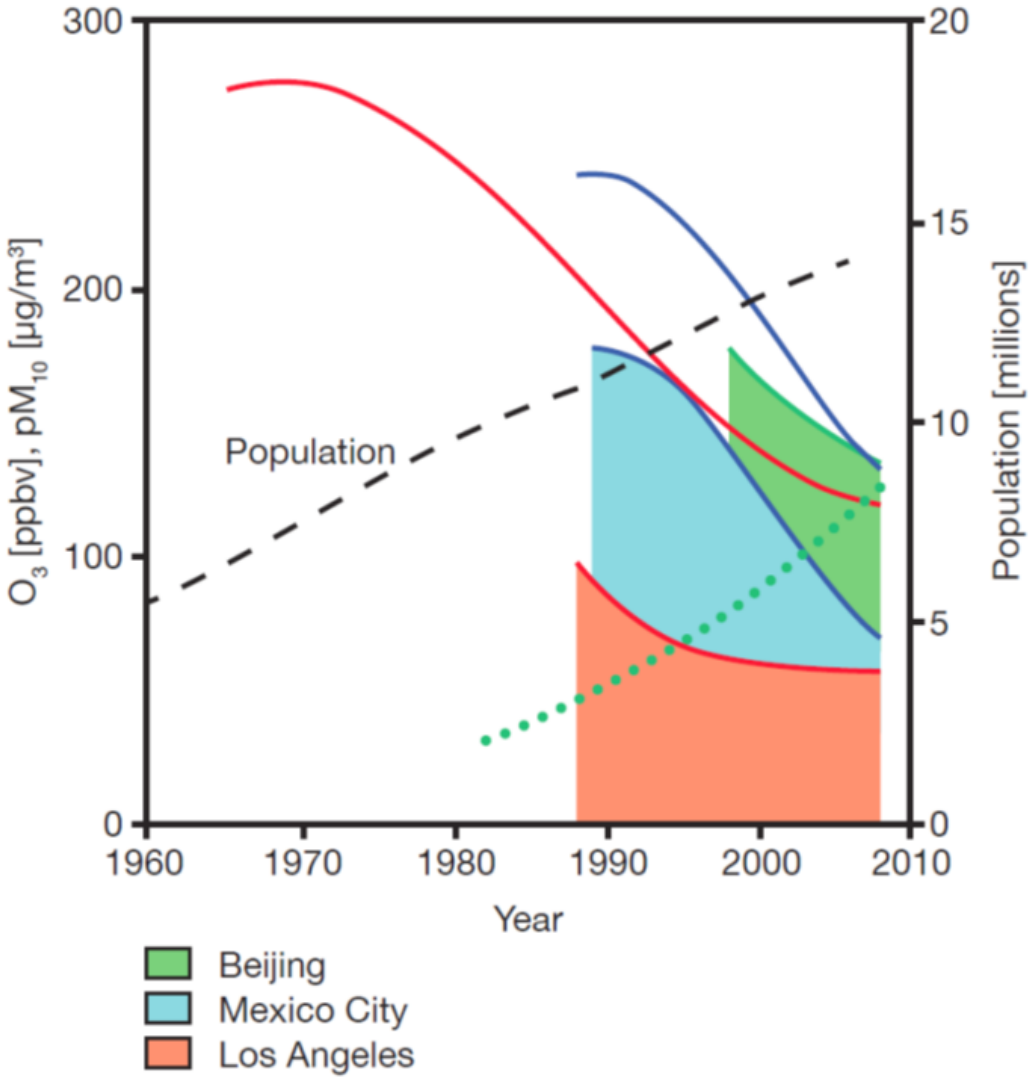
Invisible Threat: Particulate Matter (PM 10 & PM 2.5)



In **Stuttgart**, in 2014, the concentration of PM exceeded the legal limit on **64 days!**

https://www.dw.com/en/stuttgart-germanys-beijing-for-air-pollution/a-18991064

Air pollution in three approx. equal-sized megacities

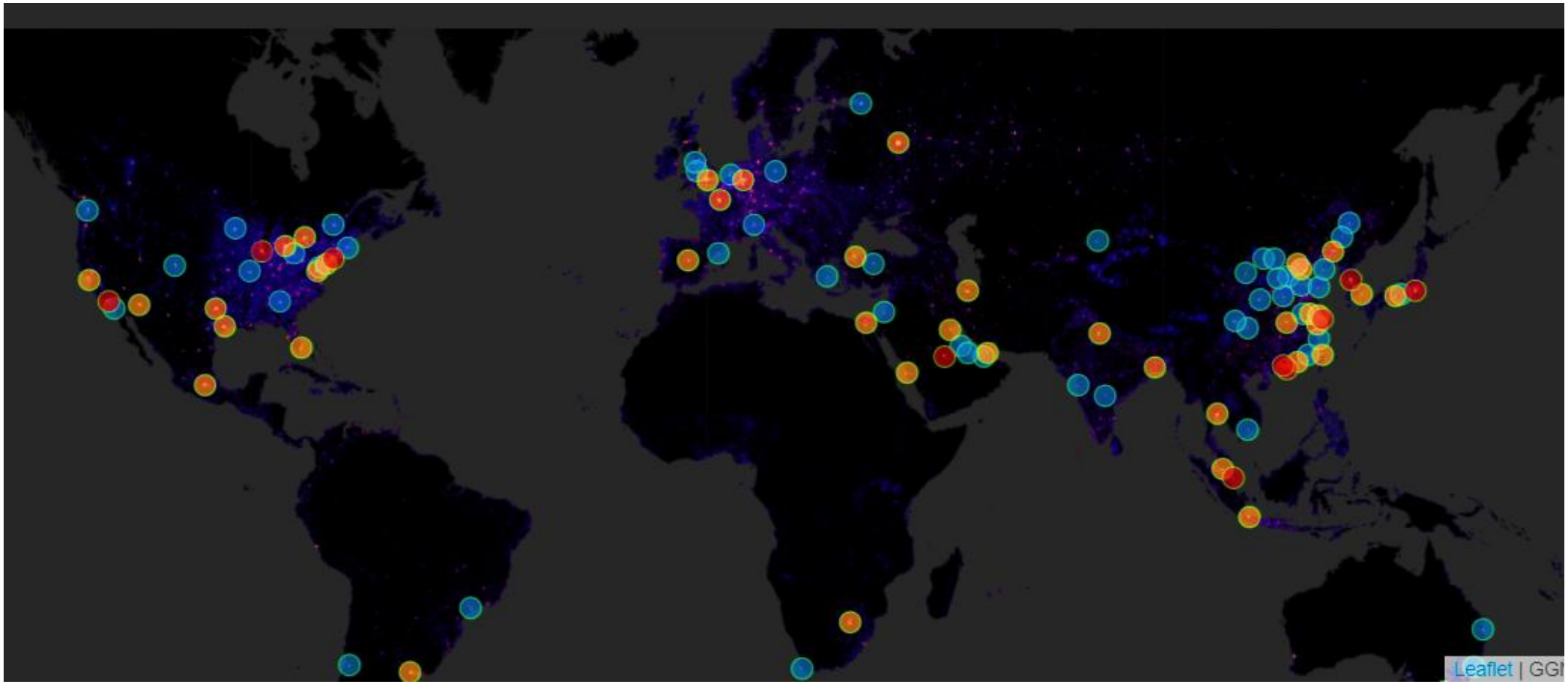


- Particulates (**PM10: thin, shaded lines**)
- Groundlevel ozone (**O3: thick, solid or dotted lines**).
- Average city size (number of inhabitants: **black, dashed line)**

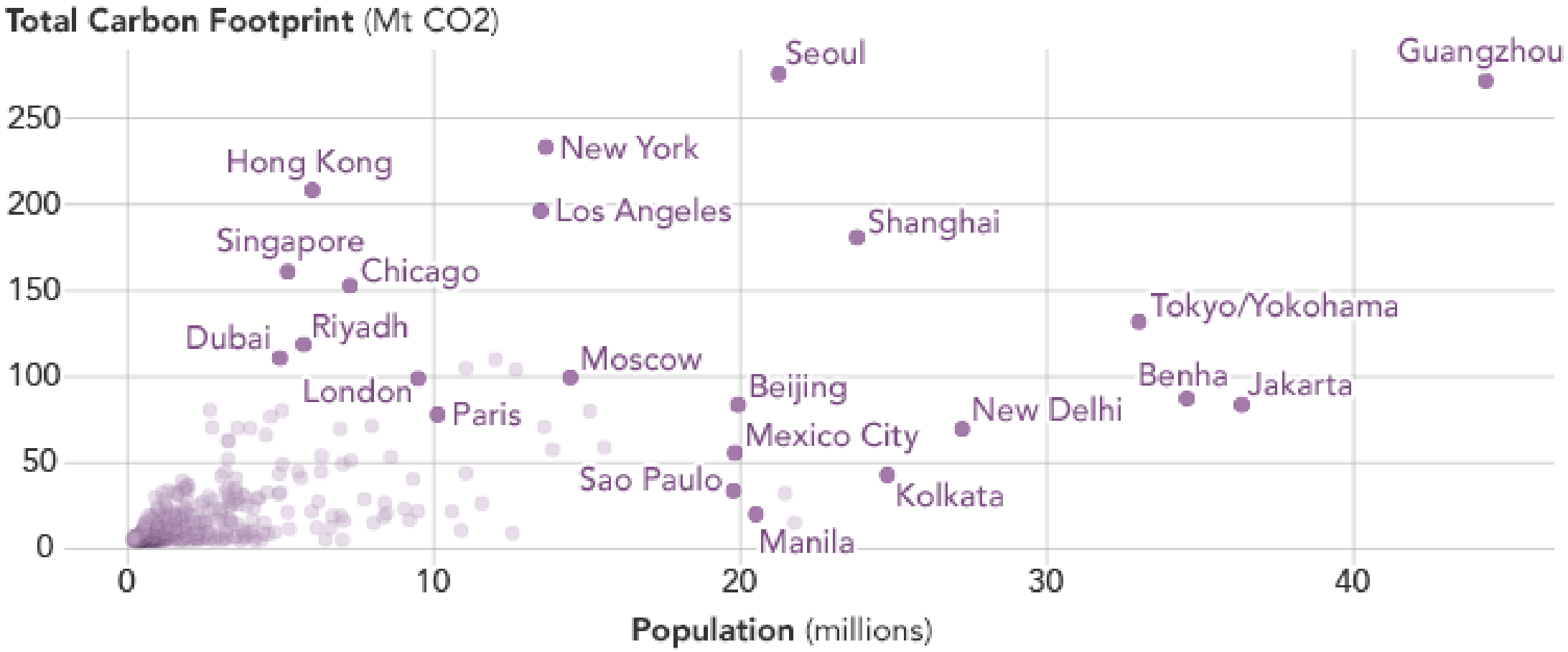
Source: WBGU 2016

Top 100 cities with largest carbon footprint

The 100 highest-emitting urban areas account for **18%** of the global carbon footprint

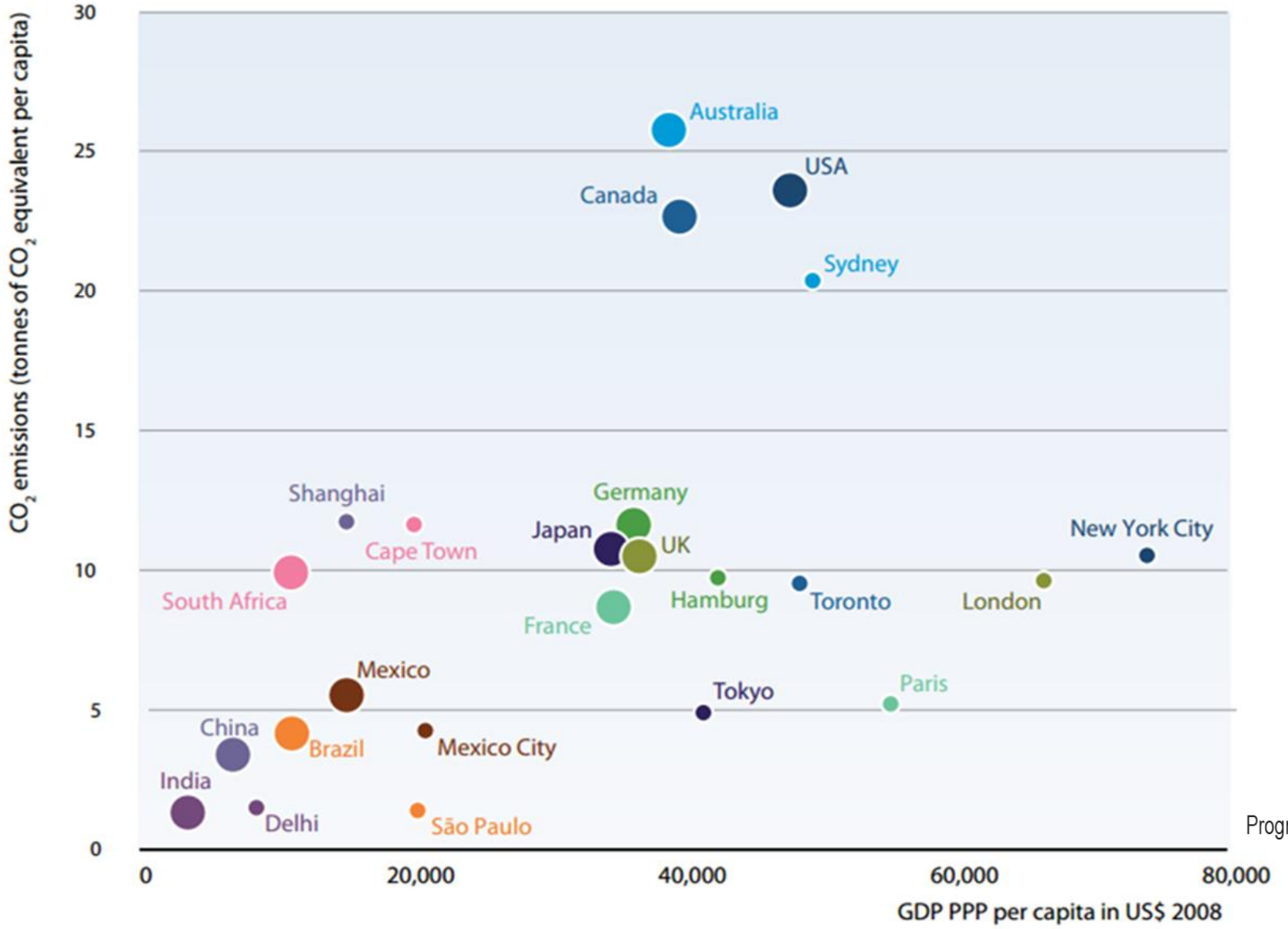


CO2 emissions related to city size



https://earthobservatory.nasa.gov/images/144807/sizing-up-the-carbon-footprint-of-cities

Cities emit less CO2 / cap. than the countries they belong to



Programme des Nations Unies pour l'environnement. 201

GHG Emissions: Rural-Urban Divide in Germany

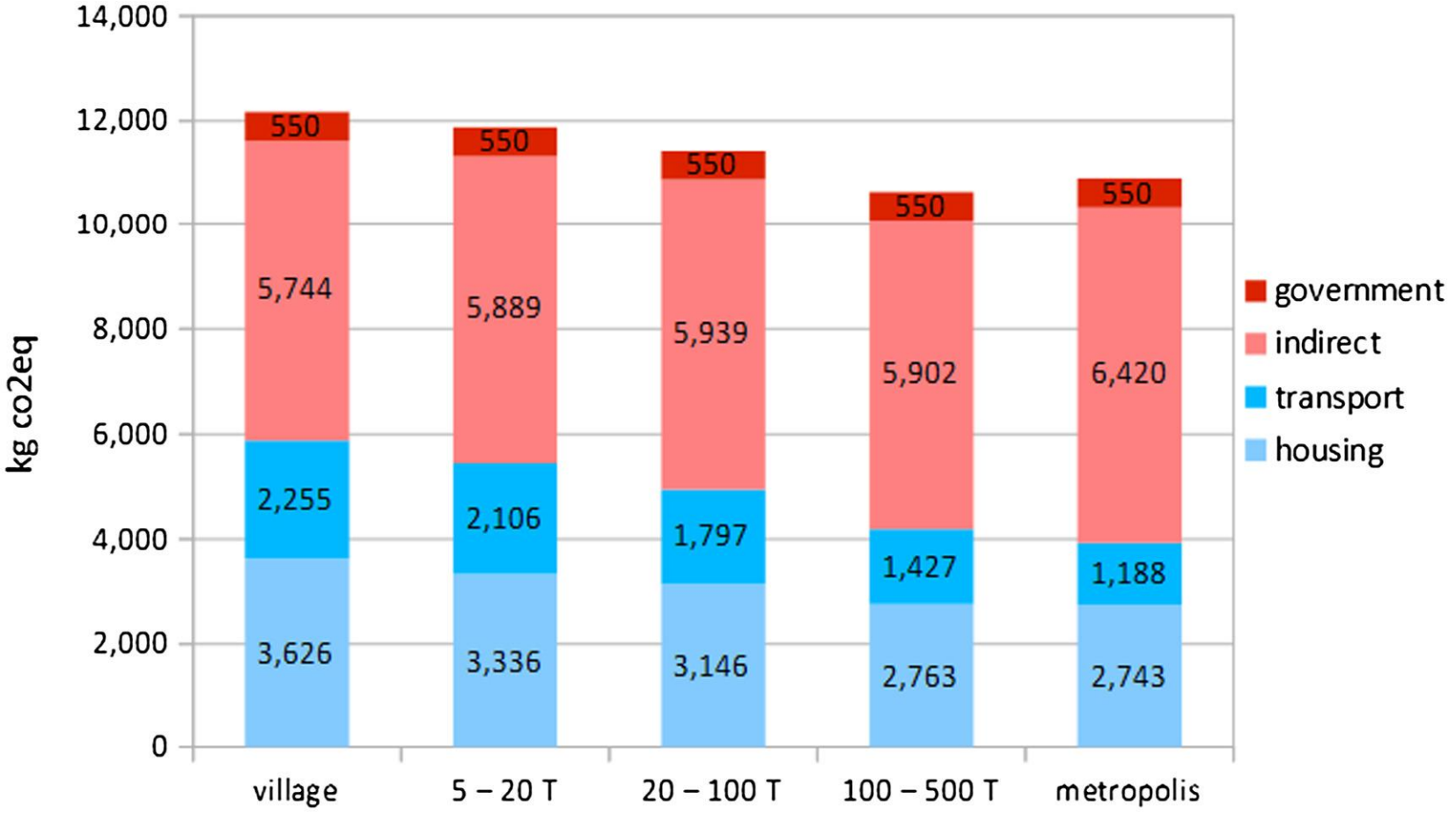


Fig. 1. GHG emissions per capita according to municipality size.

Direct: transport and housing
(heating, electricity, fuel consumption)

Indirect: consumption of goods and services

Source: Gill et al., 2018

ENVIRONMENTAL RESEARCH
COMMUNICATIONS

LETTER • OPEN ACCESS

Urban carbon footprints: a consumption-based approach for Swiss households

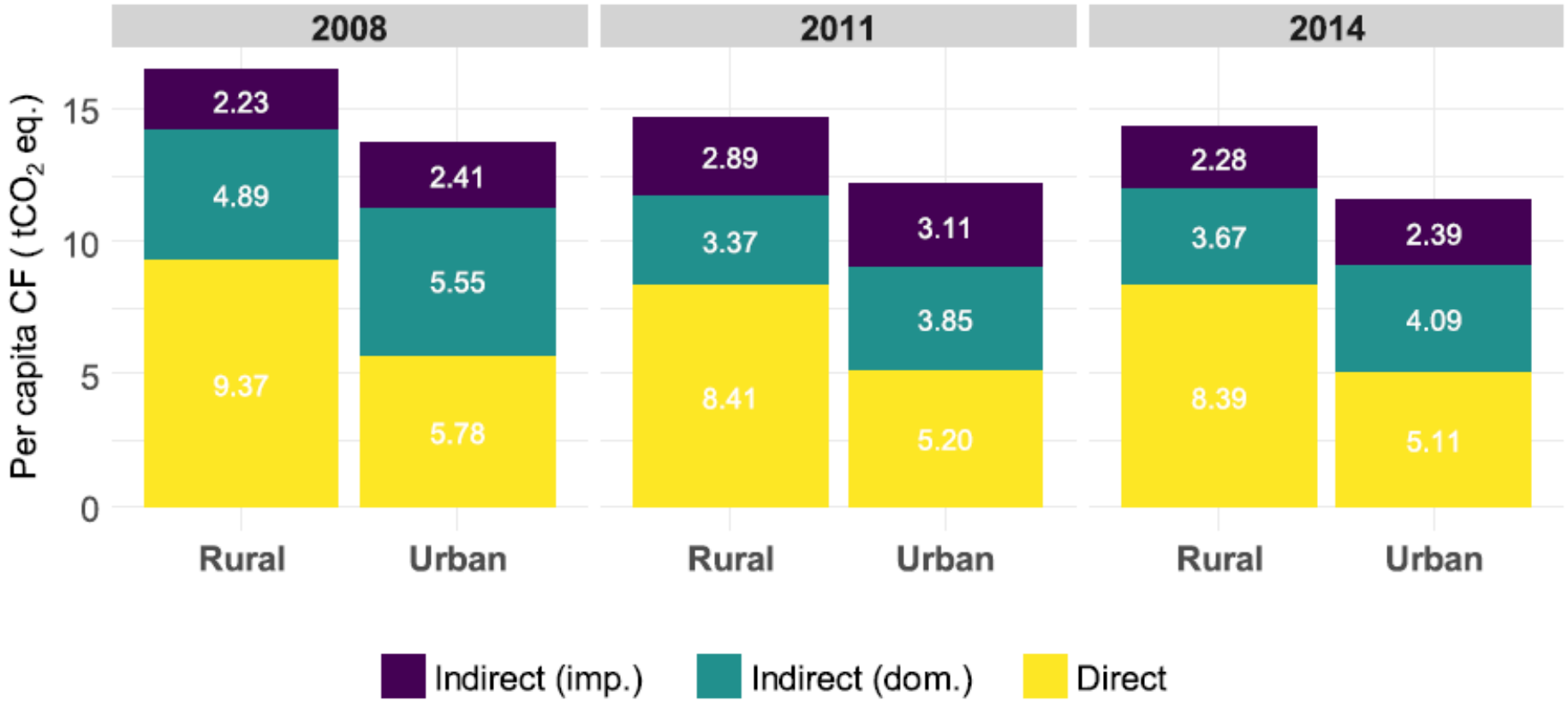
Melissa Pang[1], João Meirelles[1], Vincent Moreau[1] and Claudia Binder[1]

Published 29 November 2019 • © 2019 The Author(s). Published by IOP Publishing Ltd

Environmental Research Communications, Volume 2, Number 1

Citation Melissa Pang *et al* 2020 *Environ. Res. Commun.* **2** 011003

Sustainable consumption and lifestyle changes at the individual-level needed

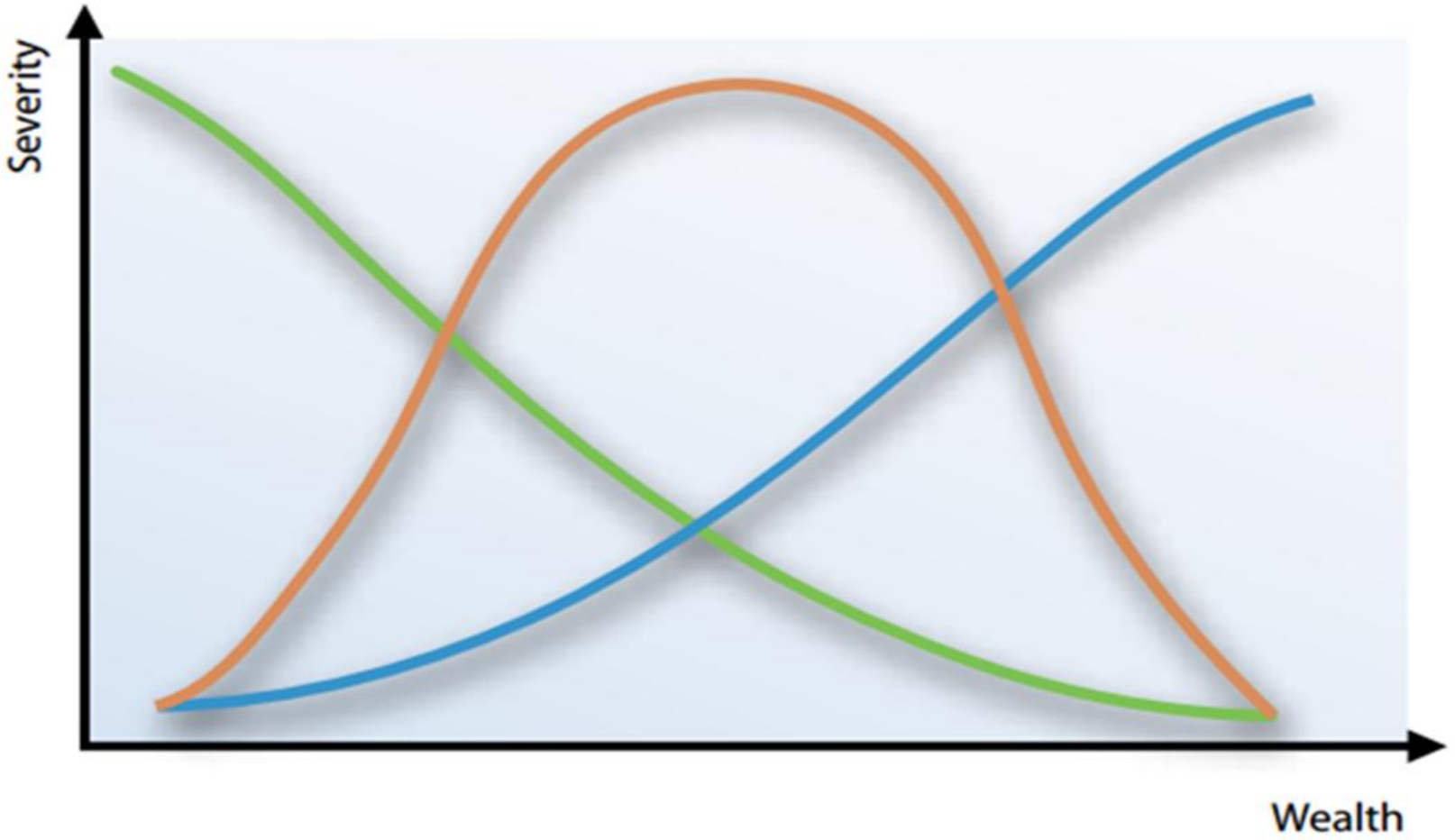


Direct: transport and housing (heating, electricity, fuel consumption)

Indirect: consumption of goods and services

Source: Pang et al., 2020

Shifting burdens (I)



Programme des Nations Unies pour l'environnement. 2011

Shifting environmental burdens

Local → Global

Immediate → Delayed

Threaten health → Threaten life-support systems

Shifting burdens (II)

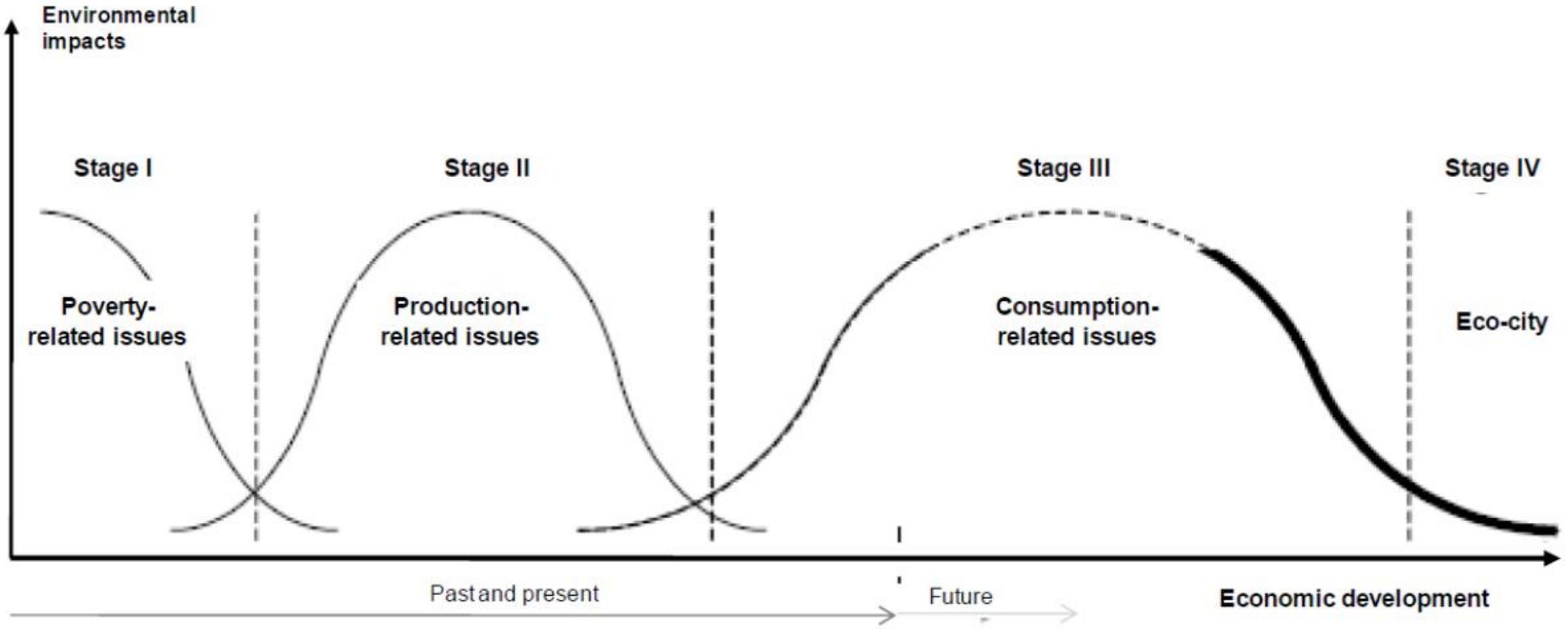


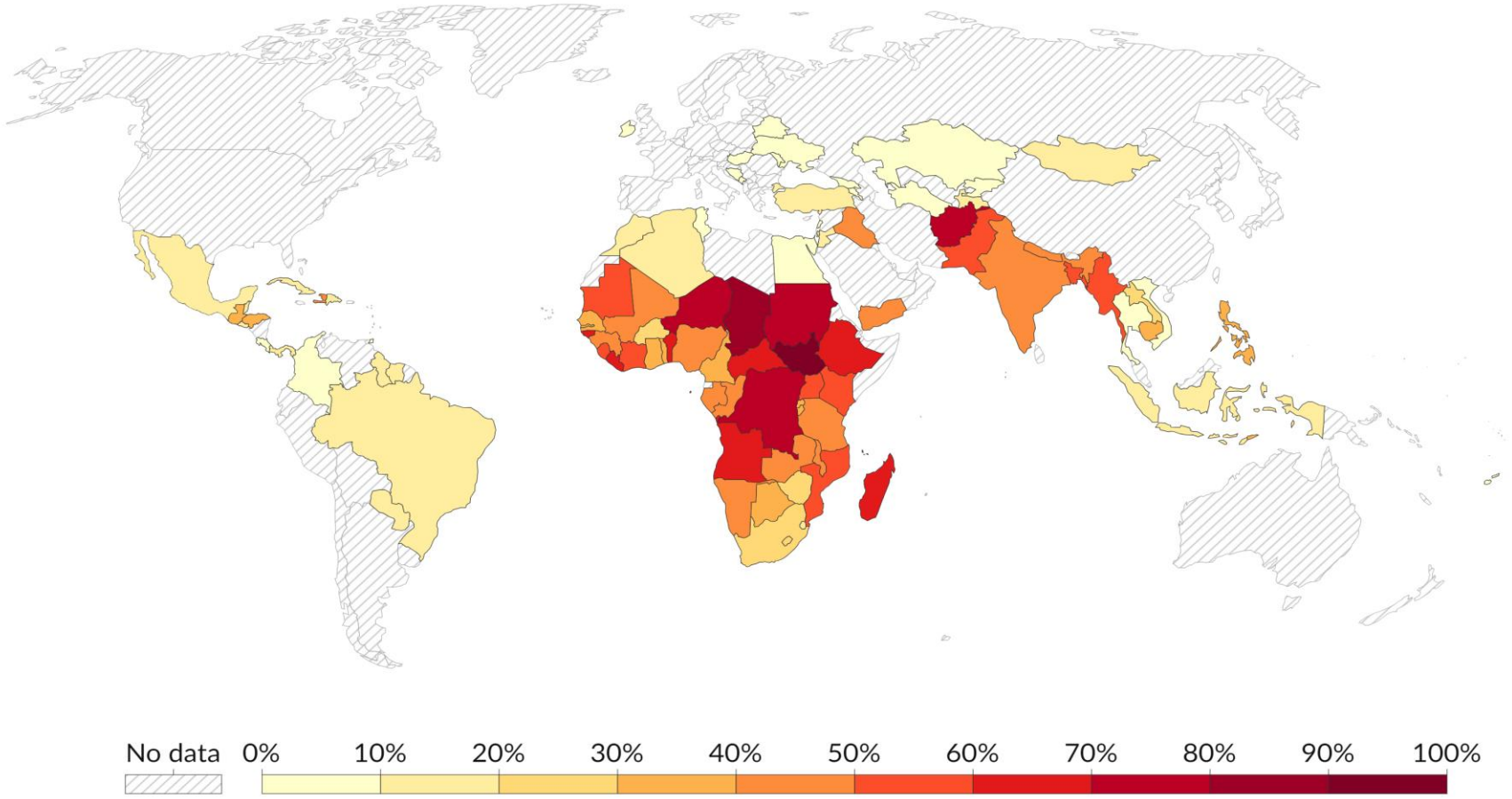
Figure 7 A Typical Evolutionary Trajectory of Environmental Problems in Relation to Economic Development (source: Bai and Imura, 2000[20])

Social issues in cities

Share of the urban population living in slums, 2020

Our World in Data

A slum household is defined as a group of individuals living under the same roof lacking one or more of the following conditions: access to improved water, access to improved sanitation, sufficient living area, durability of housing, and security of tenure.

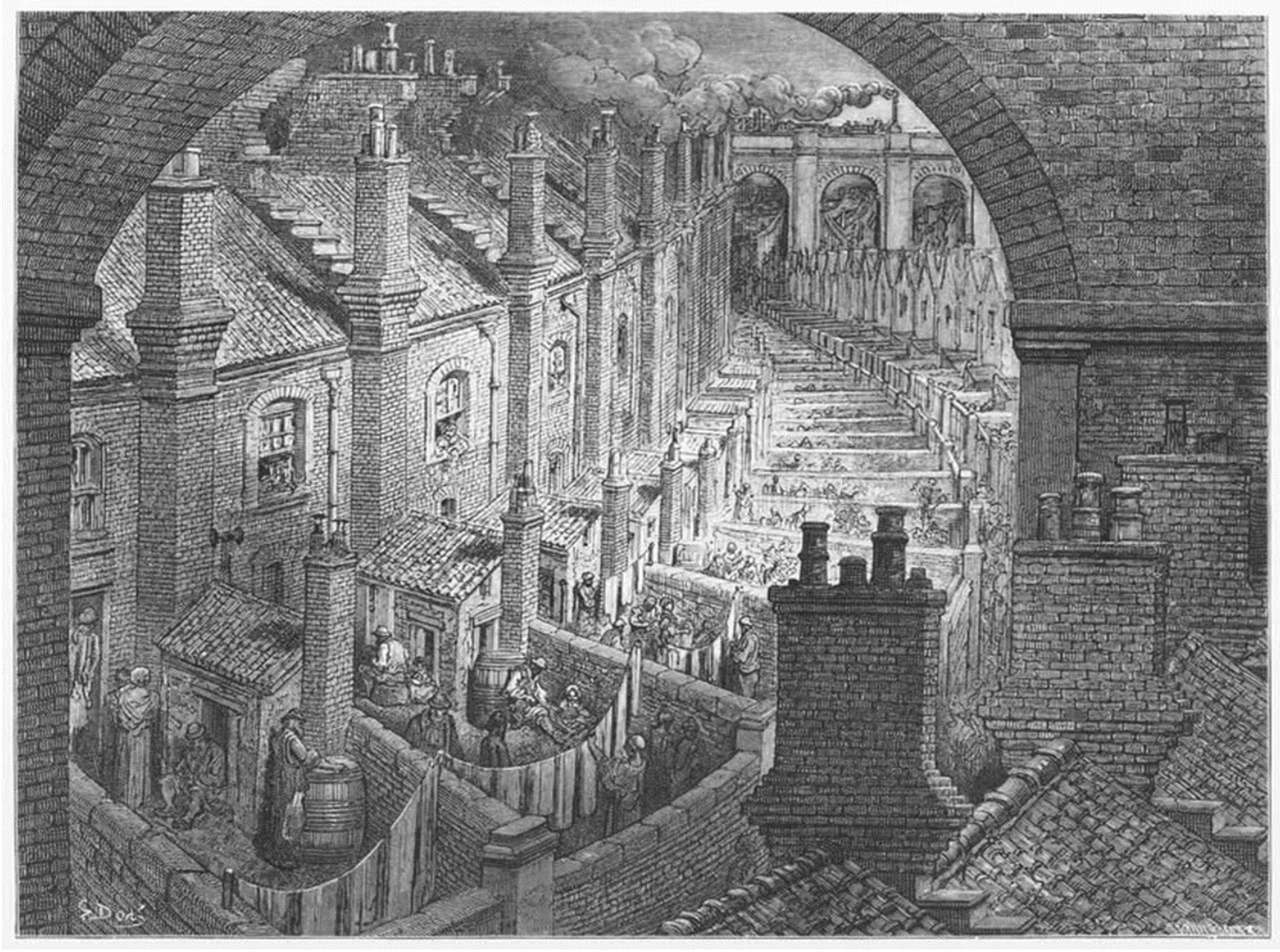


Data source: UN Human Settlements Programme

OurWorldInData.org/urbanization | CC BY

https://ourworldindata.org/grapher/share-of-urban-population-living-in-slums

Slum Cities of the 19th Century



https://en.wikipedia.org/wiki/Slum#/media/File:London_slums_Wellcome_L0000877.jpg

Slum Cities of the 19th Century

https://www.historyextra.com/period/victorian/life-in-19th-century-slums-victorian-londons-homes-from-hell/

Slums in 21st century

https://www.habitatforhumanity.org.uk/what-we-do/slum-rehabilitation/what-is-a-slum/

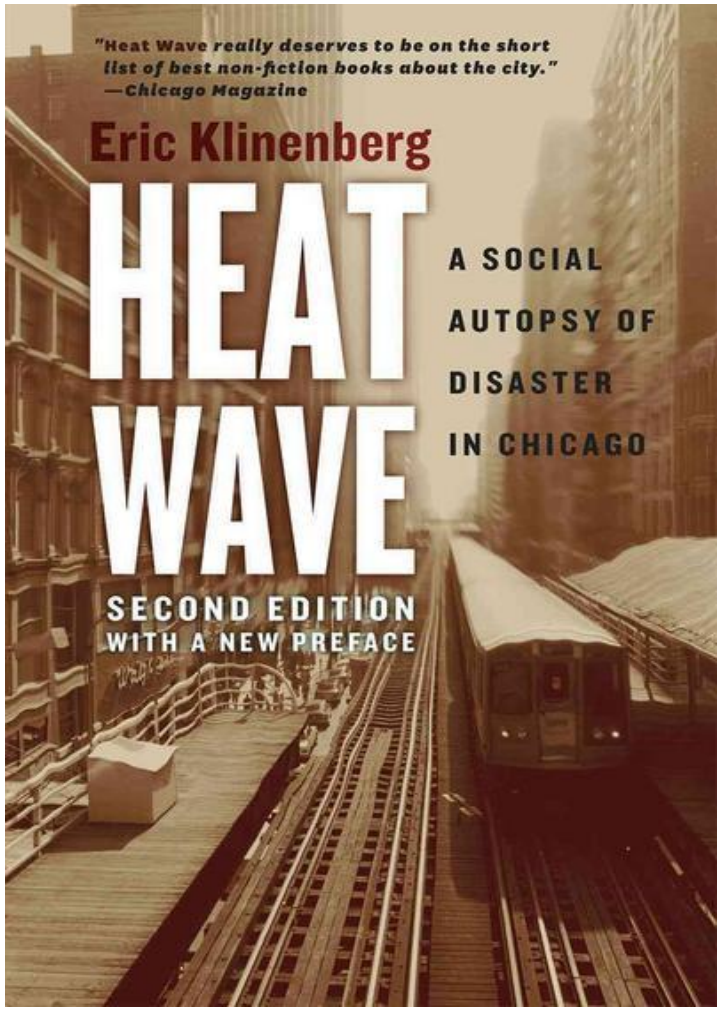
Credit: Tatiana Nurieva - stock.adobe.com

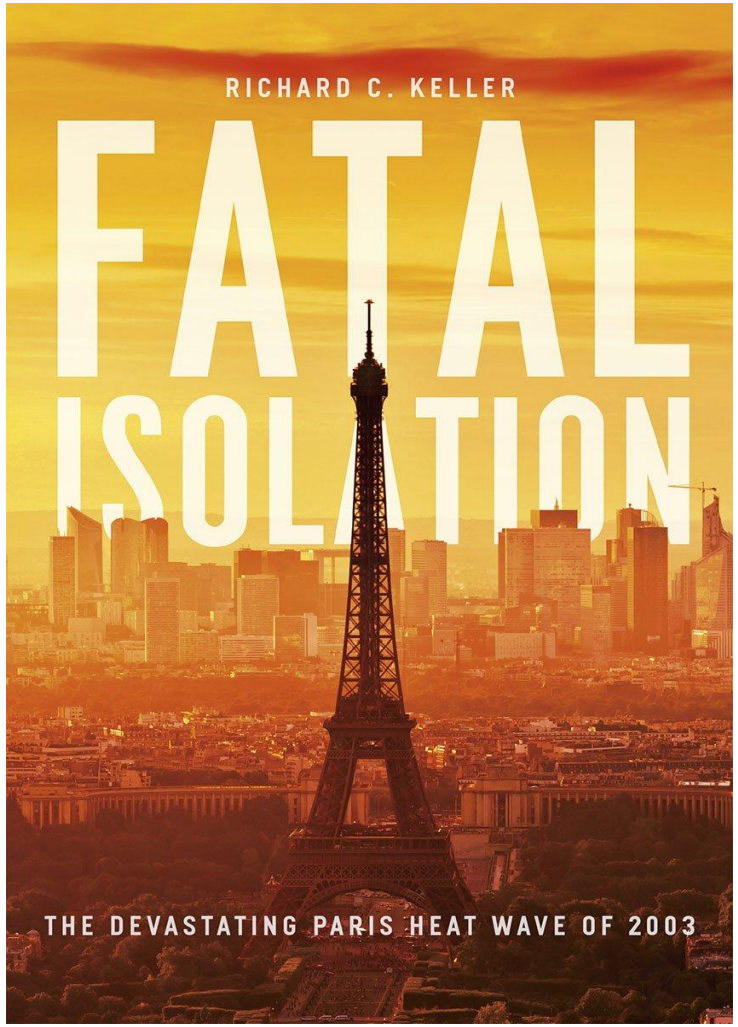
Heat Waves – Urban Heat Islands

2003 Heatwave in Europe: excess mortality of 70’000

July 1995 Chicago Heatwave

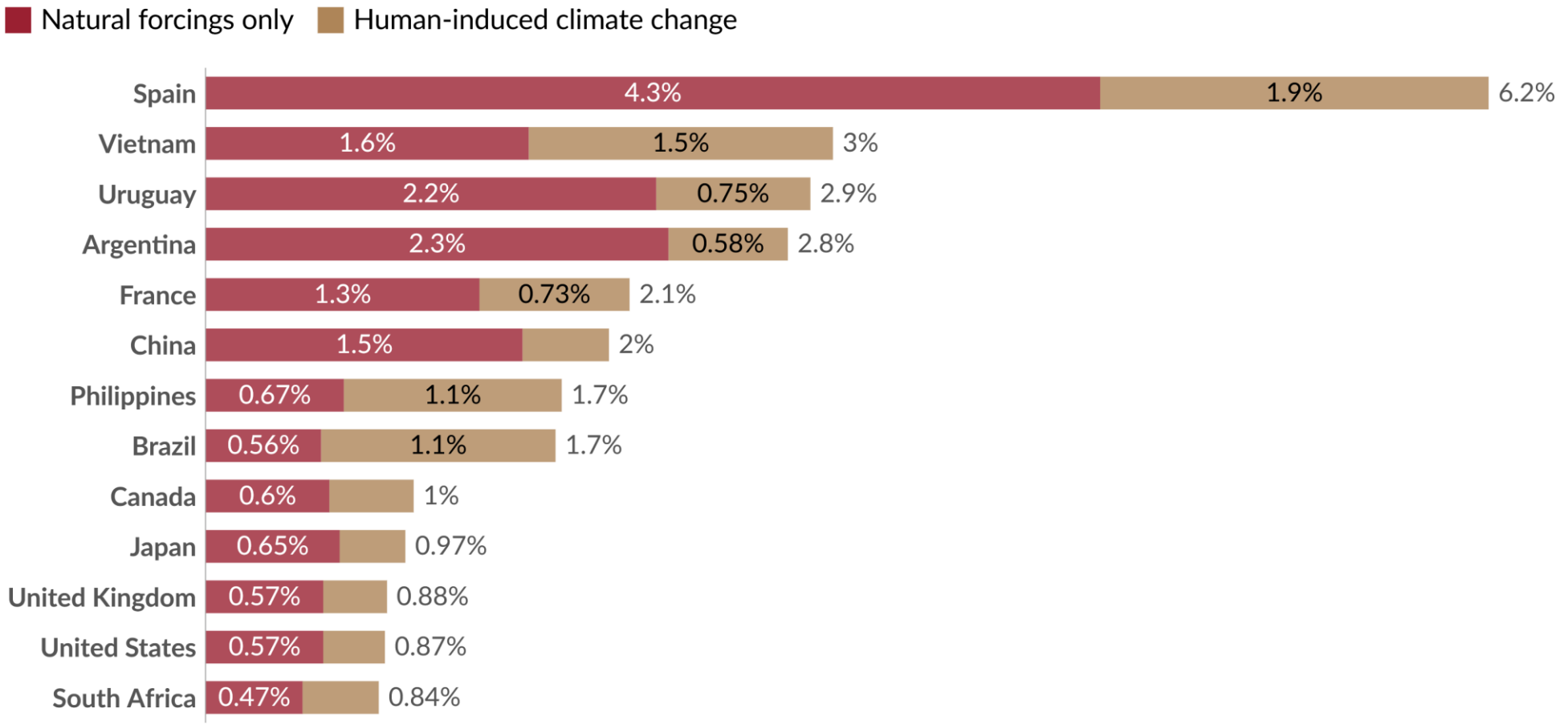
Heat Waves – Social and Geographical Accounts of Disaster





Share of warm-season deaths attributed to heat in a world with and without climate change

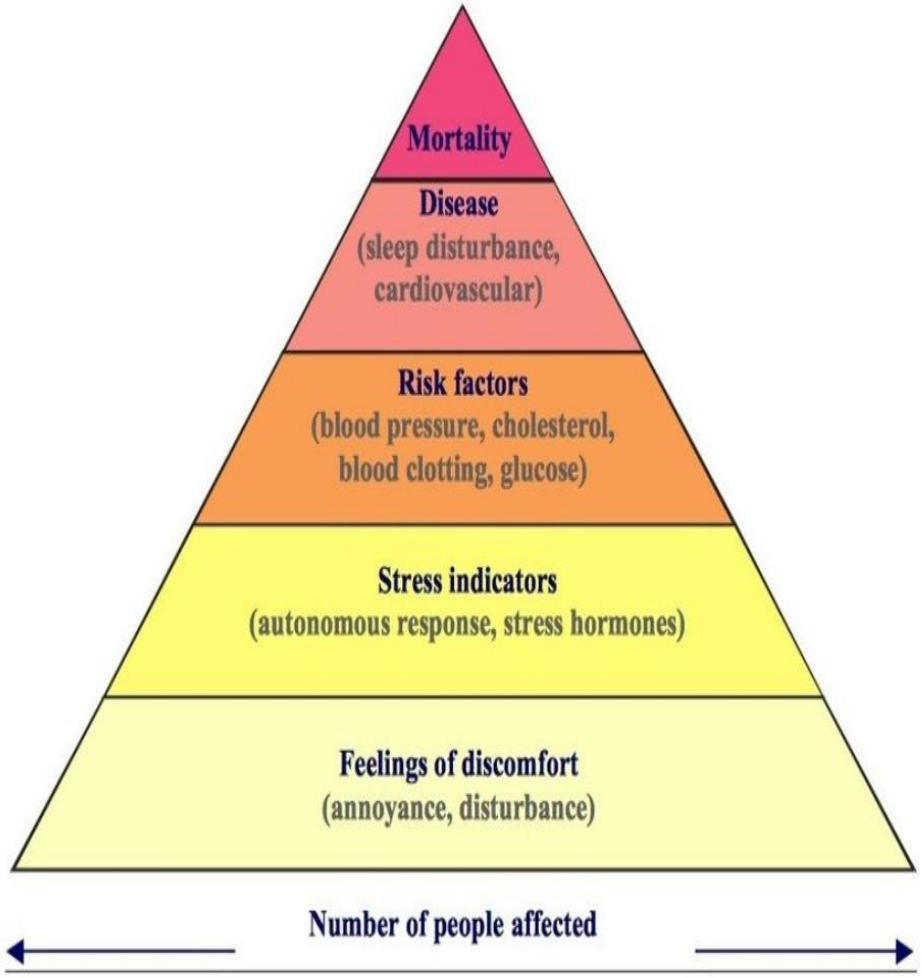
The "warm season" varies by country, but typically lasts 3 to 5 months of the year. Shown is the share of premature deaths in this season that can be attributed to heat, with the natural climate and extra warming from human-induced climate change. Based on data over the period from 1991 to 2018.



Data source: Vicedo-Cabrera et al. (2021). The burden of heat-related mortality attributable to recent human-induced climate change. Nature Climate Change.

OurWorldinData.org/climate-change | CC BY

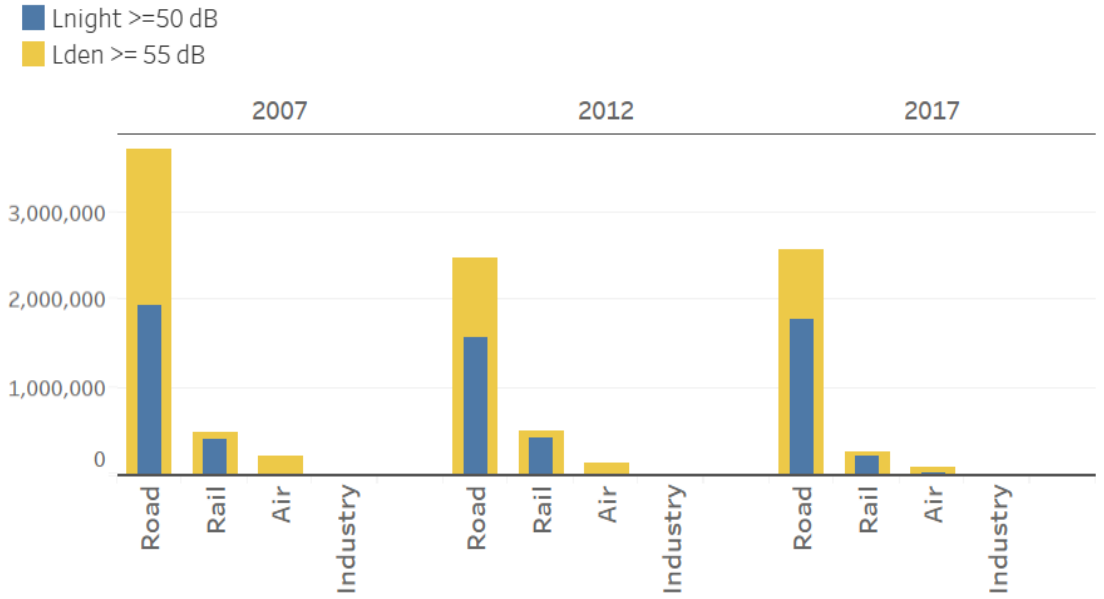
Noise



https://www.weforum.org/agenda/2017/03/these-are-the-cities-with-the-worst-noise-pollution/

Number of people exposed to high noise levels - Switzerland

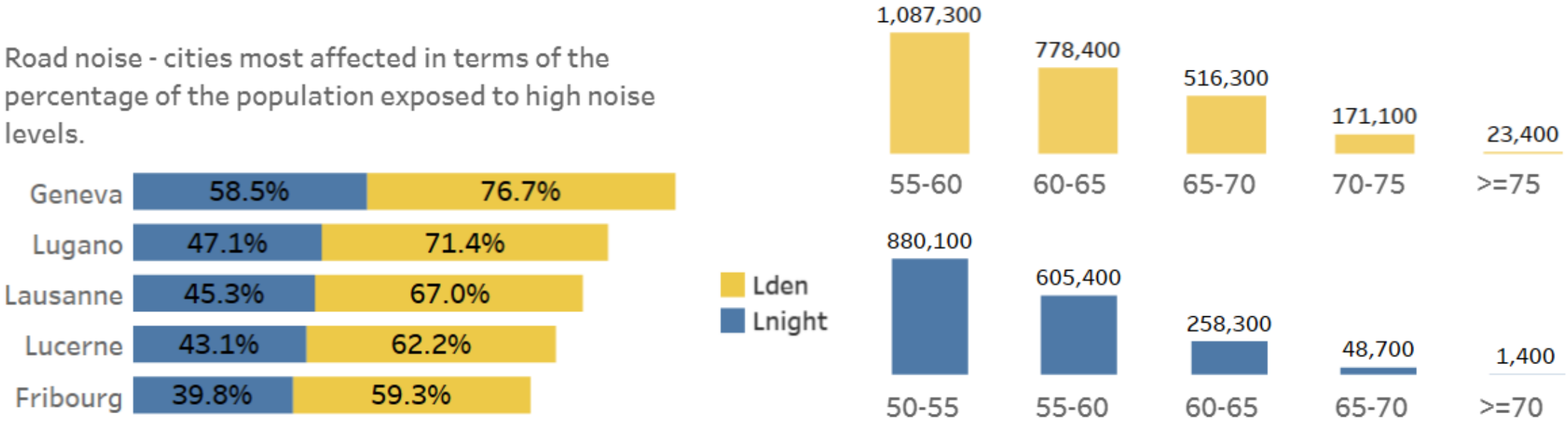
	Lden >= 55 dB			Lnight >=50 dB		
	2007	2012	2017	2007	2012	2017
Road	3,701,300	2,475,200	2,576,500	1,945,000	1,566,900	1,793,900
Rail	496,000	514,900	283,000	407,300	428,000	220,200
Air	213,100	135,200	93,700	8,800	15,300	32,600
Industry	-	-	-	-	-	-



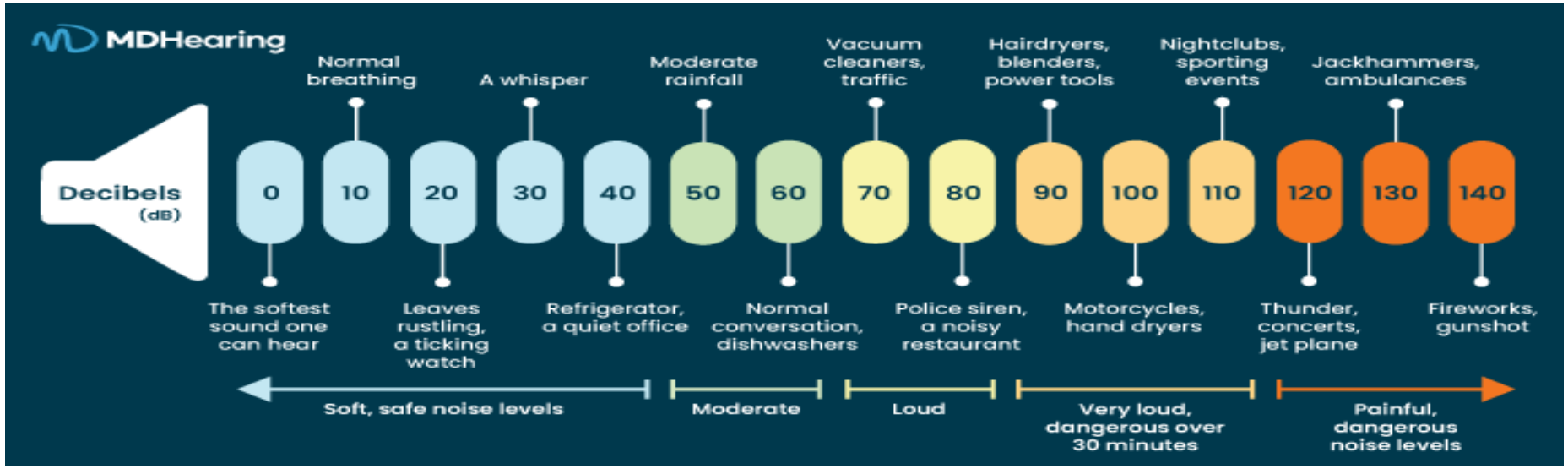
https://www.eea.europa.eu/themes/human/noise/noise-fact-sheets/noise-country-fact-sheets-2021/switzerland-noise-fact-sheet-2018

Which is the noisiest city in Switzerland?

Noisiest Cities in Switzerland



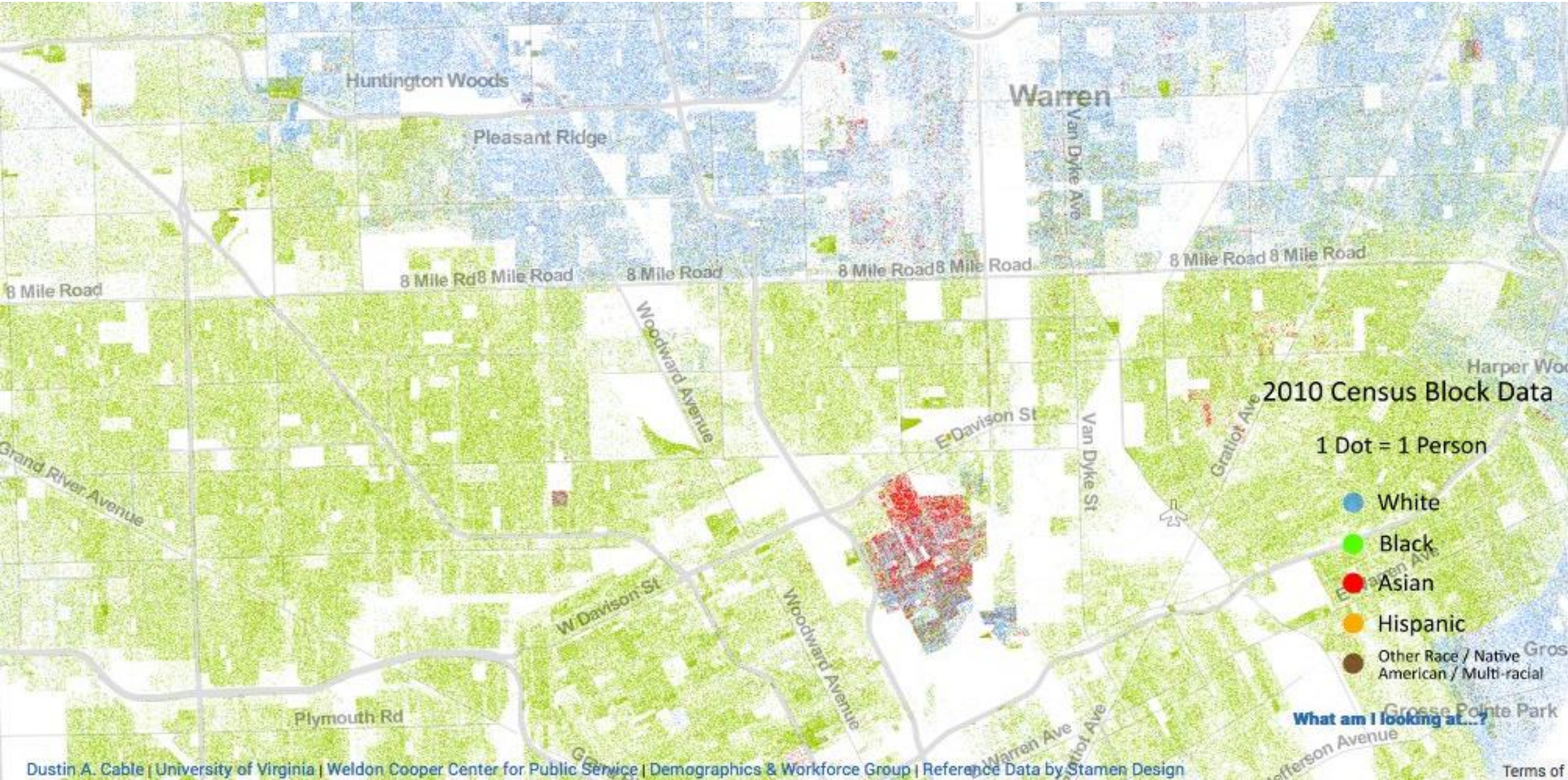
https://www.eea.europa.eu/themes/human/noise/noise-fact-sheets/noise-country-fact-sheets-2021/switzerland-noise-fact-sheet-2018



https://www.mdhearingaid.com/blog/decibel-chart/

Infectious Diseases

Segregation

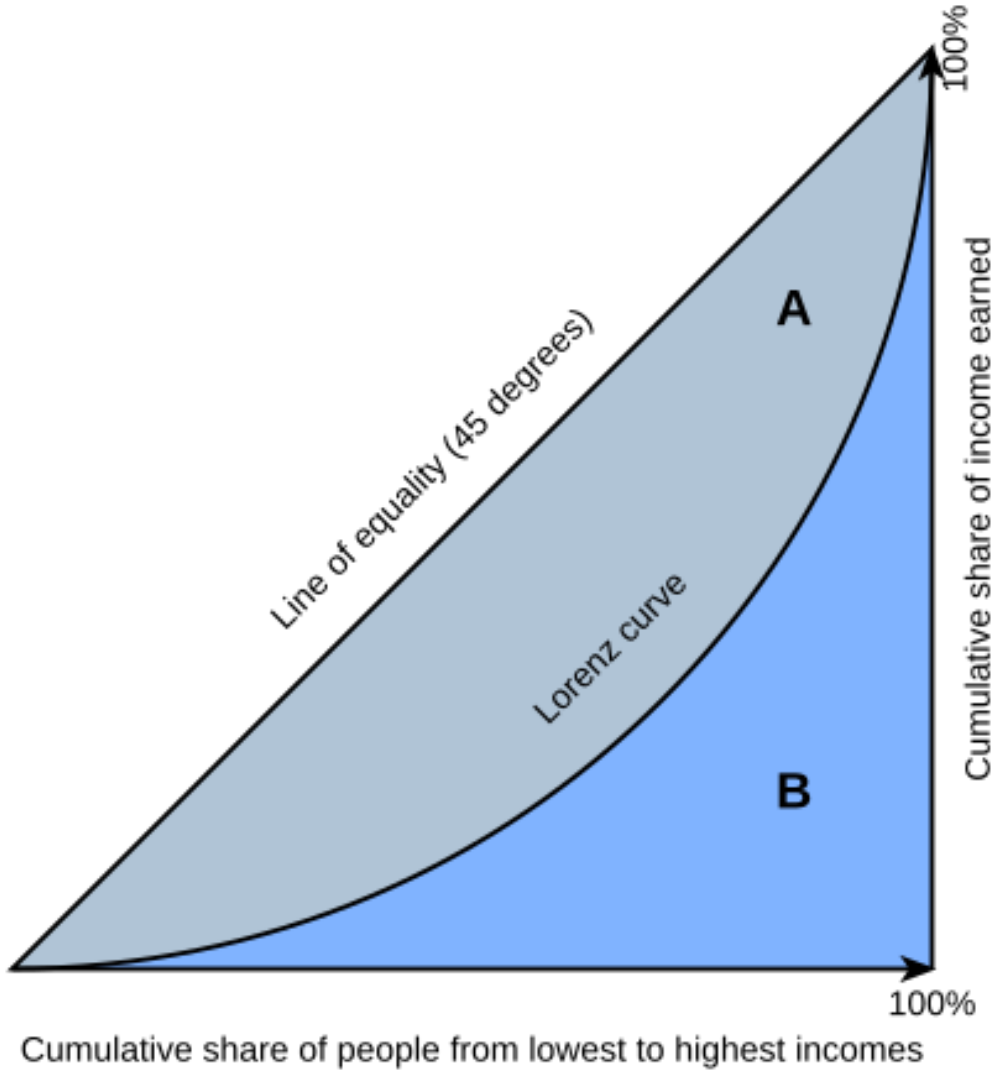


Inequality: The Gini coefficient

The Gini coefficient is **an index for the degree of inequality in the distribution of income/wealth, used to estimate how far a country's wealth or income distribution deviates from an equal distribution**.

https://ourworldindata.org/grapher/economic-inequality-gini-index?time=2023

Gini coefficient calculation



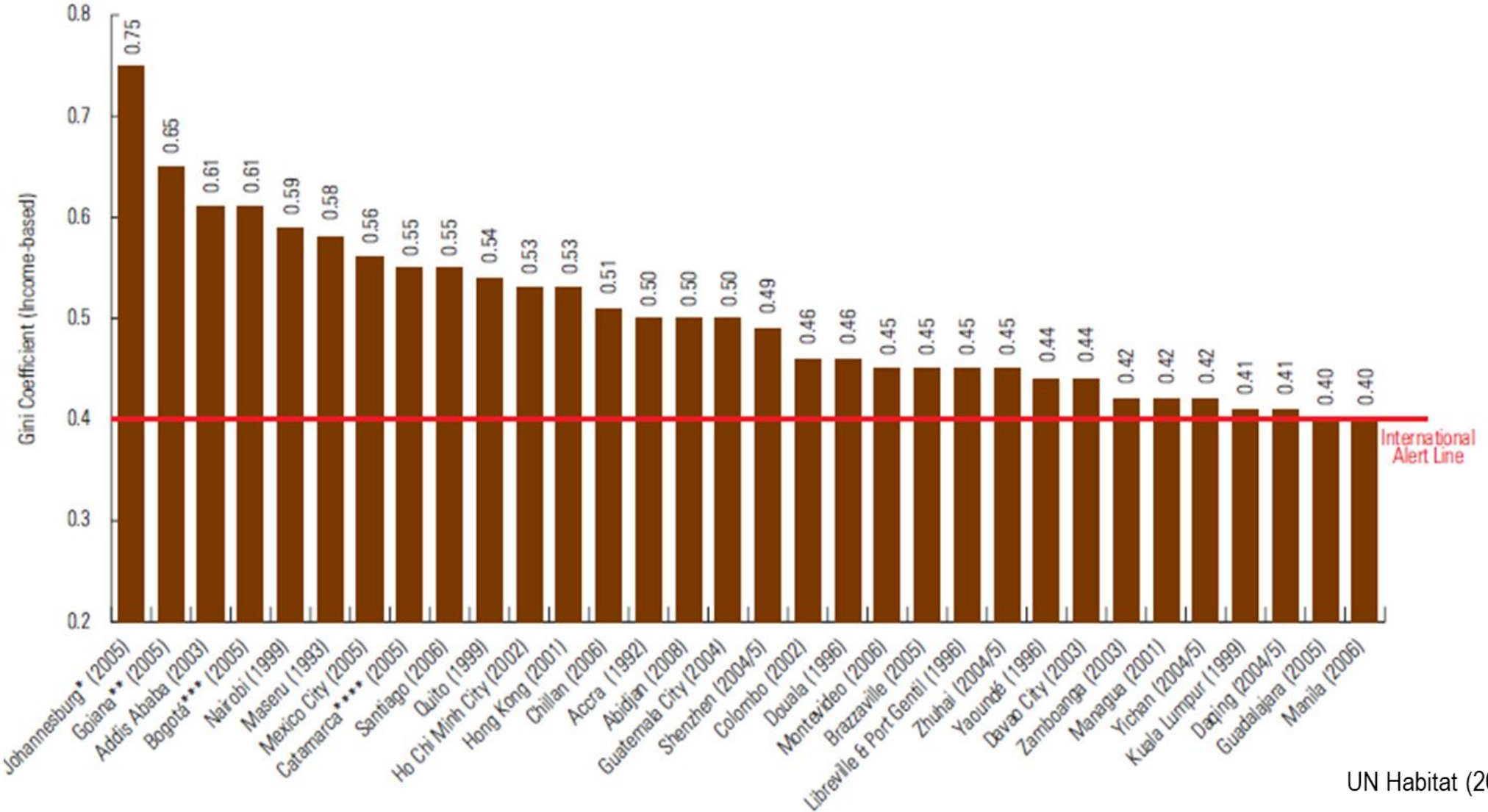
The Gini coefficient is equal to the area marked *A* divided by the total area of *A* and *B*, i.e. Gini = A /A + B .

The axes run from 0 to 1, so *A* and *B* form a triangle of area 1/2 and Gini = 2 A = 1 − 2 B .

Source: Wikipedia

Inequality in cities

FIGURE 2.3: **MOST UNEQUAL CITIES (INCOME-BASED GINI). SELECTED CITIES IN THE DEVELOPING WORLD (1993-2008)**



UN Habitat (2009)

Safety, Crime, Drugs

- Crime rates are often times higher in cities
  - Higher inequality, higher financial returns
  - Low social cohesion
  - Less sense of ownership / community
  - Easier to find accomplices

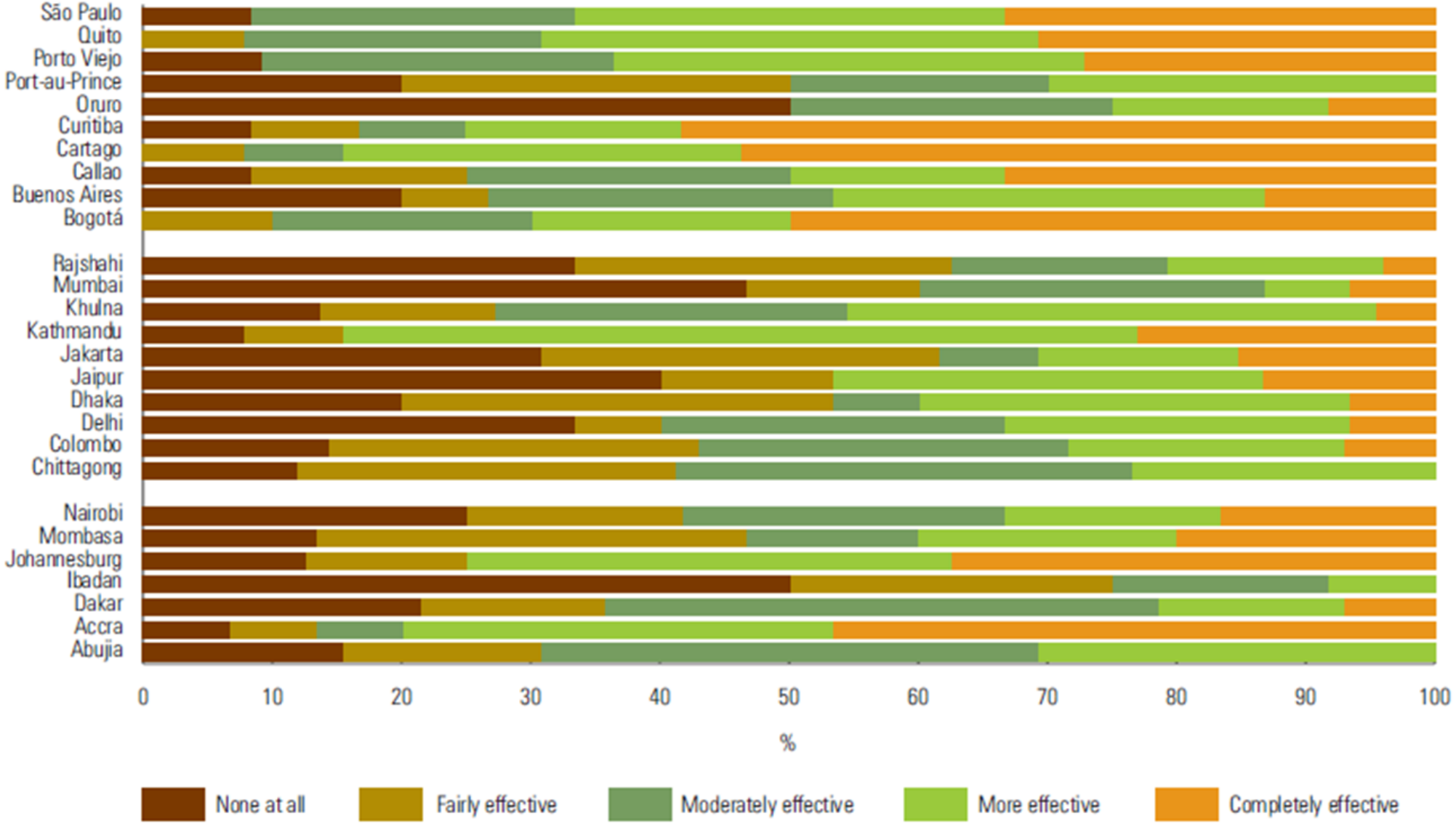
Heygate Estate, South London

- Crack epidemic in US cities, heroin in Zürich

Zurich, Platzpromenade (a.k.a. Platzspitz / Needle Park) in 1980s

Partici-pation

FIGURE 3.2: **PERCEPTIONS OF POLITICAL INCLUSIVENESS: EFFECTIVE RIGHT TO VOICE POLITICAL OPINIONS FREELY - 27 CITIES**

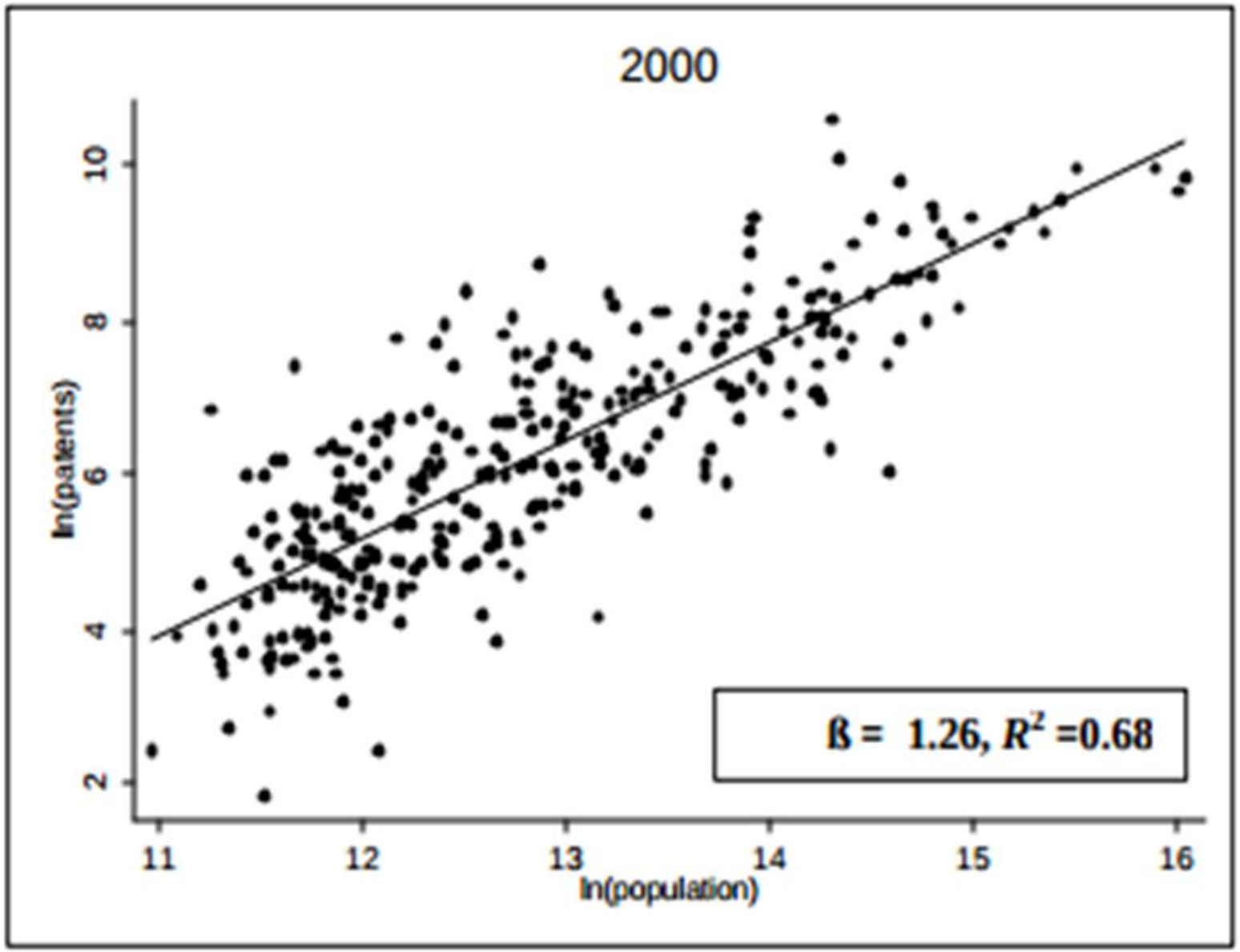


Source: UN-HABITAT, City Monitoring Branch, Policy analysis 2009.

Cities as the core of innovation

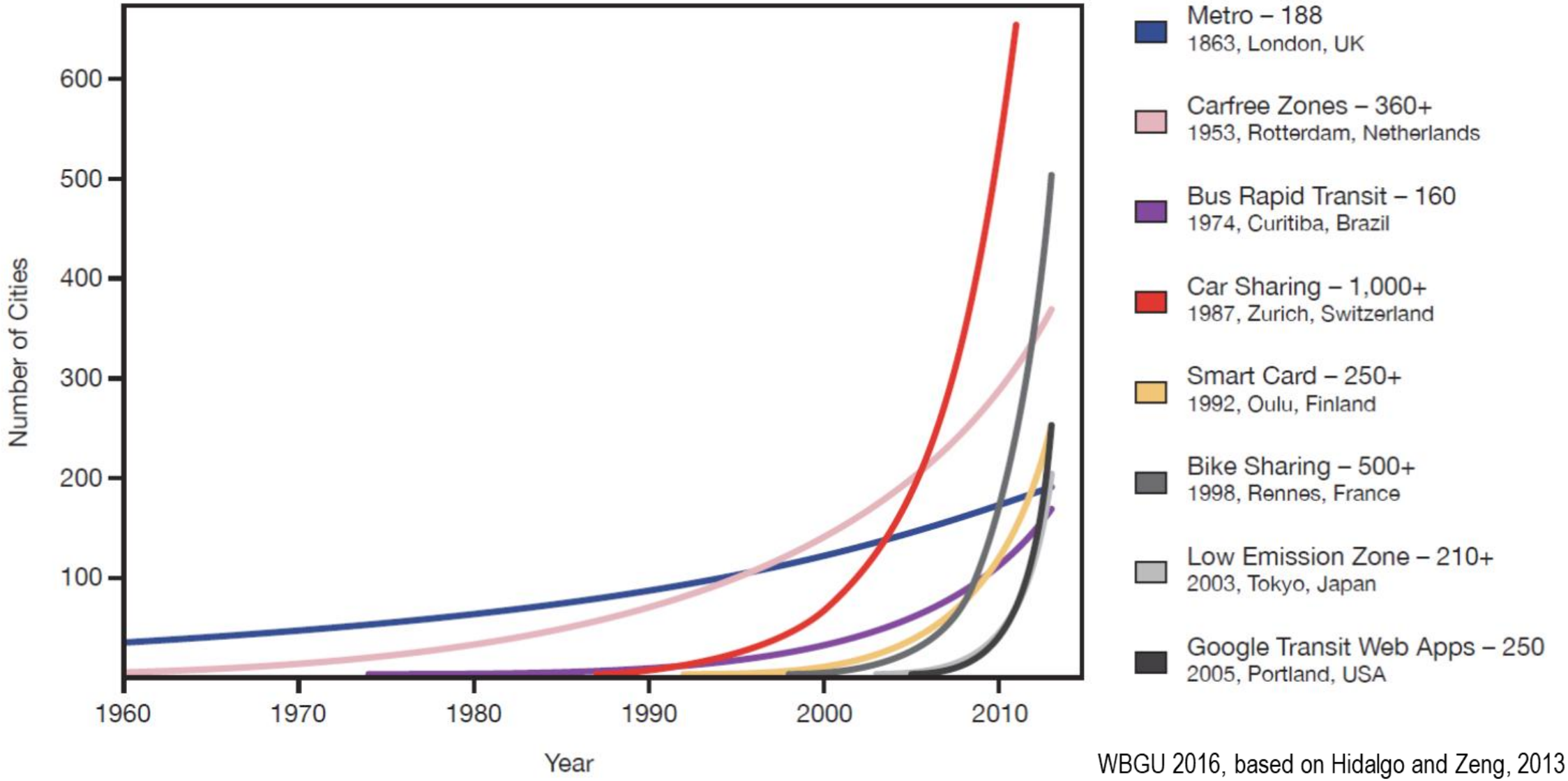
Laboratory on Human-Environment Relations in Urban Systems

Metropolitan patents related to population in cities



Bettencourt, et al. 2004

Urban mobility in upheaval



WBGU 2016, based on Hidalgo and Zeng, 2013

Summary

- **Urbanization** is an ongoing process:
  - More than 50% of global population lives in cities
  - By 2050, about 2/3 of humanity is expected to live in cities (UN & WBGU)
- **Definition of cities** and their boundaries affects sustainability assessments
- Different types of cities are likely to face different **kinds of challenges**
- Sustainability assessments need to be **tailored** to the type of city
- Cities present benefits and challenges to sustainability, **trade-offs**
- Issues are linked (social, environmental, economic...) which is why it makes sense to have a **holistic approach** to sustainability
- Sustainability assessment of urban systems is very important to understand trade-offs and guide decision-makers

”The 19th century was a century of empires, the 20th century, a century of nation states. The 21st century will be a century of cities”

Wellington Webb, former mayor of Denver

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