UNIVERSITÀ
DEGLI STUDI DI TRIESTE

Smart & Sustainable Cities

Giuseppe Borruso

Prof. Giuseppe Borruso

Department of Economics, Business, Mathematics and Statistics “Bruno de Finetti”

University of Trieste - A.Y. 2025 - 2026

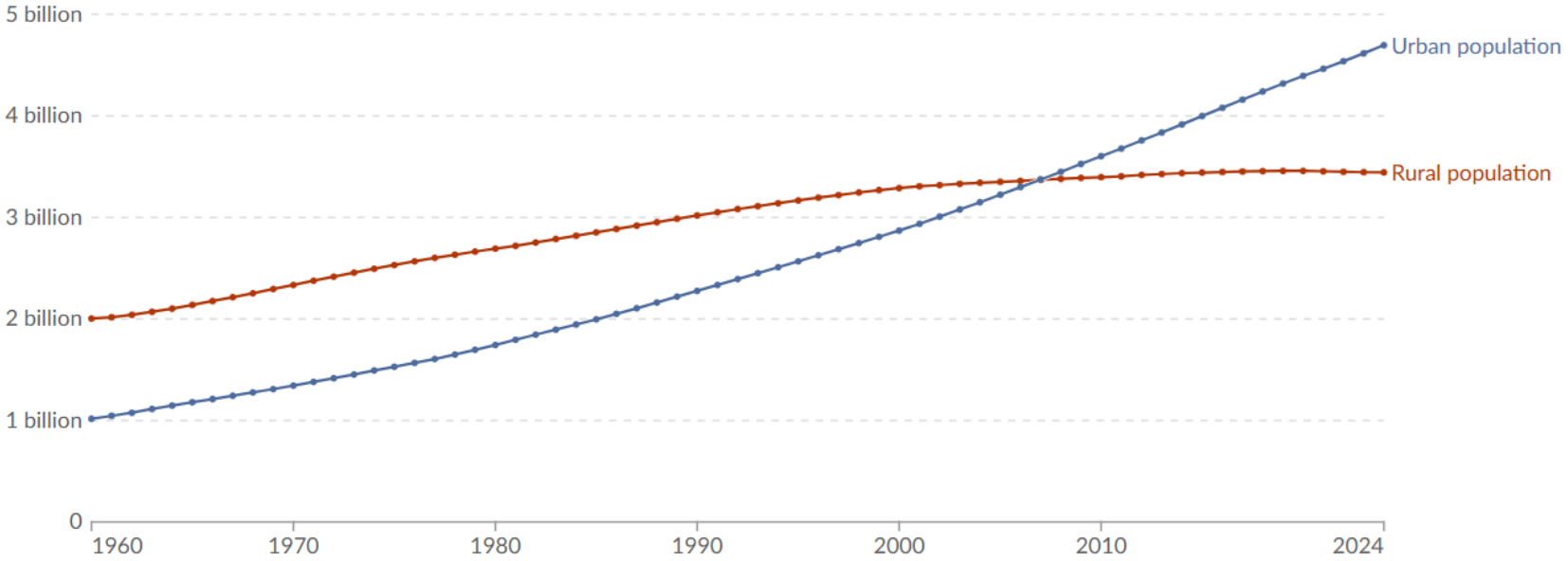
Smart & Sustainable Cities

- Cities represent todays the major **evidences of human footprints** on Earth, hosting 55% of the World population ecosystems, and they produce around 78% of carbon emissions and related pollutants. The growth of the World population over the 8 billion people reached in 2022 will be urban, thefore cities, as major living, production, consumption and decision making places, will be asked to tackle the challenges of the 21st Century.
- The population growth and the ecological transition will require tackling an **unprecedented need of energy, mainly from renewable and new sources**, to reduce the fossil fuel dependence and follow a more sustainable development path.
- As always happened in urban history, cities will need to **adopt the most modern and efficient technologies** to grow and to sustain themselves also in the long run.
- The idea beyond the Smart City is that of relying on the most modern applications of the ICT to the urban environment, in order to adequately manage resources, reduce unbalances and provide present and next generations with a liveable and adequate urban environment.
- An overview on the main characteristics of Smart Cities will be presented, as well as on the different geographical perspectives and applications. Myths, challenges and opportunities will be also analysed, in line with the latest keywords - - as circular, resilient, walkable, 15-minutes, etc. - involving 'cities'.

Number of people living in urban and rural areas, World

Our World in Data

Table | Line | Bar



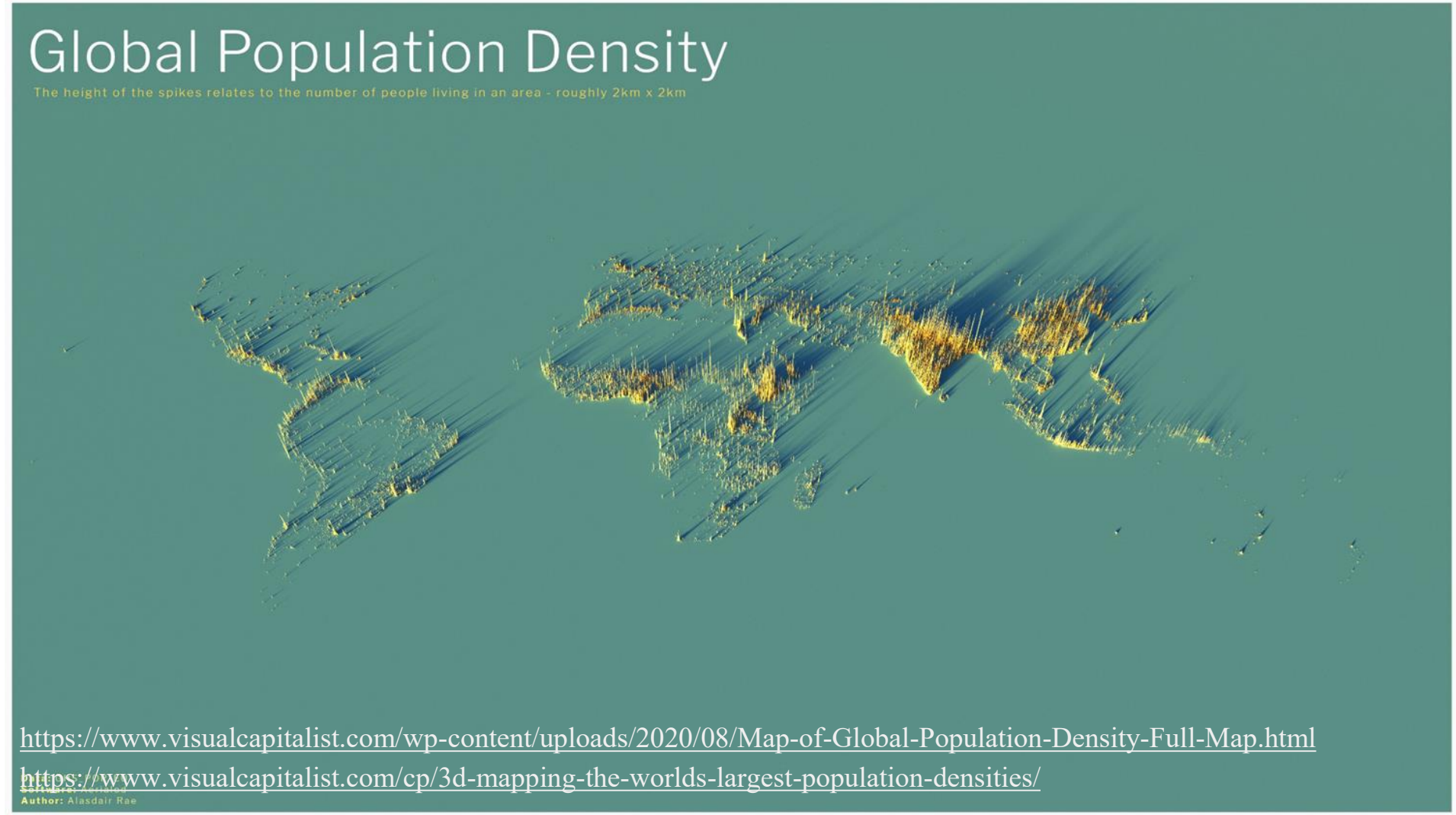
1960 — 2024

Data source: World Bank based on data from the UN Population Division (2025) – Learn more about this data

OurWorldinData.org/urbanization | CC BY

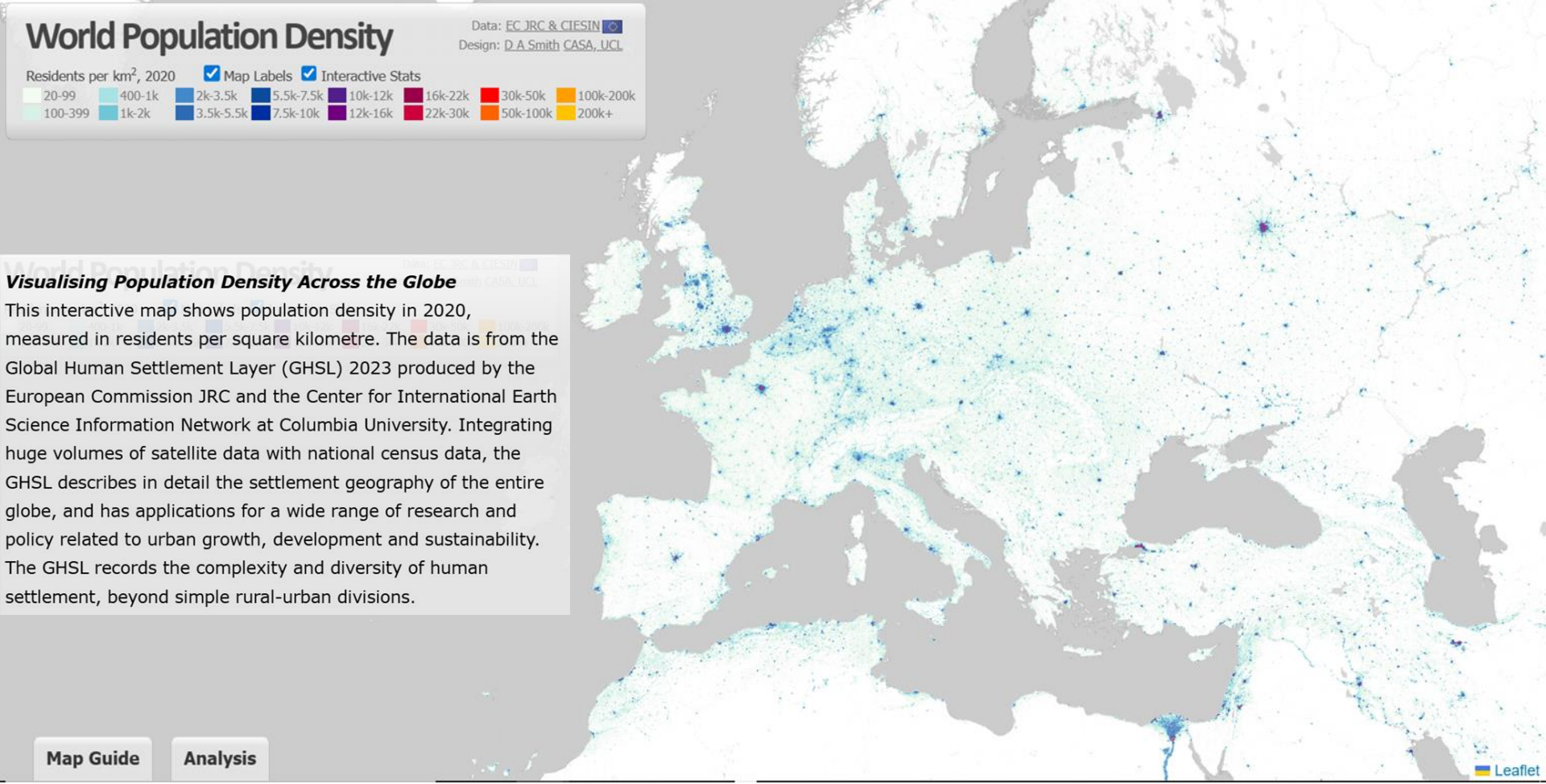
Note: Because the estimates of city and metropolitan areas are based on national definitions of what constitutes a city or metropolitan area, cross-country comparisons should be made with caution.

https://ourworldindata.org/urbanization



https://www.visualcapitalist.com/wp-content/uploads/2020/08/Map-of-Global-Population-Density-Full-Map.html

https://www.visualcapitalist.com/cp/3d-mapping-the-worlds-largest-population-densities/



https://luminocity3d.org/WorldPopDen/#4/48.98/1.23
https://citygeographics.org/2023/05/21/world-population-density-map-update/

Cities

The city: a difficult definition. Criteria:

- Topographic – construction (= concentration of buildings)
- Demographic (= concentration of inhabitants)
- I.e., urban population in centres > 2.000 inhabitants
- Economic (= concentration of activities)

Quantity and quality of concentration:
different activities and different from agriculture, extra-urban demand

=>

- Functional definition:
- Aggregation of people to better realise some activities

(activity = a function of the city);

- Cities as rare, ,non ubiquitous in the geographical space produce functions over a service area

https://ourworldindata.org/grapher/countries-with-minimum-urban-threshold

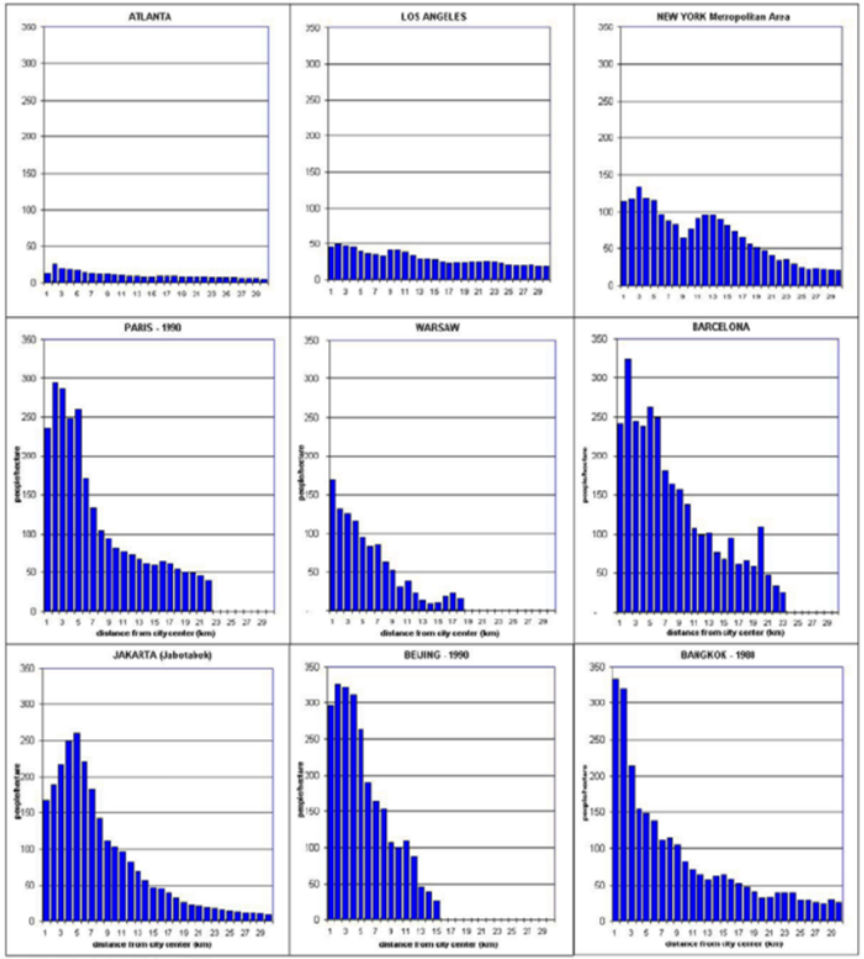
Urban functions and gravitation

Urban functions:

- *city serving*
  - Activities that depend on the existence of the city itself;
  - Aimed at satisfying inhabitants' needs (i.e., retail, schools, etc.)
- *city forming*
  - Essence of the city: i.e., specialized medical services, university and research centres, specialized banks, etc.
  - Sectors of activity or single companies can work both for the internal urban market and for a wider area

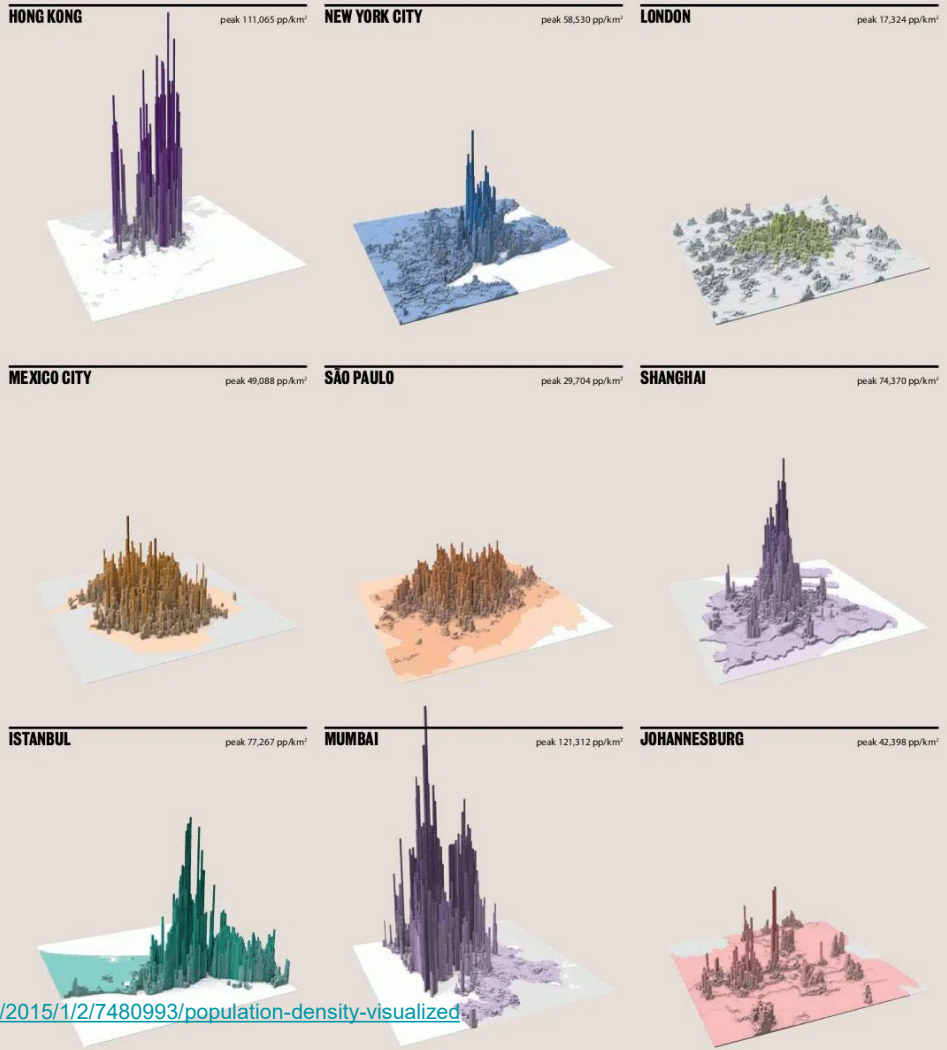
=>

Analysis on gravitation towards cities to identify the borders of such area

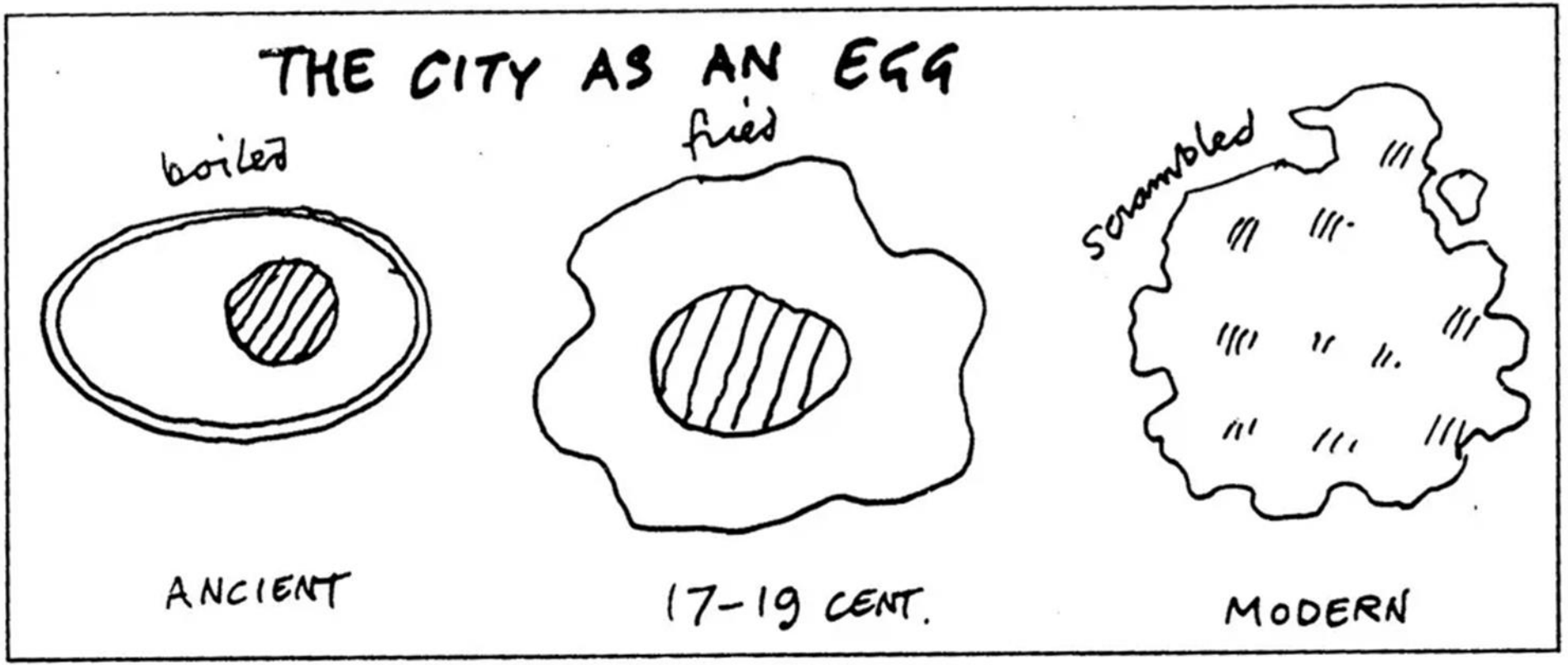


https://www.researchgate.net/figure/Density-Profile-of-9-Cities_fig4_45131759; https://www.vox.com/2015/1/2/7480993/population-density-visualized

Density Profile of 9 Cities

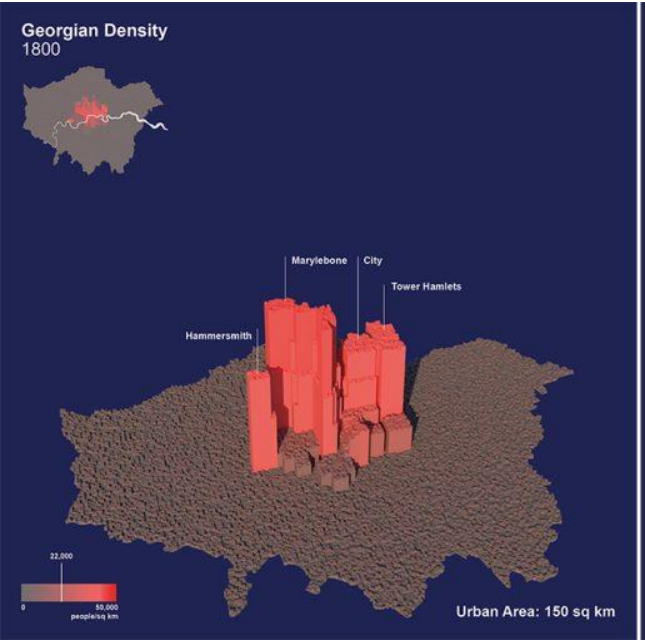


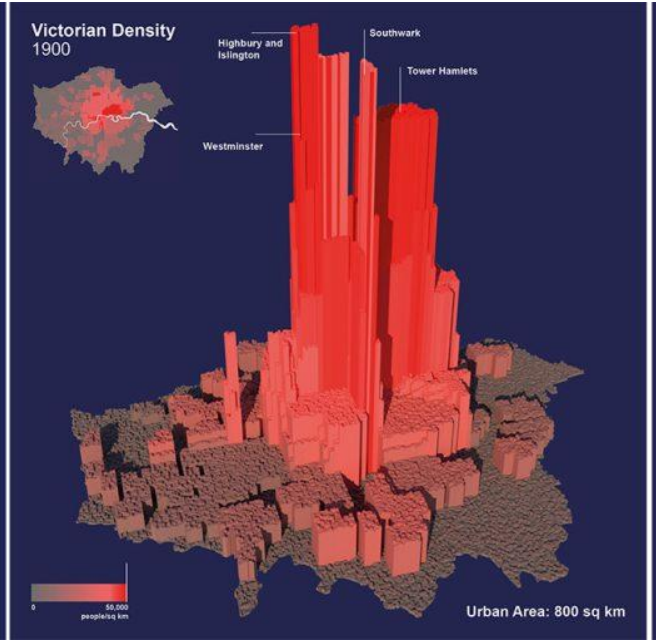
The city as an egg

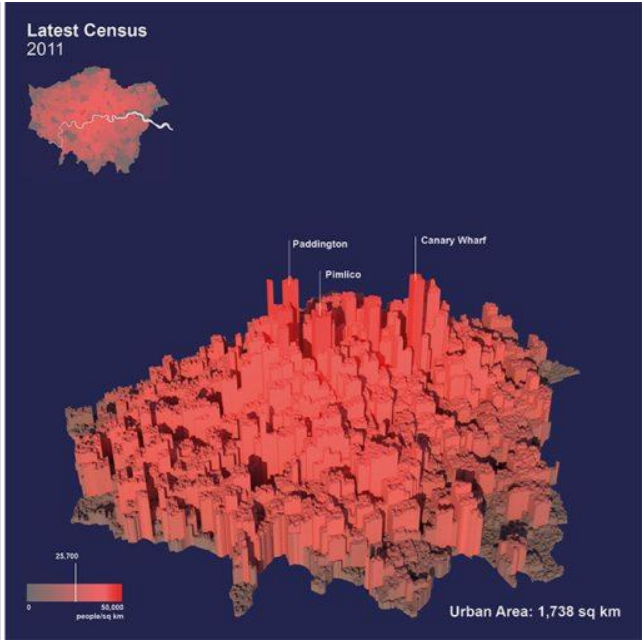


https://bigthink.com/strange-maps/534-the-eggs-of-price-an-ovo-urban-analogy/

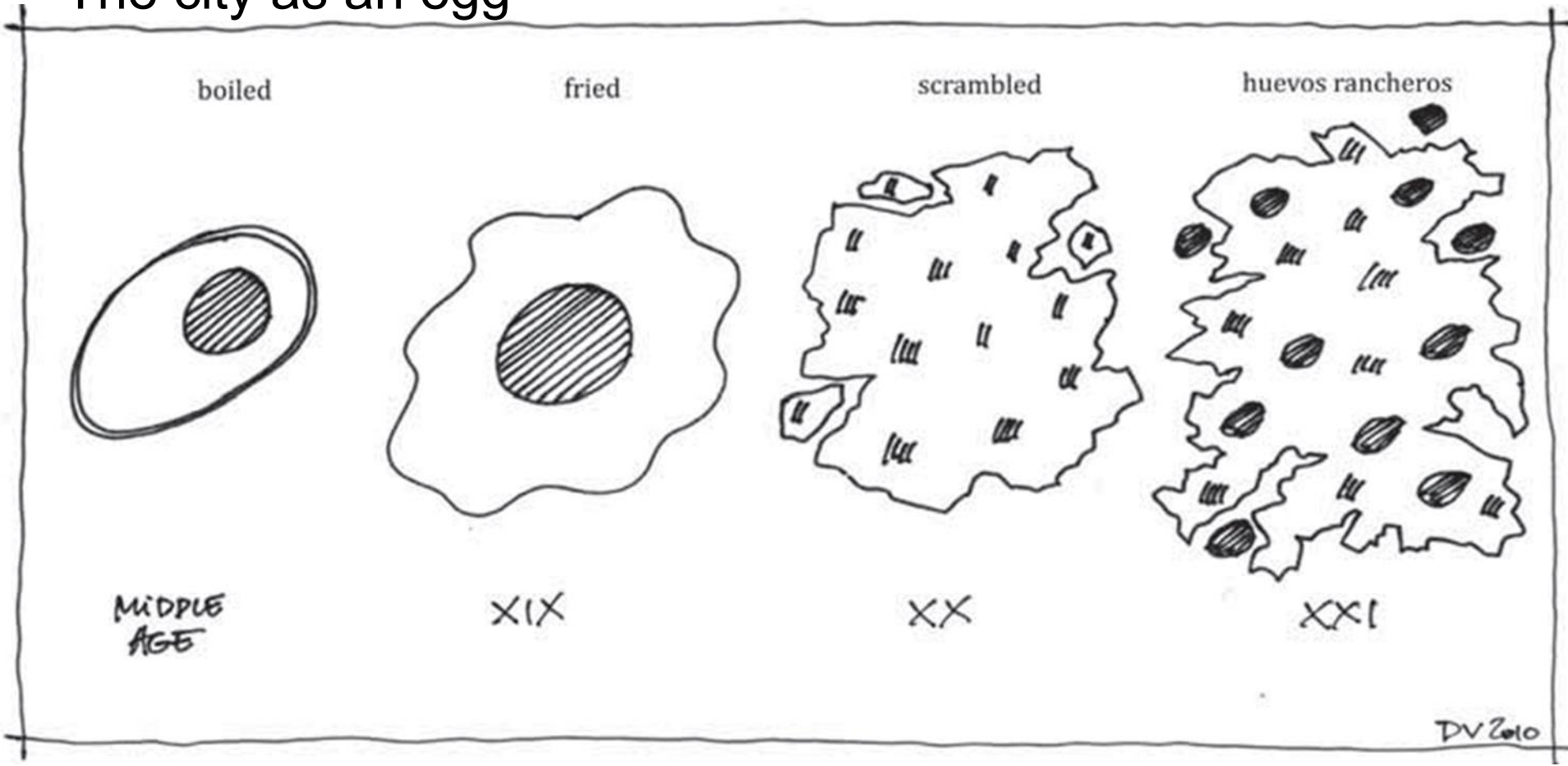
Understanding urban density







The city as an egg



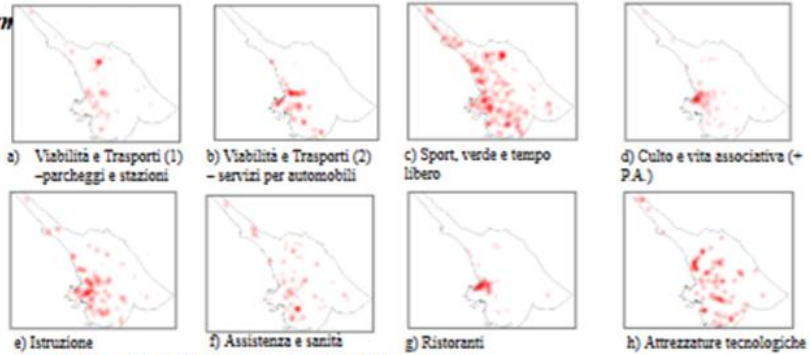
èhttps://www.researchgate.net/figure/The-Form-of-the-City-Vancutsem-2010-adapted-from-The-City-as-an-Egg-Source-Price_fig2_255717111

1) Disaggregazione dei dati

Tabella 1 – indicatori intermedi e tipologie di servizi urbani

In questa fase iniziale dello studio i servizi sono stati raggruppati in otto raggruppamenti, corrispondenti ad altrettanti *layers* nel database, in qualità di servizi di tipo urbano. Altre tipologie di servizio verranno considerate in successive fasi

2) Analisi di densità sugli indicatori intermedi



a) Viabilità e Trasporti (1) –parcheggi e stazioni
b) Viabilità e Trasporti (2) – servizi per automobili
c) Sport, verde e tempo libero
d) Culto e vita associativa (+ P.A.)
e) Istruzione
f) Assistenza e sanità
g) Ristoranti
h) Attrezzature tecnologiche

Figura 3 KDE su alcuni indicatori intermedi (soglia di 500 m; grid 100 m)

3) Standardizzazione

Gli indicatori intermedi si presentano come layers composti di celle i cui attributi rappresentano valori di densità del fenomeno. Tali valori vengono normalizzati secondo la funzione

$$Z = \frac{X - \mu}{\sigma}$$

al fine di ottenere dei valori omogenei e confrontabili.

4) Overlay

Gli indicatori intermedi sono stati sommati nei loro valori standardizzati. Le diverse celle di ogni *layers* sono così state sommate tra loro a fornire l'indice finale di offerta dei servizi urbani.

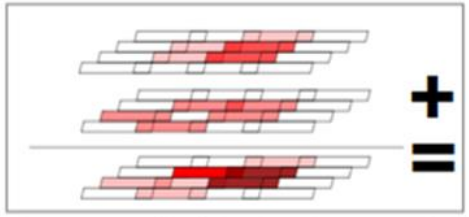


Figura 4 Schema di sovrapposizione dei *layers* intermedi e ottenimento dell'indice finale

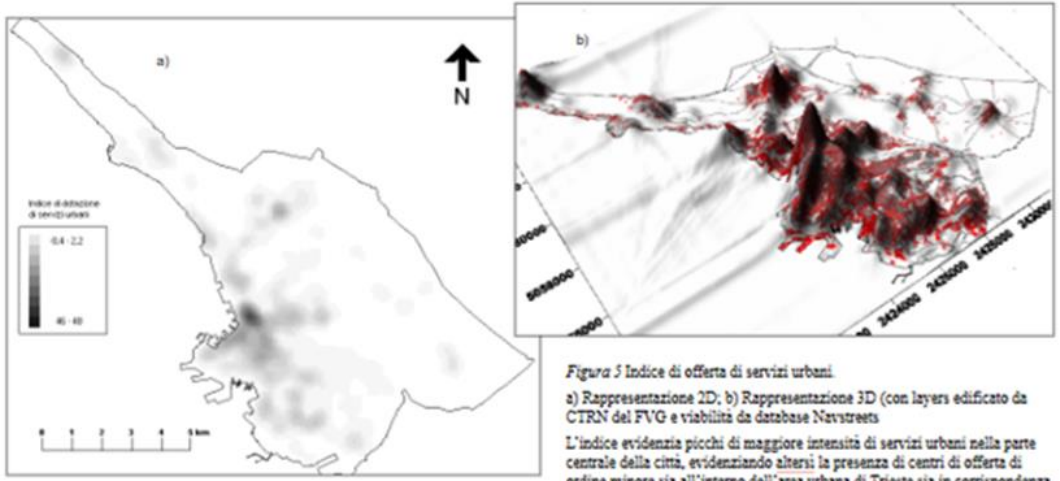


Figura 5 Indice di offerta di servizi urbani.

a) Rappresentazione 2D; b) Rappresentazione 3D (con layers edificato da CTRN del FVG e viabilità da database Navstreets

L'indice evidenzia picchi di maggiore intensità di servizi urbani nella parte centrale della città, evidenziando altresì la presenza di centri di offerta di ordine minore sia all'interno dell'area urbana di Trieste sia in corrispondenza agli insediamenti di cintura alla città

Sustainability & Cities

Sustainability: meeting the needs of the present without compromising the ability of future generations to meet their own needs (Brundtland Commission, 1987)

A sustainable city is an urban area designed to balance social, economic, and environmental priorities to ensure a high quality of life for both current and future generations. It aims to adapt to and mitigate environmental changes while promoting resilience, inclusivity, and economic vitality.

A smart city can be defined as an urban area that leverages advanced digital technologies, data analytics, and innovative governance to enhance the efficiency, sustainability, and quality of life for its residents.

What is a smart city?

A smart city is a place where traditional networks and services are made more efficient with the use of digital solutions for the benefit of its inhabitants and business.

A smart city goes beyond the use of digital technologies for better resource use and less emissions. It means smarter urban transport networks, upgraded water supply and waste disposal facilities and more efficient ways to light and heat buildings. It also means a more interactive and responsive city administration, safer public spaces and meeting the needs of an ageing population

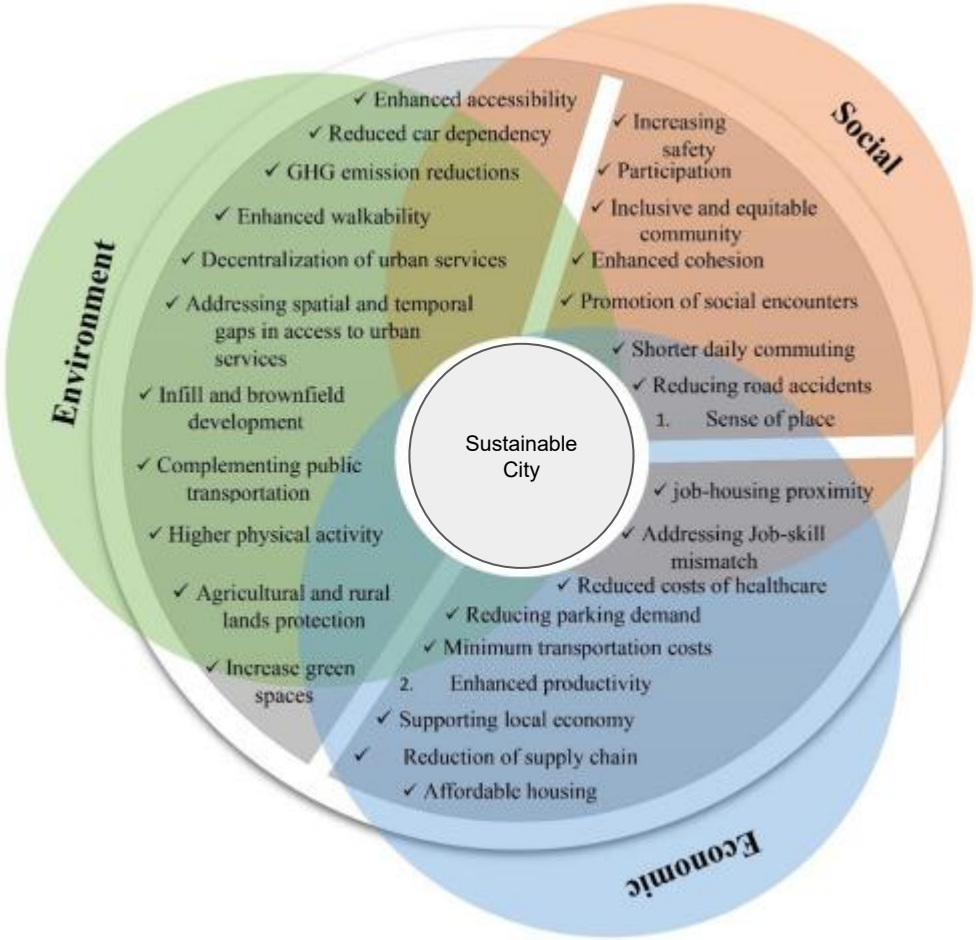
https://commission.europa.eu/eu-regional-and-urban-development/topics/cities-and-urban-development/city-initiatives/smart-cities_en

What is a smart city?

A city is smart when investments in human and social capital and traditional (transport) and modern (ICT) communication infrastructure fuel sustainable economic growth and a high quality of life, with a wise management of natural resources, through participatory governance.

Smart cities in Europe Andrea Caragliu, Chiara Del Bo, Peter Nijkamp

degree.ubvu.vu.nl/repec/vua/wpaper/pdf/20090048.pdf


Environment
✓ Enhanced accessibility
✓ Reduced car dependency
✓ GHG emission reductions
✓ Enhanced walkability
✓ Decentralization of urban services
✓ Addressing spatial and temporal gaps in access to urban services
✓ Infill and brownfield development
✓ Complementing public transportation
✓ Higher physical activity
✓ Agricultural and rural lands protection
✓ Increase green spaces
Social
✓ Increasing safety
✓ Participation
✓ Inclusive and equitable community
✓ Enhanced cohesion
✓ Promotion of social encounters
✓ Shorter daily commuting
✓ Reducing road accidents
1. Sense of place
Sustainable City
✓ job-housing proximity
✓ Addressing Job-skill mismatch
✓ Reduced costs of healthcare
✓ Reducing parking demand
✓ Minimum transportation costs
2. Enhanced productivity
✓ Supporting local economy
✓ Reduction of supply chain
✓ Affordable housing
Economic

Smart & Sustainable Cities

Dimension	Variables
Smart Economy	Employment rate; presence of innovative enterprises, presence and quality of universities and research institutes; infrastructures (roads, railways, airports, electronic infrastructures, etc.).
Smart Environment	Air quality, percentage of separate collection of municipal waste (also electrical and electronic equipment waste), presence of green spaces in the city, efficiency and quality of water supply (water leakage and water treatment).
Smart Governance	Not only related to e-government, percentage of ecological cars, use of recycled paper, energy saving, adoption of ecological policies for city planning and development, ability to network with other municipalities.
Smart Living	Investments in culture and welfare providing several services, from childcare facilities to community libraries, from counselling structures for old people to cinemas, number of people below poverty level, hospital emigration rate, immigrants social integration, criminality rate.
Smart Mobility	Extensive and efficient public transportation network, park and ride, great diffusion of ecological cars, limited traffic areas, cycle paths, bike and car sharing.
Smart People	Education and early school leaving level, number of women working and holds positions within the administration, presence of foreign students, political participation, involvement in voluntary associations, newspapers diffusion and level of participation to cultural events.

Characteristics of a Sustainable City

- Energy saving
- Pedestrian friendly
- Lots of vegetation
- Accessible public transportation
- Sustainable buildings
- Urban farming
- Community engagement

The concept of Smart City

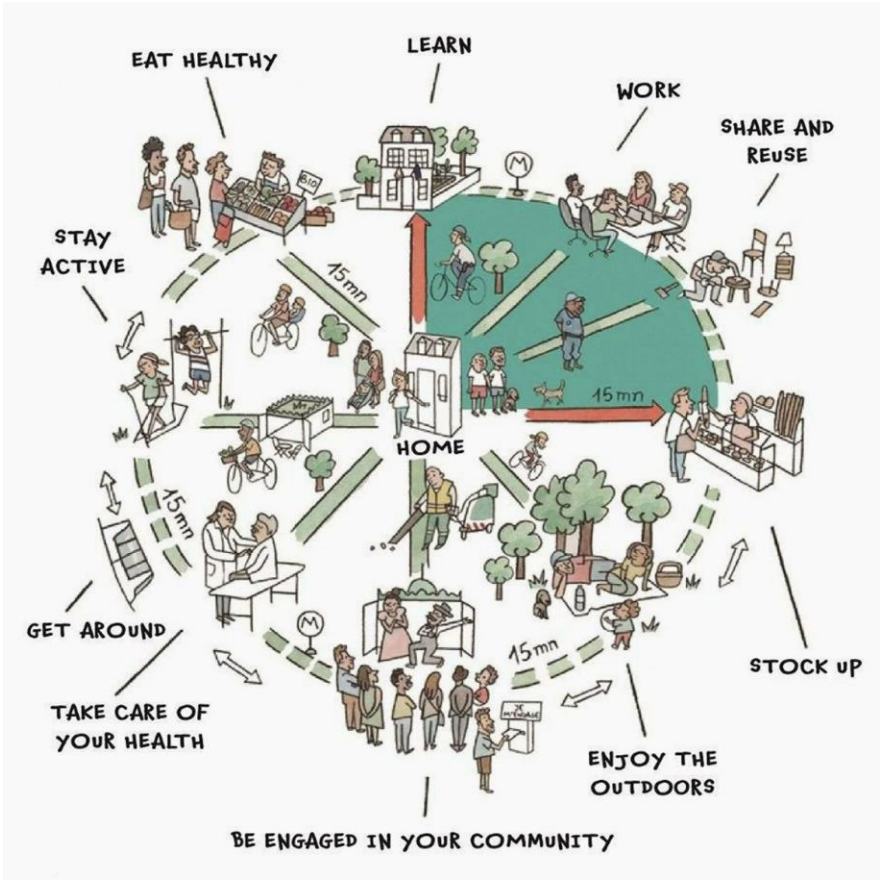
Table 1. Evolution of the concept of Smart City. Authors: Borruso G. and Balletto G., 2021. Source: Original elaboration by authors, inspired by ABB and TEH—Ambrosetti, 2012 [27].

Years	Concept of Smart City	Focus
Early 2000	Digital City	Hardware
Mid 2000	Socially Inclusive City	Software
2010	Quality of Living City	Hardware/Software
From 2020	Health and Sustainability City	Orgware

Table 2. Synthetic comparison of the Smart City concepts (Authors: Borruso G. and Balletto G, 2021).

Smart City	Blueprint-Greenfield	Brownfield	Blueprint-Brownfield
Characteristics	City was born from a real estate project, often on a private initiative, with strong support from the central/local government. ICT infrastructures, new materials, and energy are designed right from the construction of new cities	City of old origin, with an ancient urban layout and with few possibilities for new infrastructures. Smart interventions concern the creation of ICT infrastructures and services. There are often initiatives of local Smart Communities for urban reuse, even temporary and low cost	It can involve new cities or cities with an old system, through the construction of new neighborhoods, or through the massive redevelopment of existing, "smart", project-based neighborhoods, with heavy investments by private initiatives, and in concert with the local government
Participation	Top Down	Top Down/Bottom Up	Top Down/Bottom Up
Geographical contexts	Newly industrialized countries (e.g., Saudi Arabia, United Arab Emirates, South Korea)	Industrialized countries (e.g., USA, Europe)	Industrialized countries (e.g., Canada, USA, Europe)
Examples	Neom (Saudi Arabia), Masdar (United Arab Emirates), Songdo	London (UK), Amsterdam (Netherlands), Copenhagen (Denmark), Milan (Italy)	Toronto—Quayside (Canada), Milan—City Life (Italy)

The 15-minute City



The 15-minute City

The 15-minute city is an urban planning concept where most daily necessities and services—such as living, working, shopping, education, healthcare, and leisure—are accessible within a 15-minute walk or bike ride from residents' homes.

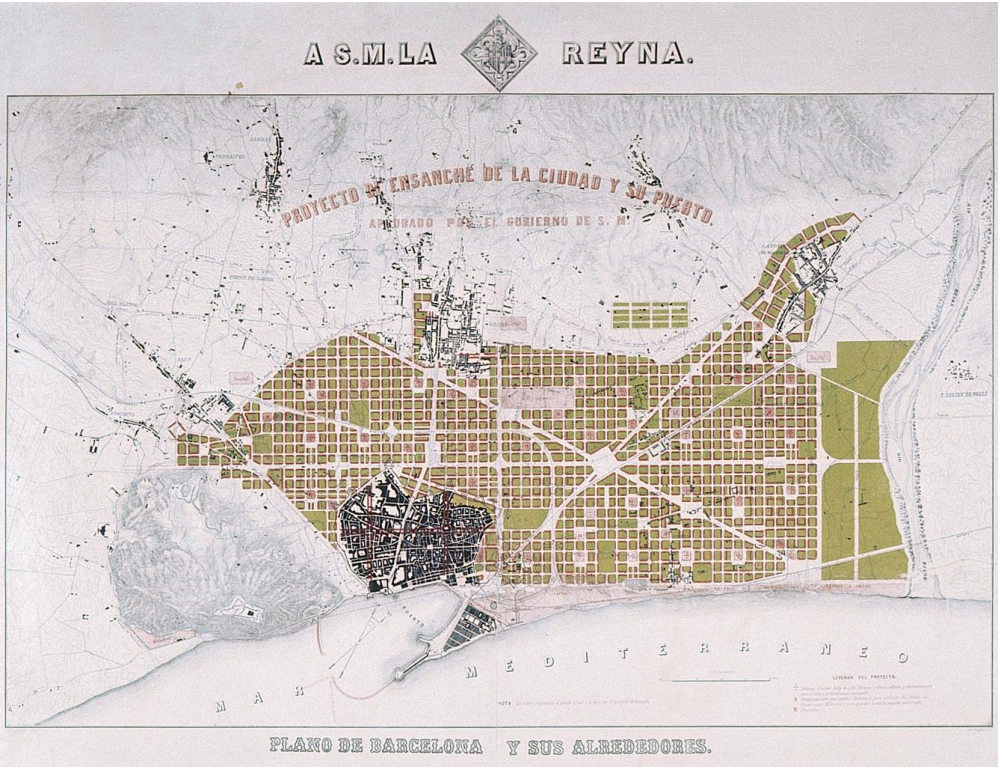
the model aims to create compact, socially connected, and functionally mixed neighborhoods that enhance quality of life, reduce carbon emissions by minimizing the need for motorized transport, and foster community interaction and sustainability.

This concept also aligns with chrono-urbanism, focusing on the value of time in urban life by making daily activities accessible within a short timeframe, rather than just physical distance. The quality of the pedestrian environment also matters, as enjoyable, stimulating streetscapes improve the perception of time spent walking.

- Proximity: Ensuring essential services and destinations are close by spatially and temporally, reducing travel time and distance.
- Diversity: Promoting mixed-use development and multicultural, multifunctional neighborhoods that foster vibrant social and economic life.
- Density: Designing for an optimal population density to support efficient service provision without overcrowding.
- Ubiquity: Equitably distributing services and infrastructure so that all urban areas have access to amenities.
- Human-centric design: Prioritizing walkability, cycling infrastructure, green public spaces, and reducing car dependency.
- Digitalization: Leveraging smart technologies to improve urban living while reducing the need for commuting (e.g., virtual communication, online shopping).

https://www.uccrn.education/15-minute-city/

The 15-minute city in action



Recipe for a Superblock

Take 9 blocks on a 3×3 grid. Close all the inner streets off to cars. Divert all traffic to the outer streets. That's a superblock.

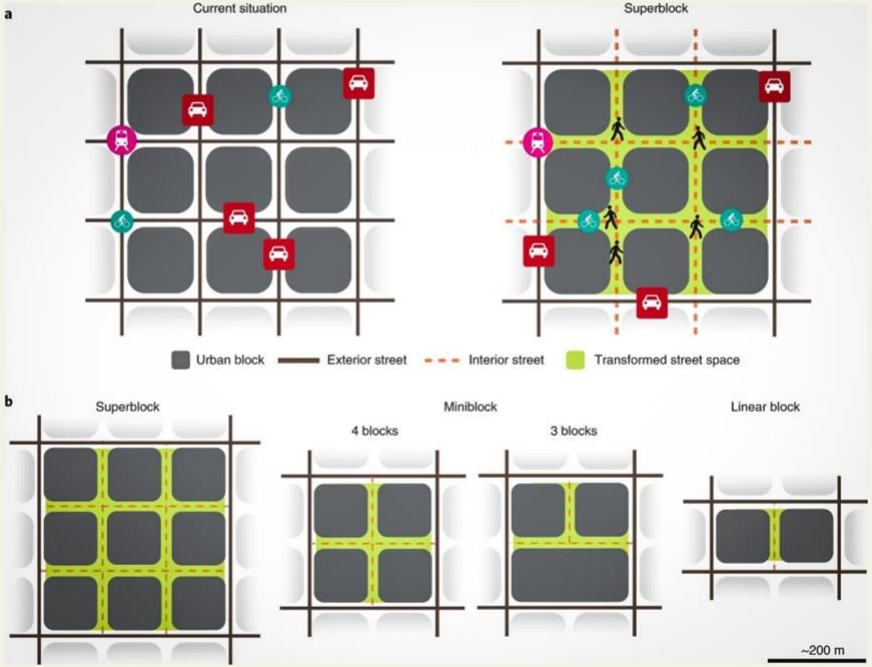


Image credit: Nature Sustainability / Sven Eggimann[1]

https://www.ub.edu/visitavirtual/visitavirtualEH/index.php/en/get-to-know-the-university-of-barcelona/the-city-in-the-nineteenth-century/the-eixample-and-the-historic-building/399-the-cerda-plan
https://citychangers.org/barcelona-superblocks/
https://www.nature.com/articles/s41893-022-00855-2

15-Minute City

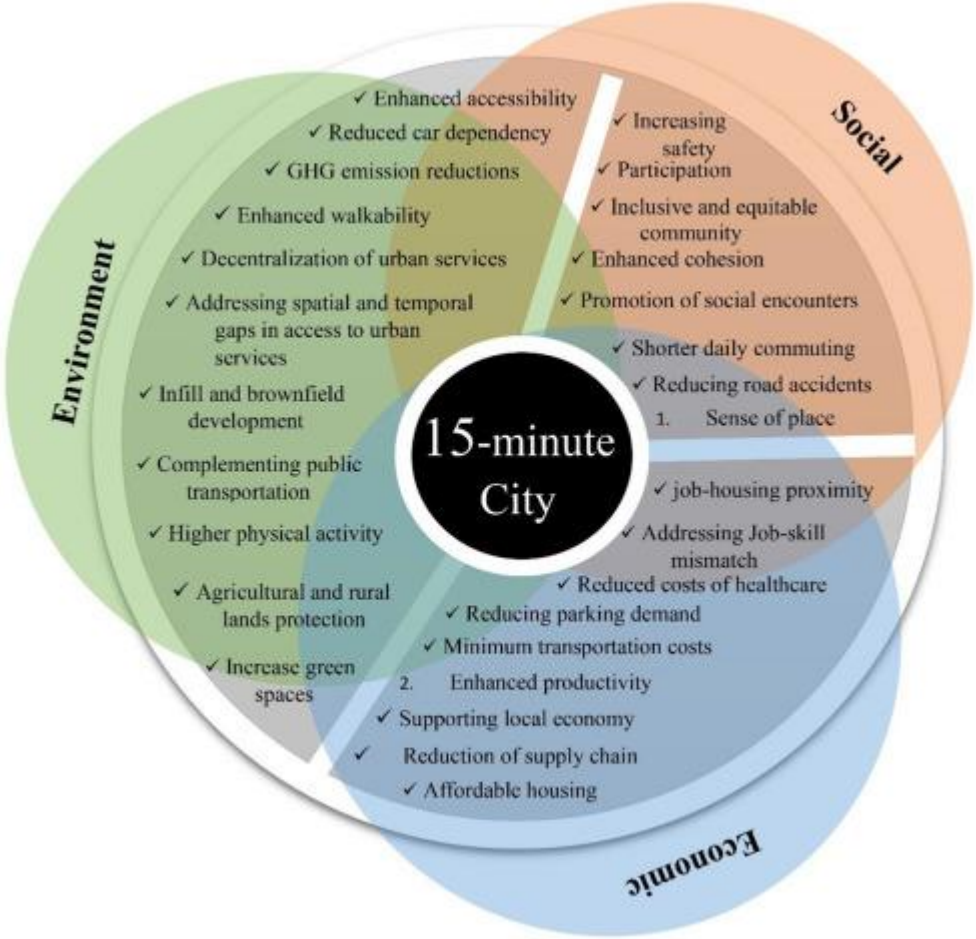
The interaction between the 15-minute city concept and public transport is complementary and essential for achieving comprehensive urban mobility and equity. While the 15-minute city emphasizes proximity, walkability, and cycling to enable residents to access most daily needs within a short travel time, public transport serves as a critical backbone, particularly for linking different neighborhoods, reaching destinations beyond the 15-minute radius, and enhancing overall connectivity across the urban area.

- Public Transport as a Connector: Public transit connects multiple 15-minute neighborhoods together, enabling residents to travel efficiently across longer distances without relying on cars. This fosters a polycentric urban form, reducing congestion and emissions.
- Mobility Equity: Public transit ensures inclusivity by providing mobility options for people who may face challenges walking or cycling, such as the elderly, people with disabilities, and low-income groups. It complements non-motorized transport modes to maximize accessibility for all.

- Integrated Planning: Cities like Utrecht and Glasgow have integrated the 15-minute city with transit-oriented development, focusing urban growth around transit hubs to increase density and service availability, thereby enhancing both sustainability and equity.
- Reducing Car Dependence: The 15-minute city model, supported by reliable public transport, encourages a modal shift away from personal car use, promoting sustainable transport modes that lower pollution and increase urban livability.
- Challenges in Inclusiveness: Despite progress, some plans insufficiently consider mobility aids or specific needs of people with disabilities, highlighting the need for more inclusive transport and urban design policies.

The 15-minute city & Sustainability

- Paris, France: Often cited as the pioneer and emblematic example of the 15-minute city, Paris has 50 fifteen-minute neighborhoods in operation. The city's mayor Anne Hidalgo and urbanist Carlos Moreno have integrated this principle into city planning to prioritize proximity, walkability, and local services.
- Melbourne, Australia: A large, fast-growing city undertaking efforts to retrofit existing infrastructure to support 15-minute neighborhoods, focusing on healthier and more connected communities.
- Ottawa and Edmonton, Canada: Both Canadian cities have adopted 15-minute neighborhoods as frameworks for urban development focusing on connectivity, accessibility, and sustainability.
- Barcelona, Spain: Known as a model for walkable urbanism, Barcelona is improving pedestrian and cycling infrastructure and using digital tools like digital twins to simulate and plan 15-minute city implementations.
- Shanghai, China: Committed to the 15-minute city as a strategy against urban sprawl, aiming for 99% of public services within a 15-minute walk by 2035.
- Bogotá, Colombia: Integrating the 15-minute city model in its land management plan with emphasis on green corridors and pedestrian-friendly infrastructure.



Smart & Sustainable Cities & Utopias

NEOM

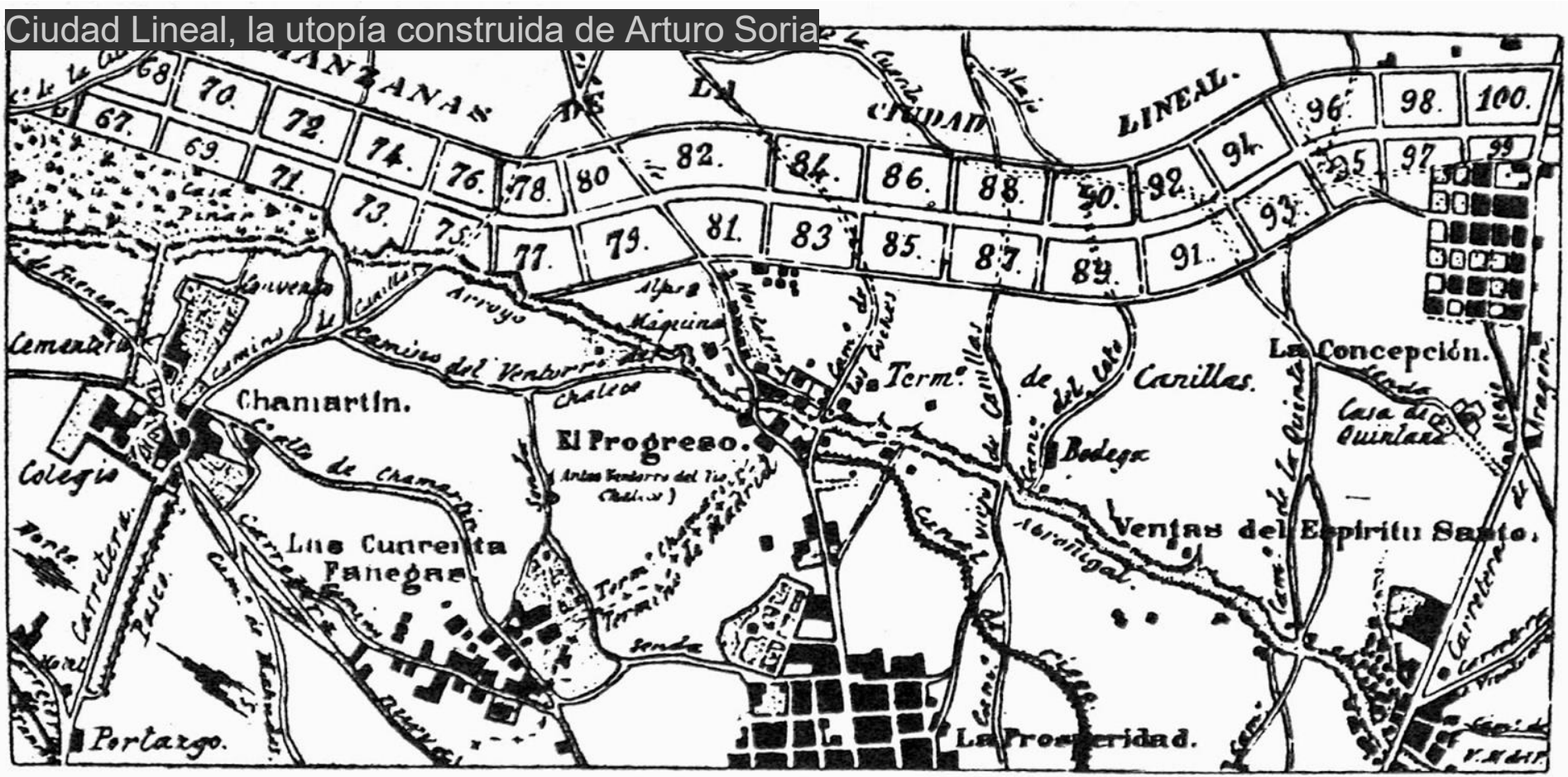
https://mobile.ilsole24ore.com/art/commenti-e-idee/2017-10-25/nasce-neom-la-citta-da-500-miliardi/AENzN1uC

https://www.neom.com


THE LINE


THE LINE
REVOLUTIONARY URBANISM
THE LINE IS COMPRISED OF A SERIES OF INTERCONNECTED MODULES, REACHING 500M HIGH.
THE CORE ELEMENTS OF EVERY MODULE ARE STANDARDIZED TO MAXIMIZE COMPATIBILITY AND DRIVE DOWN CONSTRUCTION COSTS.
170 KM
LENGTH OF THE LINE
500 M ABOVE SEA-LEVEL
HEIGHT OF THE LINE
200 M
WIDTH OF THE LINE
34 SQ.KM
FOOTPRINT OF THE LINE
2% OF CONVENTIONAL CITIES
NEOM
NEOM.COM

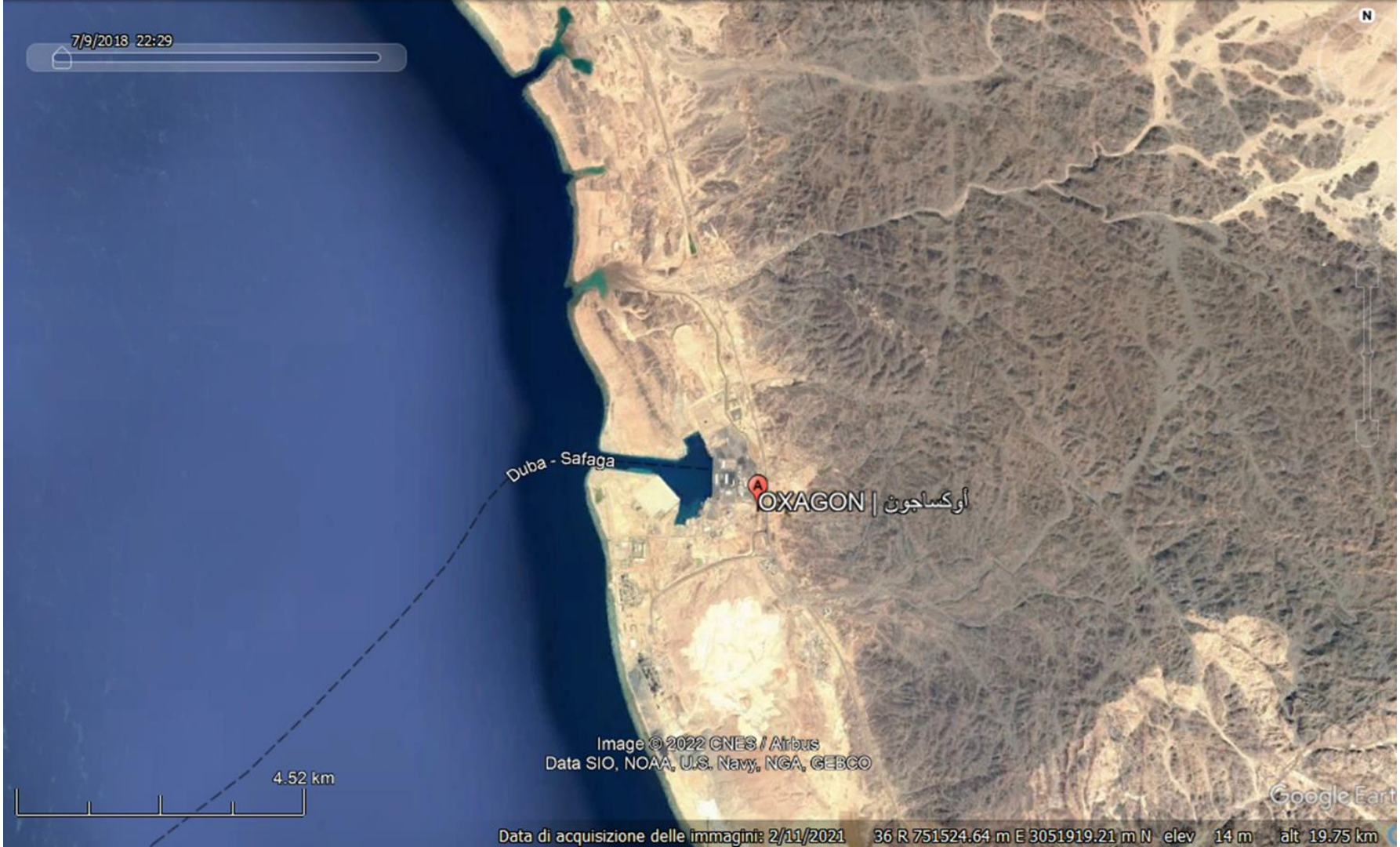
Ciudad Lineal, la utopía construida de Arturo Soria



División en manzanas de la Ciudad Lineal de Madrid.

https://arqui-2.blogspot.com/2014/07/ciudad-lineal-la-utopia-construida-de.html

https://www.youtube.com/watch?v=47eZb_Q9ZTc


7/9/2018 22:29
N
Duba - Safaga
OXAGON | أوكساجون
Image © 2022 CNES / Airbus
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
4.52 km
Google Earth
Data di acquisizione delle immagini: 2/11/2021 36 R 751524.64 m E 3051919.21 m N elev 14 m alt 19.75 km

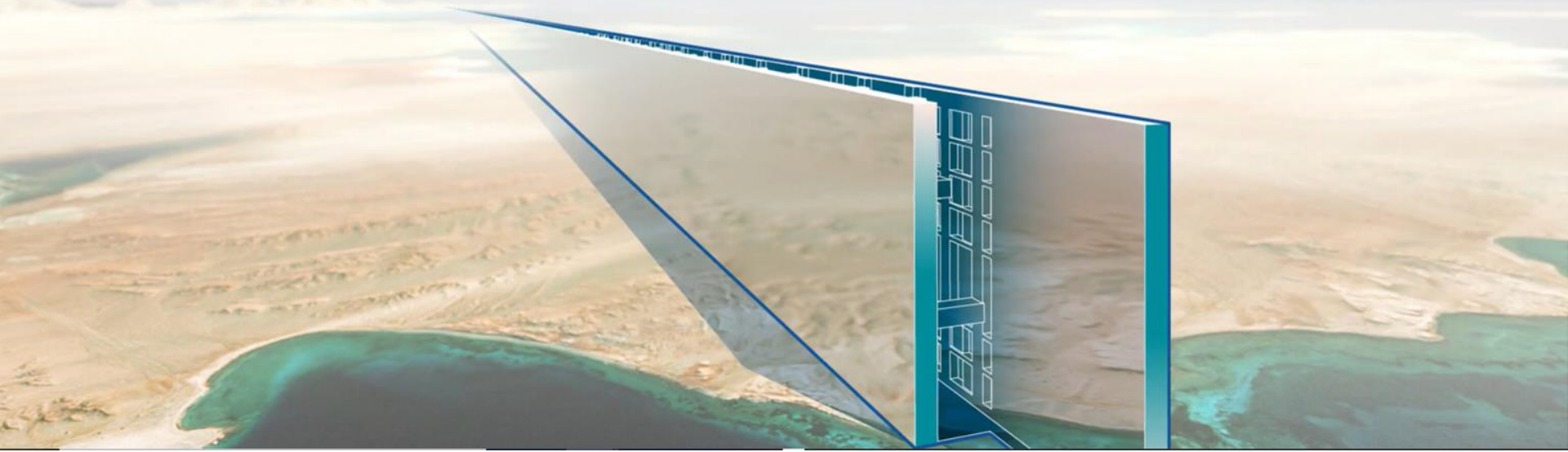

OXAGON

FINANCIAL TIMES

Visual investigation

End of The Line: how Saudi Arabia's Neom dream unravelled

Mohammed bin Salman's utopian city was undone by the laws of physics and finance



https://ig.ft.com/saudi-neom-line/

Sindalah, part of NEOM

https://www.constructionbriefing.com/it/news/sindalah-inaugurato-il-primo-dei-progetti-neom-dell-arabia-saudita-ad-essere-completato/8053847.article?zephr_sso_ott=crDLSu

Smart Village vs. Smart City: A Paradigm Shift

The Smart Village paradigm diverges from urban approaches to smartness in several key ways, signaling a transition from a technocratic, city-centric vision to a more inclusive, community-based approach to rural development.

Origins and Focus: While the concept of Smart City emerged as a tool to optimize urban governance and promote technological innovation in urban areas, the Smart Village paradigm was launched in 2017 to address the decline of rural areas, focusing on the specific needs of these communities.

Scale and Scope: Smart City approaches tend to concentrate on large urban centers, with an emphasis on technology and digital infrastructure. Conversely, the Smart Village model applies to smaller rural communities, recognizing the importance of combining technological and non-technological solutions for community well-being.

Development Approach: The Smart City concept often prioritizes "top-down" technological solutions implemented by governments and large corporations. In contrast, the Smart Village model emphasizes a "bottom-up" approach to development, encouraging community participation and leveraging endogenous resources.

Definition of "Smartness": Smartness in urban areas is frequently associated with the use of digital technologies to improve efficiency and sustainability. In rural areas, the concept of smartness expands to include social innovation, local capacity building, and the creation of resilient communities.

Conceptual and Operational Shift

The Smart Village initiative marks a shift in scale and perspective within European policies. While smartness policies were traditionally applied to urban areas or limited to technological innovation at the corporate level, the Smart Village initiative shifts the focus to rural development, recognizing the potential of social innovation and community participation.

References

https://www.un.org/sustainabledevelopment/cities/

https://www.un.org/en/academic-impact/sustainability

https://www.un.org/en/conferences/environment/rio1992

https://sustainabledevelopment.un.org/content/documents/Agenda21.pdf

https://www.c40.org/it/

https://www.globalcovenantofmayors.org/

https://www.visualcapitalist.com/anatomy-smart-city/

https://www.c40knowledgehub.org/s/article/How-to-build-back-better-with-a-15-minute-city?language=en_US

https://www.deloitte.com/an/en/Industries/government-public/perspectives/urban-future-with-a-purpose/15-minute-city.html

https://www.frontiere.polimi.it/the-inventor-of-the-15-minute-city/?lang=en

https://www.uccrn.education/15-minute-city/

https://www.ub.edu/visitavirtual/visitavirtualEH/index.php/en/get-to-know-the-university-of-barcelona/the-city-in-the-nineteenth-century/the-eixample-and-the-historic-building/399-the-cerda-plan
https://citychangers.org/barcelona-superblocks/
https://www.nature.com/articles/s41893-022-00855-2
https://human-settlement.emergency.copernicus.eu/index.php
https://ig.ft.com/saudi-neom-line/